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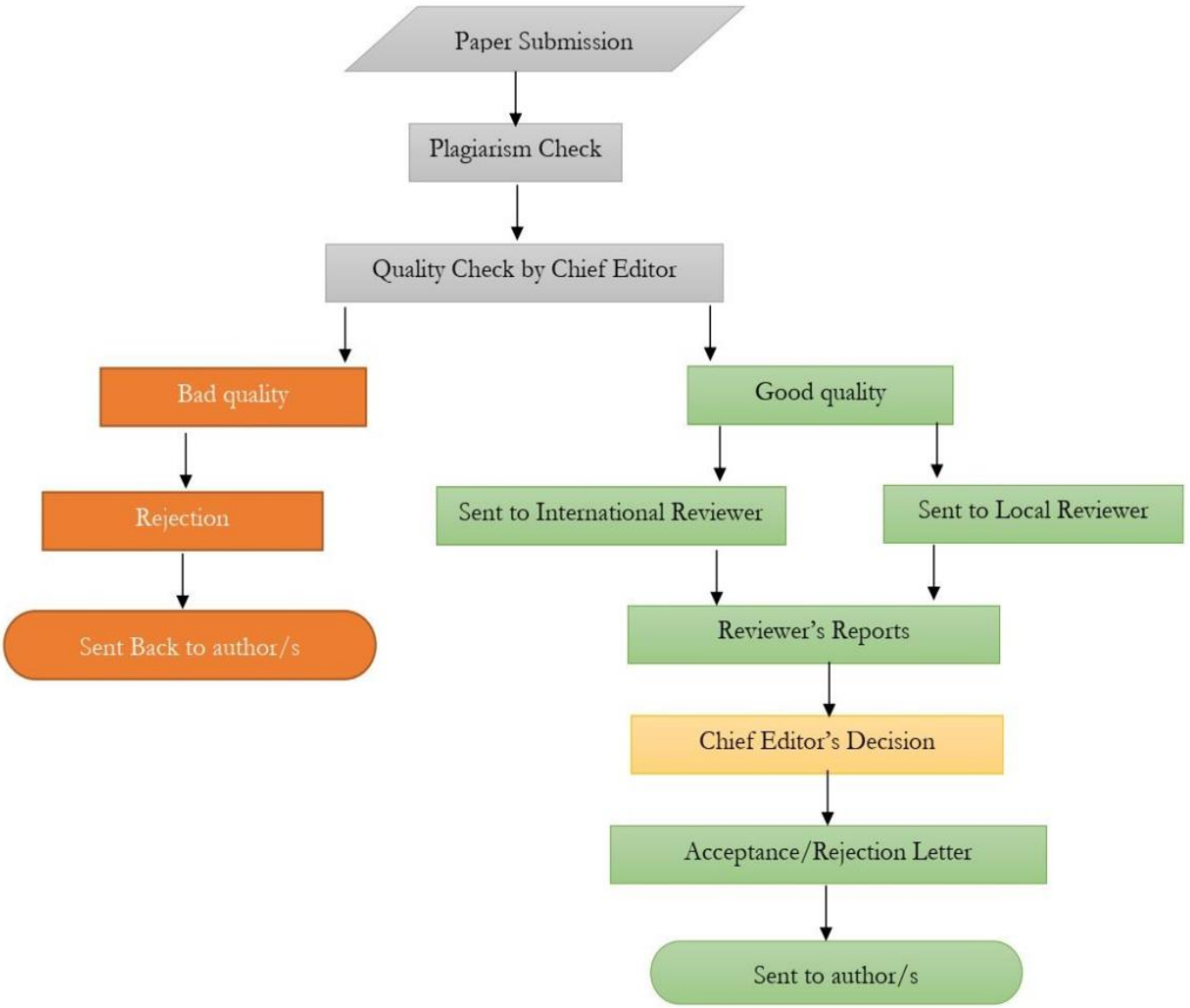

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ASSESSMENT OF SERVICE QUALITY AND EFFICIENCY OF BUS RAPID TRANSIT SYSTEM

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Abstract
Transportation is an indistinguishable component of any society. Provision of luxury transportation at favorable rates to general public is the need of the day for societal comfort. Research has been done to assess the service and efficiency level of(Bus Rapid Transit)BRT system by evaluating initial parameters including passenger's attitudes towards quality, safety, security, and service provided by Metro bus Lahore as well as identifying problems encountered by passengers. In Pakistan, local transportation play significant role for travelers to commute whereas the vast transportation system of Lahore and construction of Metro Bus Transit System with consideration to balance demands of traffic has provided safer, economical and secure public transport system to the people. This research has been carried out from Shahdara to Gujjumata. The questionnaire-based survey was conducted. which was comprised of questions according to problems, needs of passengers and indicators which were set to identify the service quality of Metro Bus. It is revealed from analysis that majority of people are satisfied from service quality, punctuality, accessibility and efficiency provided by BRT system. It is also observed that this service is user-friendly for physically impaired persons. Dissatisfaction level was also observed on low seating capacity in buses, security, safety of users on board. This research suggests concerned authority to improve, enhance current passenger services and provide better services so that current users can enjoy services and attract new passengers to use Metro bus as well as imply international best practices in Pakistan urban transport.

Keywords: Bus Rapid Transit (BRT), Passenger satisfaction, Metro Bus,

INTRODUCTION

Transportation is important part of any society. Buses, LRT (Light Rail Transit), BRT (Metro Buses), wagon, mini-vans, auto-rickshaws and taxis are the types of urban transport. Public transport is to satisfy the passengers, by providing the high-quality services [1]. The passenger's perception is an important measure in evaluating the level of the quality of bus service [2]. Both the developed and developing countries, have faced many problems in urban transportation such as poor quality infrastructures, mismatch between demand and

supply, crowd of passengers and congestion on roads that lead to increase travel time due to improper segregation of bus lanes [3]. Urbanization and increased number of vehicles are responsible for environmental degradation [4]. Burning of fuels by vehicles add a considerable amount of CO_2 in the atmosphere which is ozone precursor. The main sources of Ozone precursors are petrol pumps, industries, residual smoke from factories, automobile emissions, water desalination plants and gas-based power stations [5]. Public transport is an alternative source for reduction of environmental pollution. To overcome such problems, BRT bus service was introduced which is a city-based, high speed transport travel framework in which buses travel on dedicated routes [6][7]. BRT is now a days broadly executed in both the developed and developing world [8]. Deng and Nelson (2012) [9] found that 75.4% people were diverted from previous bus system to BRT [9][10]. Nugroho et al. (2010) [11] studied almost 14% private car users altered their transportation mode to BRT within four months in the city. Echeverry et al.(2004)][12] studied the travel time for users of the city reduced by 32%. Gutierrez (2010)[13] mentioned that BRT showed better performance, user satisfaction, travel time, reliability and improved urban environment than the previous bus system [14,15, 16, 17].

The aim of this study was to assess the current public bus services in the city and to suggest a sustainable and suitable rural-urban bus system. This study includes identification of research problem, research questions formulation, formulation of research objectives, reviewing the literature of developed countries, and to suggest measures for improvement in current metro system in local context. A questionnaire was designed by considering the research questions and objectives which helped in data collection and in analysis of collected data.

The main objective of this research was to review the literature regarding quality of BRT (Metro bus), its efficiency and passenger's satisfaction level in international and national context. Other objectives include the establishment of the performance indicators, assessment of the service quality and efficiency of BRT (Metro Bus) using that criteria. To improve quality of bus service conclusions and recommendations are drawn upon analysis.

Material and Methods

Metrobus is operating in various cities of Pakistan but here we are specifically concerned with metro bus working in Lahore Punjab, Pakistan which is one of the biggest rapid bus (transit services). Lahore Metrobus service is coordinated with Lahore Transport Company's (LTC) local bus service to function as an urban transport system, which provide transit benefits across Lahore with association to neighboring suburban communities. Till May 01, 2017 the system had transported 210 million passengers supported by 64 buses. Metro bus infrastructure was developed in Lahore covering a distance of 27 km on Ferozepur Road corridor comprising of 27 stations with an average distance of 1.04 km from station to station. The terminal stations are Shahdara, in the North west side and Gajjumata, in the South-East side of Lahore. Metro bus stations are showing in Figure 1.

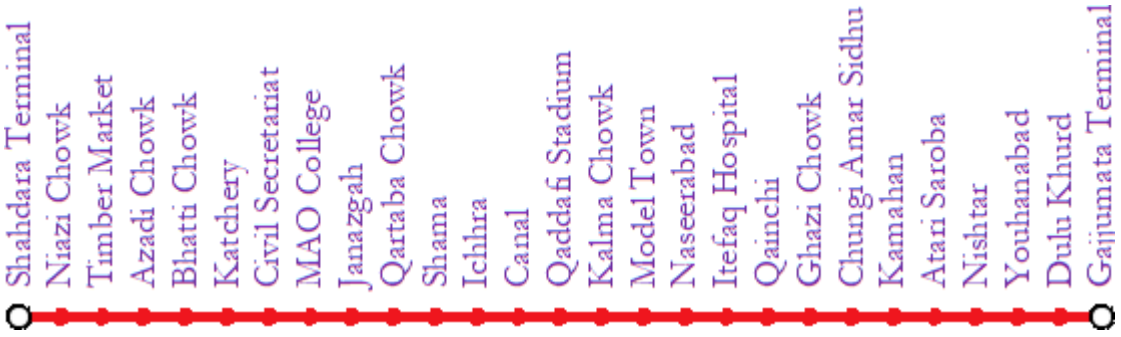

Figure 1. Route map of metro bus stations.

Seating capacity of buses utilized in BRT Lahore is 160 which create a normal directional capacity of 3906 travelers per hour. Normal everyday ridership of Metro transport Lahore is nearly 125,000. Working hours of metro bus service are 16, from 6am to 10pm. Peak hours starts from 7am to 10am and from 4pm to 8pm. The frequency of Metro bus Lahore is 20 buses per hour in off-peak hours and 27 buses per hour in peak hours. In off-peak hours, the time headway is 3 minutes. From terminal to terminal the maximum time required is 63 minutes which is achieved mostly but sometimes, when peaking takes place at stations, dwell time is increased.

Material:

Primary data was comprised of questionnaires designed to achieve the real-time information about the passengers' perceptions. In this research, secondary data sources were Government or Metro bus offices, books, magazines and daily papers, reports arranged by researchers, open records and measurements.

Thus, a total of 125000 daily ridership came into calculations when sample size was known. The sample size is determined from the Solvin sample size formula (1960) [18]:

$$n = N/1 + Ne2$$

The calculated sample size was 2400, the sample was determined through random sampling from different stops. The collected data was further processed by the chi-square test, t-test, and regression analysis on SPSS to draw the best results. After applying these analyses, the best method was a correlation to support the defined variables.

Table 1: Evaluation criteria of performance indicators

Performance Indicators	Evaluation Criteria
Headway	Bus on Time / Punctuality
	Easy Access to Bus
	Easy to Switch Buses
Station Services	Restroom Availability Sufficient Benches Available
	Guidance About Services (Availability of Maps, Timetables And Information On Delays)
	Card/ Ticketing System
	Enough Shelters for Bus Stops
	Provision of Ramps/ Escalators for Disabled Persons

Bus Comfort	Enough Seating Capacity in Buses
	Bus Level Boarding
	Enough Leg-Space in Buses
	Easy to Carry Items on Board
	Security (Not Afraid of Being Pickpocketed on Bus)
	Safety of Passengers on Board
	Ceiling Heights of Buses Are Convenient
	Convenience for Elderly, Disabled
	Enough Widened Door for Wheelchair
	Enough Space for Wheelchair Inside Bus
	Staff Behavior
Bus Condition	Cleanliness
	Comfortable Seats
	Proper Maintenance of Buses
	Ventilation
Facilities Inside Buses	Air Conditioning Service

A closer cross examination reveals that passengers were divided in different satisfaction levels towards the bus service-quality. These divisions were used to examine the level of disagreements and agreements in term of their perceptions. The satisfaction levels were categories as 0% 20% 40% 60% and dissatisfied levels as 47% 36% 17%.

Table 2 Summary of Public response to various quality attribute

Performance Indicators	Evaluation Criteria	Performance Grades		
		Satisfied	Indifferent	Dissatisfied
Headway	Bus on Time / Punctuality	69%	19%	12%
	Easy access to Bus	53%	38%	9%
	Easy to switch buses	41%	31%	28%
Station Services	Restroom Availability	51%	36%	13%
	Sufficient Benches Available	11%	37%	52%
	Guidance about services (availability of maps, timetables and information on delays)	69%	29%	2%
	Card/ Ticketing System	71%	24%	5%
	Enough shelters for bus stops	38%	20%	42%
	Provision of Ramps/ Escalators For Disabled Persons	50%	31%	19%

Bus Comfort	Enough Seating Capacity in buses	20%	25%	55%
	Space availability at Level Boarding	40%	42%	16%
	Enough leg-space in buses	70%	25%	5%
	Easy to carry items on board	60%	30%	10%
	Security (Not afraid of being pickpocketed on bus)	11%	20%	69%
	Safety of Passengers on Board	33%	18%	49%
	Ceiling Heights of Buses are Convenient	78%	13%	9%
	Convenience for Elderly, Disabled	26%	29%	45%
	Enough Widened door for wheelchair	65%	25%	10%
	Enough space for wheelchair inside bus	50%	20%	30%
	Staff Behavior	71%	22%	7%
Bus Condition	Cleanliness	56%	33%	11%
	Comfortable seats	65%	30%	5%
	Proper Maintenance of buses	30%	44%	26%
	Ventilation	53%	29%	18%
Facilities Inside Buses	Air Conditioning Service	47%	36%	17%

Discussion

In Pakistan, Metro bus was the first bus rapid transit project and the aim to implement this project was to provide high efficiency and better service quality through fast, reliable and comfortable BRT system that fulfills the demand of passengers for achieving high satisfaction level. By evaluating service quality, attributes such as station services, bus comfort, bus condition, facilities inside buses are ensured which reveals that Metro Bus is solving many problems in term of mass transportation e.g., reduced travel time, easy accessible to long distance users and the cost-efficient as compared to other public transport. Analysis on service quality and efficiency of Metro bus service were drawn on the basis of passenger's perception. The result regarding the performance of headway shows that mostly passengers are satisfied from the punctuality and accessibility of buses.

As per analysis, predominant satisfaction level was observed on efficiency of Metro bus service like the guidance availability (maps, timetable, information on delays, etc.), provision of ramps/ escalators for disabled persons, availability of enough space at bus level boarding, enough leg space in buses, space for wheelchair inside bus, widened door for

wheelchair and carrying items. Bus conditions like ventilation, comfortability of seats and cleanliness were also observed satisfied by users. Analysis show that most of users show dissatisfaction level on sitting area at Metro stations because of inadequacy of benches, in adequate seating capacity in buses, security, safety of users on board and in adequate seating capacity for elderly people inside buses.

Majority of the users showed ordinary behavior on regular monitoring and maintenance of Metro bus services as BRT system of Lahore is confronting numerous maintenance issues with respect to BRT hallway, lifts, washrooms, water coolers and sewerage framework. Escalators were observed collapsed due to maintenance work. We assessed the quality of the service, efficiency and passenger's satisfaction using quality indicators of bus transport service. By assessing quality attributes, it was found that respondents showed positive attitude toward most of the indicators while least of the indicators revealed negative attitude. Some recommendations have been given below to overcoming the problems that cause the dissatisfaction level.

Installations of up to date framework to get the arrangements for economical transport system in future, which is the reason to extend customer satisfaction. Recurrence, punctuality, and travel time are vital factors observed during survey that are responsible for bringing a higher level of satisfaction. Adequate seating capacity should be increased at each bus stop so that passengers can wait for buses patiently and their comfort level can be improved.

Availability of seats in a bus is linked with crowd condition when there will no crowd, passengers will get more chances to get a seat. So, the schedule of buses should be designed to accommodate crowding, and everyone should have access to a seat in buses. Ease for elder people should be improvised by making seats reserved for them and allow them to board the bus easily by taking as much time as they want.

Lahore BRT corridor needs maintenance as corridor is damaged badly at various points. Buses should be monitored and maintained properly after specific time periods to ensure the quality. For improving service quality, passenger security is very important. To keep customers safe and secure inside buses and at boarding, buses should have good lighting system, security cameras and should keep an eye on the pickpockets and other criminal activities and should also be monitored in cooperation with the police especially at high demand routes and terminals. Quality and management of Metro Buses should be improved by cleaning the environment onboard, running on schedule, providing pleasant environment at stations and maintaining air-conditioning onboard, are prerequisites to obtain passenger satisfaction

Social and Environmental impacts of metro bus:

Socially, BRT is economical, affordable, time saving as well as health promoting, environment protecting, discipline instilling, a source to create social homogeneity, and community acceptance or satisfaction. It has reduced traffic congestion, air pollution, noise pollution, and road accidents to some extent**.** According to the survey, respondents wanted that the fares must be less than 20 rupees. About 90% people were very optimistic and hopeful for the BRT with positive opinions. Almost 50% people were agreed with opinion that MBT has reduced the unemployment rate. Most of the people thought BRT has reduced traffic on roads. People used motor bikes within the city but by the advent of BRT most people left their own vehicles and shifted on this service. Some people shifted from

conventional buses to BRT because of poor services and inconvenience of old transport system. Poor were not able to afford the high fares of reasonable public transport like Daewoo, meanwhile, rich people did not agree to leave their own vehicles.

MBT has reduced the commuting time and increased the accessibility towards work. Accessibility to other establishments such as hospitals, schools and colleges also improved since these are situated along BRT route.

Acknowledgement. Author would like to thank Allah Almighty as well as the concerned government official of Metro Bus Authority and people for providing necessary information and guidance while conducting research activities and specially Ma'am Maria(assistant professor, Department of City and Regional Planning LCWU) who assisted us in the proofreading of this paper.

Author's Contribution. I did this work by my own.

Conflict of interest. Authors has no conflict of interest.

Project details. NIL

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Annexures- 1

SURVEY QUESTIONNAIRE DESIGNED FOR THE ASSESSMENT OF SERVICE QUALITY, EFFICIENCY & PASSENGERS SATISFACTION LEVEL TOWARDS BUS RAPID TRANSIT (METRO BUS LAHORE)
DEPARTMENT OF CITY AND REGIONAL PLANNING
LAHORE COLLEGE FOR WOMEN UNIVERSITY, LAHORE

1. Name of Respodent:

   _____

2. Gender:

   ☐ Male ☐ Female

3. Age Group:

   ☐ <25 Years ☐ 26-35 Years

   ☐ 36-45 Years ☐ >45 Years

4. Occupation:

   ☐ Student ☐ Business

   ☐ Private Employee ☐ Govt. / Semi- govt Employee

   ☐ Other (please specify) _____

5. Frequent access mode to metro bus station

   ☐ Foot ☐ Car/bicycle

   ☐ Rickshaw/ Qingchi ☐ local bus/ Wagon

   ☐ other (please Specify) _____

6. How often do you take metro bus as a transport measure?

☐ Daily ☐ Once a week ☐ Once a month

☐ Rarely ☐ First experience

7. What is your trip purpose?

☐ Work ☐ Education

☐ Medical

☐ Shopping ☐ Social

☐ Other

8. Total No. of trips per day

☐ 1 ☐ 2

☐ 3 ☐ More than 3

☐ Not Applicable

9. Total travel time from Residence to metro station

☐ 5-10 min ☐ 10-20 min

☐ 21-30 min ☐ >30 min

10. Satisfaction on Travel time reduction by metrobus as compared to other public transport

☐ Satisfied ☐ Indifferent

☐ Dissatisfied

11. Satisfaction level on effective cost by metrobus as compared to other public transport

☐ Satisfied ☐ Indifferent

☐ Dissatisfied

12. Do you use Park n Ride? If Yes, then are you satisfied with the facility of Park n Ride?

☐ Yes ☐ No

Do you feel buses are overcrowded at peak hours of travel?

☐ Always ☐ Sometimes

☐ Rarely

13. Are you satisfied with Metro bus service schedule?

☐ Satisfied ☐ Indifferent

☐ Dissatisfied

14. Are you satisfied with Metro bus service routes?

☐ Satisfied ☐ Indifferent

☐ Dissatisfied

15. Are you satisfied with frequency and reliability of bus service?

☐ Satisfied ☐ Indifferent

☐ Dissatisfied

16. Will you recommend Metro bus service to others?

☐ Yes ☐ No

Performance Indicators	Evaluation Criteria	Performance Grades		
		Satisfied	Indifferent	Dissatisfied
Headway	Bus on Time / Punctuality			
	Easy access to Bus			
	Easy to switch buses			
Station Services	Restroom Availability			
	Sufficient Benches Available			
	Guidance about services (availability of maps, timetables and information on delays)			
	Card/ Ticketing System			
	Enough shelters for bus stops			
	Provision of Ramps/ Escalators for Disabled Persons			
Bus Comfort	Enough Seating Capacity in buses			
	Space availability at Level Boarding			
	Enough leg-space in buses			
	Easy to carry items on board			
	Security (Not afraid of being pickpocketed on bus)			
	Safety of Passengers on Board			
	Ceiling Heights of Buses are Convenient			
	Convenience for Elderly, Disabled			
	Enough Widened door for wheelchair			
	Enough space for wheelchair inside bus			
	Staff Behavior			
	Cleanliness			
	Comfortable seats			
Bus Condition	Proper Maintenance of buses			
	Ventilation			
Facilities Inside Buses	Air Conditioning Service			

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Efficient Strategy to Remove Potable Water Scarcity in Lahore

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Abstract.
"Water is life" is not only a phrase but also a reality which ensure human survival. This study provides an important tool to analyze different water management strategies that can be helpful in saving available water resources in an efficient way. Consultation with the public and officials of Water and Sanitation Agency (WASA), Lahore Development Authority (LDA), and Water & Power Development Authority (WAPDA) made this easier to understand the acceptability of the explored strategies in Lahore. A sample size of 400population was observed a supportive method to draw favorable results from the collected primary data. It is estimated that Lahore and its outskirts receive highest rainfall which contributes 40% to the annual groundwater recharge but the water table is still depleting gradually. This research provides necessary information regarding the conservation of ground water. The correlations method was applied to check the significance of the variables. The findings proposed that authorities must communicate awareness among general public regarding importance of water or should start programs for water management. The other way of correlating strategies implemented in other similar countries led us towards billing and taxing as the topmost strategy to be implemented in our case study. A total of 66% targeted population was willing to make this strategy implemented through government support. Although other strategies like flash flooding, water recycling, rainwater harvesting, and equitable access to water all the time were following the acceptance as 60%, 61%, and 62% respectively. Finally, imposition of strict laws on water usage leads toward water saving for a sustainable future.

Keywords: Water recycling, Direct Potable Reuse (DPR), Scarcity, Rainfall harvesting.

Introduction

This fact is proved that with the increase in urbanization the demand for fundamental amenities like potable water is increased. The recent migration trends of masses toward developed cities in search of basic needs of life are very common around the world. It is the main reason of extensive urbanization [1]. The rapid urbanization and the population growth

have increased the demands of fresh water to manage various tasks from domestic to industrial scales [2]. The increase in demand has put an intolerable liability on the natural water reserves. Correspondingly, the rapid changes that had been seen in the climate are also the major factors in the scarcity of water in different cities. In this situation, the strategies for water management can be a progressive step towards preserving this natural resource for the challenges that the future beholds. The enhanced cycle of various human activities like agriculture, urbanization, and industrialization have put huge pressure on available reservoirs of fresh water [3]. The recent study on the assessment of adoption of rainwater harvesting system in residential building in Lahore is also supporting one of the best strategies for management. Various countries faced this challenge and implemented different strategies and approaches to cope with this. The major issues seen in South Africa are the extraordinary level of poverty and inequality (water services problems), higher need of already stressed water capitals through the developing economy, annual rainfall which has been recorded is lesser time, fast-flowing rivers and huge underground reservoirs, exacerbation of scanty rainfall by high levels of evaporation, consumption of half of the available resources, abandoned growth in population and decrease of water resources, low level of social flexibility, the amount of water per capita, unmanageable use of water resources, unaware and uneducated population, and poor technological capability[4].In India, the challenges faced during portable water management are to access of the general public to adequate safe water, institutional challenges, service provision, over-extraction of groundwater, increasing monetary crisis, absence of affected people involvement, and inadequate transparency[5]. The policies implemented to overcome these challenges are to develop and to manage these resources, to promote river basin organization, to guarantee integrated water resource management, to support groundwater governance, to scale community-based tanks rejuvenation, to endorse public-private partnership, and to set up and strengthen water regulatory authorities [6]. Sri Lanka is also falling on the line of those countries which faced water management challenges [7]. The main challenges are ejection of the private sector participation, the feeble institutional arrangement, the contamination of water resources from urban, industrial, and agricultural wastes, and soil erosion of water by mismanagement of land-use [7]. The strategies adopted by the Siri Lankans are the institutional arrangements in the water sector, the planned water policies and laws, maintainable water resources management, water transfer competence, construction of new hydraulic infrastructure, and the availability of more water storage through dams [7]. In Lahore, the main challenges identified are inaccessible safe water, institutional challenge, and undiversified service provision, over-extraction of groundwater, growing financial crunch, lack of advanced technology, and lack of awareness to manage portable water.[8]. The solutions derived in the light of the above countries are to apply taxing/billing over high usage, institutional arrangements in the water sector, to improve our technological capacity, try alternate models (Intern-Basin Transfer Approach, Auto-flush system), incentive-based voluntary programs, water conservation measures (groundwater recharge), and rainwater capture[9]. Amendments concerning potable water management in building regulations are a very important tool to support policy measures taken by the authorities.

We are living in the modern era but still, people of our far furlong, as well as urban dwellings are in a state of water shortage. Thus, intentionally or unintentionally people are forced to drink either unhygienic water, bottled, or tap water. Communities have been facing

deficiencies of potable water supply due to the rapid growth of population and development patterns[10]. At the same time Pakistan is struggling to manage natural hazards for survival from nastiest catastrophic conditions which may occur in future. [11]

Pakistan lacks in reliable statistics due to the unavailability of safe and sufficient drinking water. Pipe water in Pakistan is contaminated either because of leakages with all sorts of bacteria or geological conditions and insufficient purification. The process of recovering drinking water from wastewater to enhance the sustainability and reliability of water supplies is called Direct Potable Reuse (DPR). This process can support the supply side. A dominant question in the planning and engineering sector is to determine how can communities continue to grow and flourish while meeting the water resource needs and providing a high quality of life to future generations? Access to adequate water supplies for municipal, industrial, and agricultural uses are important factors among these needs.

Many regions around the world face freshwater shortages due to poor management of the increasing population and development burdens. This research aims to bridge this gap through assessment of different water management strategies in Lahore.

Methodology

The methodology involves the widespread review of relevant literature and collection of primary data through interviews with relevant stakeholders. Literature review convinced and pushed for the initiation of research which was majorly supported by research articles from peer-reviewed journals. A good number of research articles/reports regarding water management strategies, mostly published in high evaluated journals, were reviewed for comprehension of different strategies adopted by countries for the removal of water scarcity. This helped in identifying the research gap and the study domain to be tapped. Primary data were collected through interviews from two sets of respondents: (I) concerned officials of WAPDA, WASA, and LDA, (ii) residents from a sampled household. As many as 8 officials were interviewed to take the viewpoint of WASA and LDA for management strategies. This is a total number of officials whose work domain is related to the scope of this research. Interviews done with concerned officials helped in understanding the motivation behind introducing water management strategies in the case study. Institutional, legislative, and operational issues concerning the introduction and implementation of the most suitable strategies were also documented through these interviews. Snowball sampling technique was used to approach the officials.

So, after reviewing literature about the challenges and strategies faced by different countries, we determined the main role of the study, based on that aim we formulated different objectives to meet our demands. After the formulation of objectives, the next important step was to define the scope of the study. We determined our target population and also the type of research to be carried out. We defined the scope to limit our study to meet the main purpose of the research.

Interviews with selected residents were conducted to consider their views on the implementation of analyzed strategies and to explore factors affecting the adaptability of the strategies. It was a daunting task to identify and select the residents for interviews who would have some knowledge and awareness about the water management strategies. The scope of the study could have been very extensive due to the large sample size if all populations would have been considered for sample size. Therefore, to calculate the sample size of residents, a discussion was held with WAPDA, WASA, and LDA officials to devise a

plan for data collection. The plan included9 official towns/zones created by authority and to collect 45 interviews from each zone.

Thus, a total of 400households came into calculations by Solvin's formula of sample size with a 95% confidence level. The population is projected till 2020 by the following formula.

$$Pt=P_0*(1+r/100)^t$$

The population was calculated as 12540846.Out of these 400, a total of 352 interviews were conducted successfully, and the remaining 48 couldn't be conducted due to the non-cooperation of respondents. Either the residents felt reluctant to respond or the houses were locked. The collected data are further processed by the chi-square test, t-test, and regression analysis on SPSS to draw the best results. After applying these analyses, the best method was a correlation to support the defined variables and study.

Case Study.

Lahore with a population of 11.13 million people is termed as the administrative, educational, business, political, and recreational hub of the province Punjab located in the sub-tropical, semi-arid region[12].The water table in Lahore has been observed depleting the freshwater layer and dropping data rate of 2 ft per annum[13].Lahore receives average rainfall as 575 mm annually, and changing from 300 mm to1200 mm[14].The monsoon period is from July to August which is the hottest spell of the year with most water demand. It is estimated that Lahore has the highest rainfall which contributes 40% of the annual groundwater recharge. Water channel include canal passing through the center, and Ravi River passing adjacent to the boundary. Hence due to rainwater harvesting, canal, and the river, it can be formulated for the varying ideas to adopt water management strategies. The most important is to make people aware of changing their water usage pattern and to contribute to recharging the underground water table. Lahore is the second-most populous city of the country with the population increasing at a frightening rate, correspondingly have an increasing water demand[15].The study site is mapped in Figure 1.

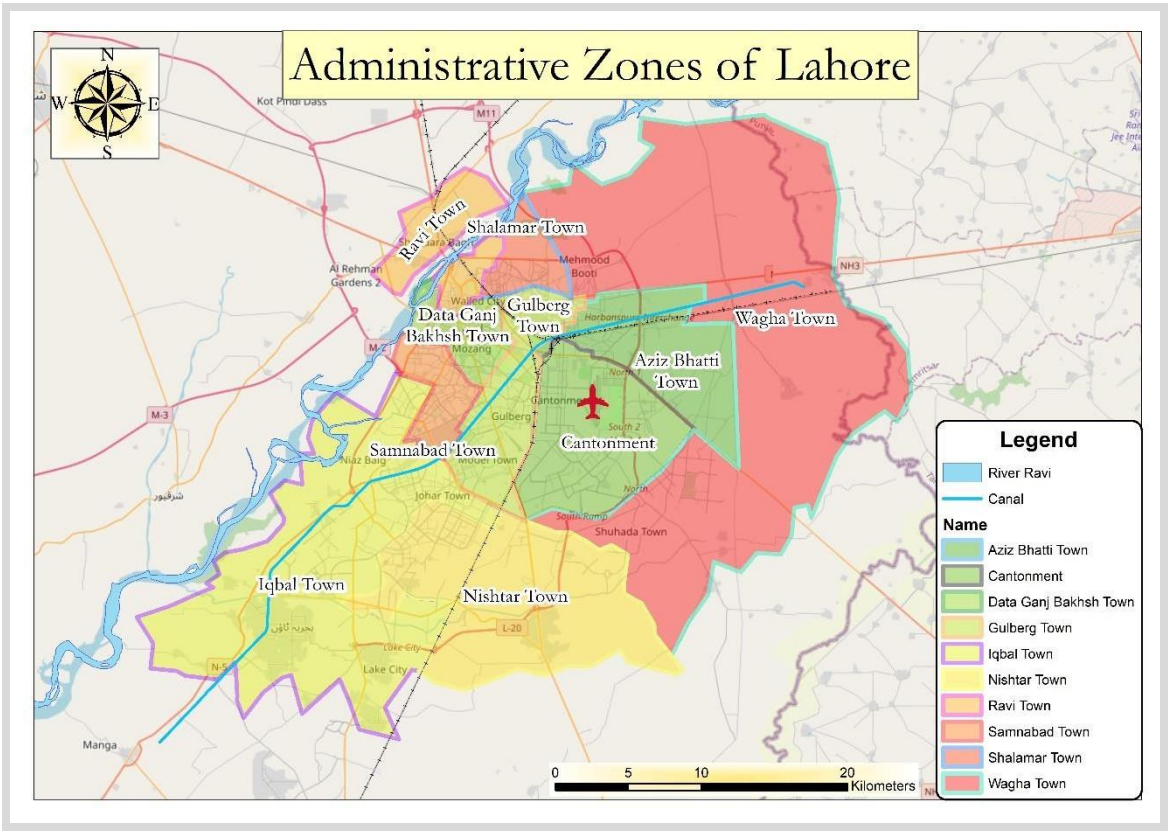

Figure 1: Geographical presentation of case study

Results

The main purpose of taking interview of officials of relevant authorities was to make them involved in introducing the best possible strategies for potable water management in our case study. These strategies were discussed with them through a checklist of strategies derived in the light of literature of different countries. As LDA officials were already doing the practice of groundwater recharging through the amended building regulations 2014. Therefore, their main focus was to get the public involved in this process and they were keen to implement these strategies with the collaboration of other authorities like WAPDA and WASA in Lahore. Likewise WASA, the WAPDA officials also focused to get the public response and to make them aware of the water management strategies and were in progress to use such models through rules and regulations.

The viewpoint of Residents. The basic aim behind getting the response was to get their viewpoint for supporting or rejecting the potable water management strategies coded into the questionnaire. Therefore, in the future, this research might be helpful to the officials for defining policies for these strategies.

Socio-economic information of the residents. The main purpose of adding this question was to get an idea of what is the comparative usage of water between bigger and smaller families. In our case study, household size contained1 to 3 which is 22%, 4 to 6 is 46% and more than 6 was 32%.

In our case study, most of the families were literate and knew how to use water effectively. Awareness programs could easily be delivered for the follow up of water

management strategies in Lahore. People were observed keenly to attend such events and to provide their feedback positively. The demographic information and literacy rate are mentioned in Figures 2 and 3. Figure 4 is showing water consumption at various levels in the city boundary.

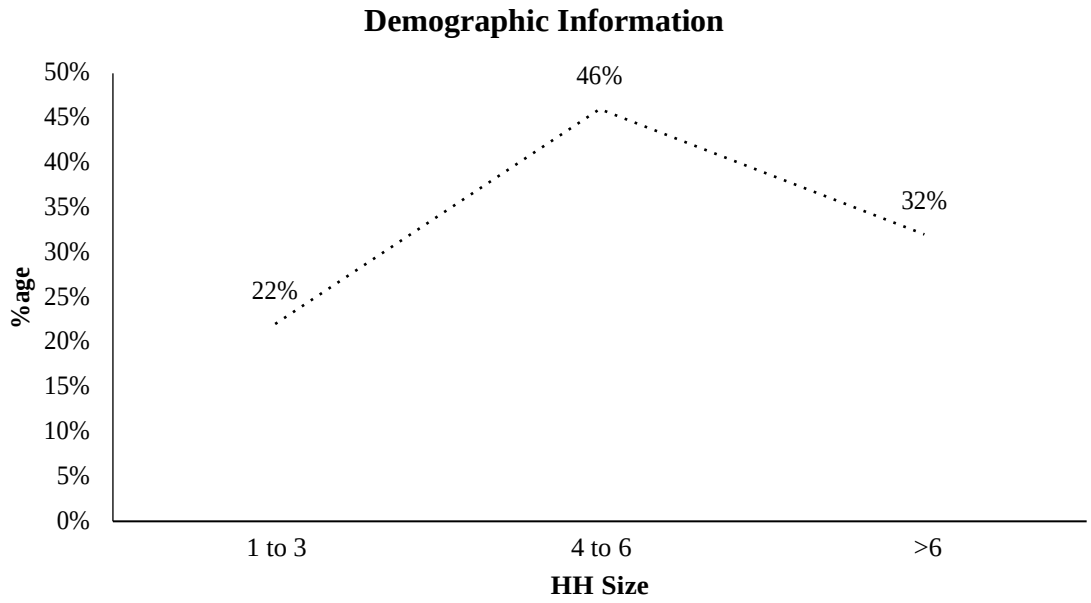

Figure 2: Demographic information of respondents

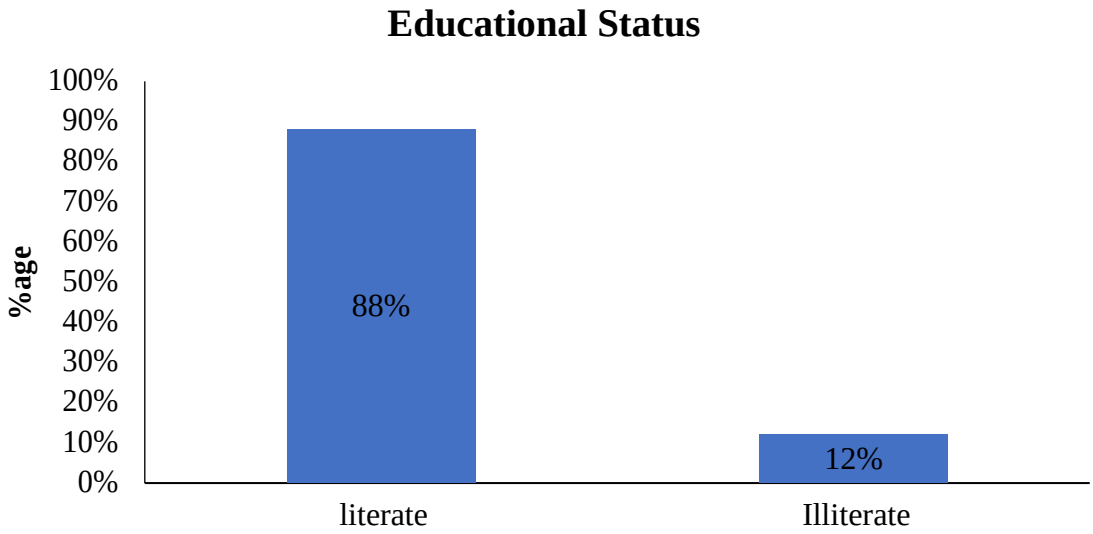

Figure 3: Literacy rate in the study site

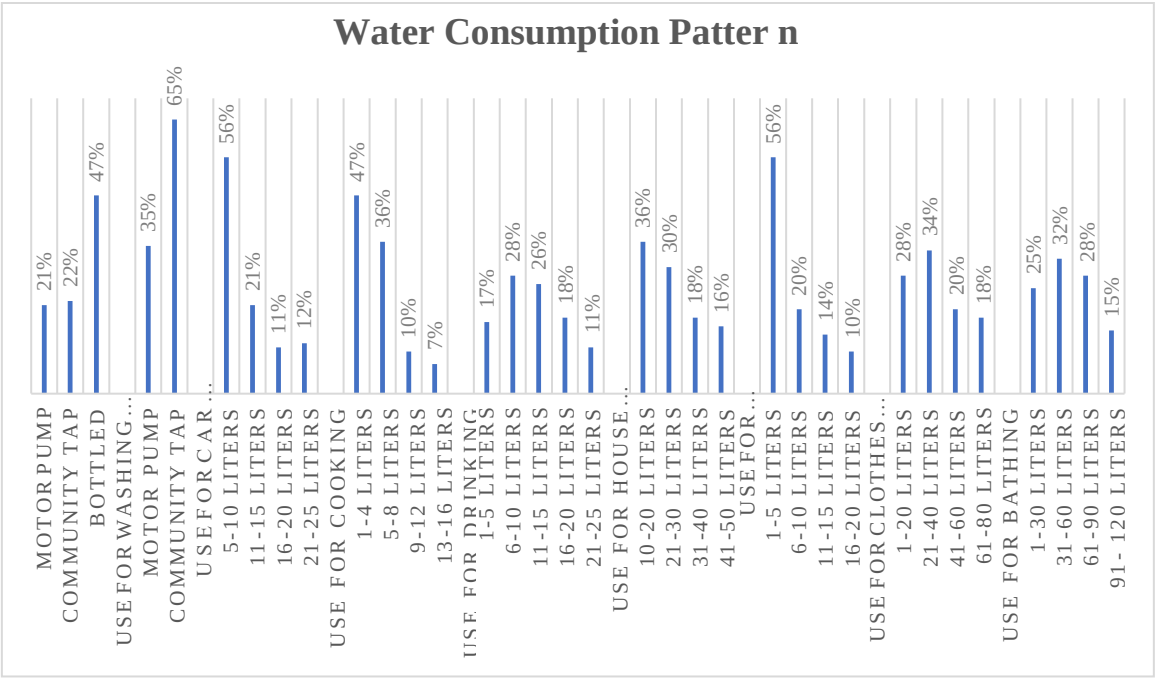

Figure 4: Water Consumption Pattern of residents

Table 1: Awareness Status of the Residents

Correlations

		1.Involvement in supporting the govt for strategies	2.Acceptability towards accessibility of water all the time	3.Acceptability towards instructions by govt for water management	4.Acceptability towards awareness through social media	5.Acceptability towards events on awareness of water management
1.Involvement in supporting the govt for water management	Pearson Correlation	1	.543**	.571**	.412**	.408**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	352	352	352	352	352
2.Acceptability towards accessibility of water all the	Pearson Correlation	.543**	1	.684**	.549**	.583**
	Sig. (2-	.000		.000	.000	.000

time	tailed)					
	N	352	352	352	352	352
3.Acceptability towards Instruction given by authority for water management	Pearson Correlation	.571**	.684**	1	.616**	.675**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	352	352	352	352	352
4.Acceptability towards awareness through social media	Pearson Correlation	.412**	.549**	.616**	1	.766**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	352	352	352	352	352
5.Acceptability towards events arranged by govt on awareness of water management	Pearson Correlation	.408**	.583**	.675**	.766**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	352	352	352	352	352

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

Table 1reveals that the general public response agreeing upon "Accessibility towards instructions given by authority for water management" as the most effective among the five correlated strategies. The public acceptability towards this strategy is 67% of the targeted population. The same strategy is dependent on others like the involvement of the public in helping the authorities to implement strategies as 69% of the total. Accordingly, work needs to be done on all the strategies to get the required results as per the public desire.

Table 2: Correlation status of water management strategies by residents

Correlations

		1.Acceptability towards billing or taxing	2.Acceptability towards flash flooding	3.Acceptability towards reusing the water	4.Acceptability towards rainwater harvesting	5.Acceptability towards Availability of water is all the time	6.Acceptability towards recycling the polluted water
1.Acceptability towards billing	Pearson Correlation	1	.791**	.792**	.769**	.785**	.607**

or taxing	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	352	352	352	352	352	352
2.Acceptability towards flash flooding	Pearson Correlation	.791**	1	.729**	.717**	.698**	.544**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	352	352	352	352	352	352
3.Acceptability towards reusing the water	Pearson Correlation	.792**	.729**	1	.685**	.689**	.681**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	352	352	352	352	352	352
4.Acceptability towards rain water harvesting	Pearson Correlation	.769**	.717**	.685**	1	.727**	.498**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	352	352	352	352	352	352
5.Acceptability towards availability of water is all the time	Pearson Correlation	.785**	.698**	.689**	.727**	1	.538**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	352	352	352	352	352	352
6.Acceptability towards recycling the polluted water	Pearson Correlation	.607**	.544**	.681**	.498**	.538**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	352	352	352	352	352	352

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

Table 2 elaborates the correlation between the public acceptability of the extracted strategies which recognizes accessibility towards billing/taxing to be executed immediately in line with other strategies. The public response towards this strategy is 66% of the sample. The public willingness towards flash flooding is 60%, reusing the water as 61%, for rainwater harvesting 61%, for recycling the water as 64%, and for equitable access for water as 62%. The analysis is based on preliminary studies and can be revised with future studies.

Discussion

As the levels and quality of groundwater in Lahore is being dejected at a very fast rate, therefore it is projected that the aquifer will not be used in near future. Therefore, there is a dreadful requirement for considering the undercurrents and aspects accountable for this worthless condition. After the analysis of interview data based on previous studies regarding potable water management problems in the case study, we can draw some direction for the strategies. In the first table, one of the most important strategies resulted is the instructions from the government authorities to the public for water management strategies. These instructions can be given through events or seminars and social media campaigns.This will

help in altering the attitude of people to take some initial steps to think for alternative options for aquifer recharge and contribute towards saving it from vanishing.

Other strategy accepted after public response and supporting views of officials is the billing and taxing mechanism for the water usage in the household. The billing system can be effective in reducing the household water wastage. At the present stages, authorities should make policies for the implementation of suggested strategies in the case study with the instructions of the government for water management. In later stages, groundwater levels monitoring is required for sustainable management of this resource, public awareness is required through different seminars for potable water use and reuse, with the collaboration of advanced technological facilities authorities. With the ongoing situation of nature, there is very important to save even tiny drops of rainwater for replacing the extraction of groundwater. Lahore receive 575 mm rainfall annually, rainfall water harvesting mechanism should be adopted to save this reserve.

Pakistan was once a water-stressed country has now become a water-scarce country. A study was conducted to prioritize the strategies required to fill the gap for potable water management. The findings of the study in form of government authorities to give public access towards instructions for water management as well as water recycling, rainwater harvesting and execute billing or taxing on a priority basis for public well-being. These strategies must be in line with all other strategies like flash flooding, and equitable access to water all the time for its effective implementation. These methods will be the best tools to save water for other fields of agriculture and biodiversity. The present data results beautifully in the above precious strategies but with the ongoing situation of nature, strategies can be altered with further studies.

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Author's Contribution. Dr. Ijaz Ahmad was responsible for the overall guidance of other authors and the monitoring of the data. Muhammad Sajid Iqbal was responsible for data analysis, Noor ul Huda Naveed was responsible for data compilation and Muhammad Junaid Iqbal was responsible for data collection. Muhammad Sajid Iqbal and Noor ul Huda have compiled this Research Paper.

Conflict of interest. There exists no conflict of interest in publishing this manuscript in IJIST.

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Questionnaire

	Title: "Novel Strategies to Meet Potable Water Scarcity in Lahore"	**Researchers:** Mohammad Junaid Iqbal Muhammad Sajid Iqbal Noor ul Huda **In Supervision of:** Dr.Ijaz Ahmad

Purpose: This interview schedule is prepared for taking inputs of public pertinent to water management in context of Lahore. It is, however, ensured that this schedule and the findings obtained through it will be solely used for educational purposes.

Name of Interviewer_____ Name of the Respondent_____

Date: _____

Sr. No.	Question	Response		
1	What is the number of households?			
2	What is the household size?			
3	What is your educational status?			
4	What is the occupation of head of household?			
5	What is the total number of earning members?			
6	What type of water do you use for drinking?			
7	What type of water do you use for washing or bathing purpose			
8	11. Does it need to engage events/Programs on water saving in your area? _____	Yes	No	Indifferent
9	12. Do want to get any information through social media about water management?	Yes	No	Indifferent
10	13. Do want to get any instructions about water saving through concerned authority of your area?	Yes	No	Indifferent
11	Is the provision of water billing and taxing on water usage is manageable for you?	Yes	No	Indifferent

12	Does rainwater harvesting need implementation in your house?	Yes	No	Indifferent
13	Will you use the strategy of flash flooding to save water?	Yes	No	Indifferent
14	Will you feel easy to reuse the water in your house?	Yes	No	Indifferent
15	Will you use the strategy of recycling the polluted water in your house?	Yes	No	Indifferent
16	Do want to get equitable access to water all the time in your area?	Yes	No	Indifferent
17	Will you cooperate authorities to impose strategies in your area?	Yes	No	Indifferent

Suggestions	Regarding the best strategies to be implement in Lahore

The End

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Hazardous Effluents and their Impacts on Human Health: Future of Industrial Boom

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Abstract
Industries, being commercial productive units perform as manufacturing agents to produce large quantity of goods to cater the needs of increasing population. Manufacturing units use raw material and goods to deliver the final product. The findings of this research are consistent and reliable. The study area mainly consists of three types of industries including iron and steel, chemical and fertilizer and plastic industry. The hazardous waste generated by industries in Pakistan was computed as 1 lac tons per day and more than 10 thousand tons/day in Lahore. These wastes played a vital role in the degradation of environment. In addition, various harmful gases such as fluoride, carbon monoxide and dust were released by these industries which mixed with fog and caused smog that resulted in respiratory diseases and the Lahore remained in smog for last 3 years. The air quality declined to alarming level because of the dust produced by these industries. Air pollution leads to skin problems, and respiratory diseases among residents living in outskirts of these industries. In this research it is estimated that industrial emission is more dangerous than any other emissions. From the year 2008 to 2019 the harmful emissions were categorized as 43% by transport sector, 25% by industries, 20% by agricultural sector and 22% by power sector. Proper planning and management is required to secure the safety of environment from the adverse effects of industries.
Keywords: Industries; GIS; hazards; human health and urbanization.

INTRODUCTION

Industries being commercial productive units perform as manufacturing agents to produce large quantity of goods causing improvements in industrial activities. Manufacturing units use raw material and goods to deliver the final product. The first industrial revolution was started initially in Europe, North America and Britain then followed by other countries including Belgium, Switzerland, Germany, and France. The Second Industrial Revolution Started after the refinement of steam engine (New Invention of Internal Combustion engine). The industries got easy access to markets by the construction of railways and canals in the east Asia and other parts of the world which become industrialized by the end of 20th century [1].

After the independence in 1947, Pakistan got only 4% of the entire industrial sector established in subcontinent. Government took initiative to establish new industries especially relating to manufacturing and service sectors. Manufacturing industry is a secondary industry according to the industrial classification. It is a type of industry that manufactures products from raw material. In Pakistan, since 1947, major stress is laid on the agriculture-based manufacturing industries including the textile industry. Currently, a large number of manufacturing industries are running in Pakistan including textile mills, Glass Mills, Rice Mills, Sugar Mills, Paper and board Mills and steel mills etc.

Besides their importance industries are a major cause of pollution. Industrial waste is hazardous for the environment. Industries are responsible for air and water pollution which produce maximum toxic gases in sunshine hours [2]. Water and air effluents such as chemicals and biological matters are released by industries. Commercial waste contains arsenic, plumage, mercury, cadmium, zinc chemicals and heavy metals which can be harmful for human health and ecosystems. These pollutants are highly involved in blockage of urban heat and the terrestrial radiations which cause to make the urban areas as heat islands [3]. Polluted water has significant effects on land production when used for irrigation. In surface and groundwater environment, the high concentration of chemical compounds and metals causes extreme damage to river ecology. Surveys have been accomplished in a number of these cities that displayed pollution of water, soil, and air [4].

Like human activities, industrialization has profound environmental impacts such as pollution and degradation. It has been a major cause of air pollution, noise, soil, impure water quality and the destruction of natural environment in general. Industrialization is fundamentally the transition between various human communities (including urbanization, and political and technological progress) and their economies (manufacturing) from an agrarian to an industrial society [5].

Industrialization not only requires technological innovations, but it also plays a vital role in society's economic and social transition. Industries also cause tremendous pollution; indeed, industries are the key factors behind ozone depletion. Industrialization has created many environmental issues for the developing world, including water, air pollution and soil depletion. The enhanced cycle of various human activities like agriculture, urbanization, and industrialization have put huge pressure on available reservoirs of fresh water [6]. Nearly 75% of the world's population is devoid of pure water for drinking and water pollution is also a problem for agriculture [7].

Rapid urbanization and industrialization were faced by various developed countries in 1800 [8]. The industrial revolution gave benefits to poor people in order to strengthen their earnings. The economy of every country was based upon economic development and

industrial revolution, and the countries were ranked on basis of their economic development e.g., Britain, North America and Japan etc. In India, the industries like cotton, jute, silk, and woolen textiles, sugar cane, and vegetable oil are very significant. These industries provide employment to 35 million people, contributes 4% to the GDP, and 14% of the total industrial production of India. industrialization is significant cause of economic development as well as pollution increase [9]. Air pollution is caused by poisonous gases like carbon mono oxide, and Sulphur-dioxide. The untreated hazardous industrial effluents which are dumped into water bodies cause water pollution. Groundwater contaminated with transition metals pose a devasting effect to public health [10]. Direct or indirect disposal of oil, fuel and other hazardous wastes from waste disposal sites are major cause of water and soil contamination.

Municipal Solid Waste (MSW) disposal includes all sorts of air, land and water contamination. Decomposition of organic waste and other contaminants release Green House gases. The health and safety concerns due to MSW include the prevalent diseases such as cholera, diarrhea and dengue fever. Pollution of water and soil is a key cause of many health problems. The US Public Health Service recognized 22 human diseases caused by MSW. However, solid waste is described on the basis of their sources, waste type and the rate of generation or composition and is categorized as industrial, institutional, medical and municipal waste. Solid waste has different characteristics that are corrosive (waste include acids and bases), ignitability (create fires), reactive (unstable in nature, cause explosions) and toxic (harmful) in nature [11].

The waste disposal is a weak system in Lahore city. UN-Habitat environmental management technique is a managed facility to dispose of or treat the waste. As a component of Lahore-2021 master plan, a proposal was made for three new landfill sites, but only one of these is currently in operational mode, Mehmood Booti. Two more LWMC sites, named as Saagian dumpsite and Bagrian/Tiba dumpsite, are also not officially used for the disposal of waste.

Various models are available to compute the effect of solid waste on eco system. The CML method is developed by the Environmental Science Institute at Leiden University which means that the effect is measured at the midpoint of the region. For the estimation of health effects, we use the USES-LCA multimedia model based on USES 2.0 [12,13,14]. Pre-consultants developed the Eco-Indicator 99 method which takes a damage-oriented approach in order to estimate damage to human health [15]. In 2009, the model used for CML and the Eco-Indicator 99 approach in terms of model settings were harmonized.

In order to compare and qualify the environmental effects, the EPS method is established. In this system, human health is divided into various sub-categories, including life expectancy, serious morbidity, serious nuisance, nuisance to find the factor [16]. The UNEP and SETAC models are of scientific consensus used for human health assessment. The EDIP method was developed under the Danish industrial product environment design scheme and has an oriental midpoint approach [17]. The MRC method is used to find inorganic gases which are inhaled by humans such as benzene, toluene, dichloromethane. The MRD is the method used to find the substances including heavy metals like cadmium, chromium, mercury and lead used in food ingestion.

Industry is a two-sided coin having both negative as well as a positive side. Besides the fact of being job provider, the industries are main cause of environmental pollution. So, for the better understanding of advantages and disadvantages of industries are required to examine. One has to know about its location, type of industry, types of products and type of

hazardous wastes which a particular industry produce. Moreover, a systematic and helpful study is conducted in this research to figure out the industrial hazardous effluents and their impacts on human health.

This study aim at investigating the impacts of industrial boom on climatic conditions of Lahore and its impact on human health by examining the hazardous affluent of industries in local environment. It also aims to provide a better picture of urbanization in Lahore and to share and review appropriate background information, views about urbanization and its frontiers, point out the major problems and suggest the possible and more relevant solutions.

Material and Methods.

Investigation site.

Lahore is the capital of Punjab Province located at 31.582045 N, 74.329376 E. It is considered to be the second largely populated city after Karachi. It is situated at the upper Indus plain of the Ravi River. Lahore district is divided into nine main towns among one zone is designated as military zone. There are total 12 million people living in the urban area of the city and about 6 million people living in the main city area. Figure 1 is showing Lahore's different Union Cornicle and their surrounding districts. People from surrounding rush towards Lahore on daily basis for their livelihood and education.

Interview

Short interviews were taken from the officials located in PHD (Public Health Department) Lahore, WASA (Water and Sanitation Agency) Lahore and EPA (Environmental Protection Agency) Lahore in order to get an interpretation of the selected area. Interviews of locals were conducted to examine the impact of industries on the health of residents.

Field Observations

Field observations are basic start to conduct a research. It is a non- experimental technique to get to know about the ongoing problem which is under observation. which may be inaccurate data and can be considered false.

As far as concerned to our personal observations, Lahore has been changed a lot since last 2 decades. The rapid increase in urbanization and development of more industries is the major reason of change in the city in both positive and negative aspects. Lahore has always been a hub of art, culture, industries, education and commerce. Due to these opportunities, people from all over the country migrate towards the city. This change is disturbing the sustainability of the city and if it would not be controlled, it can result in the major of the city .

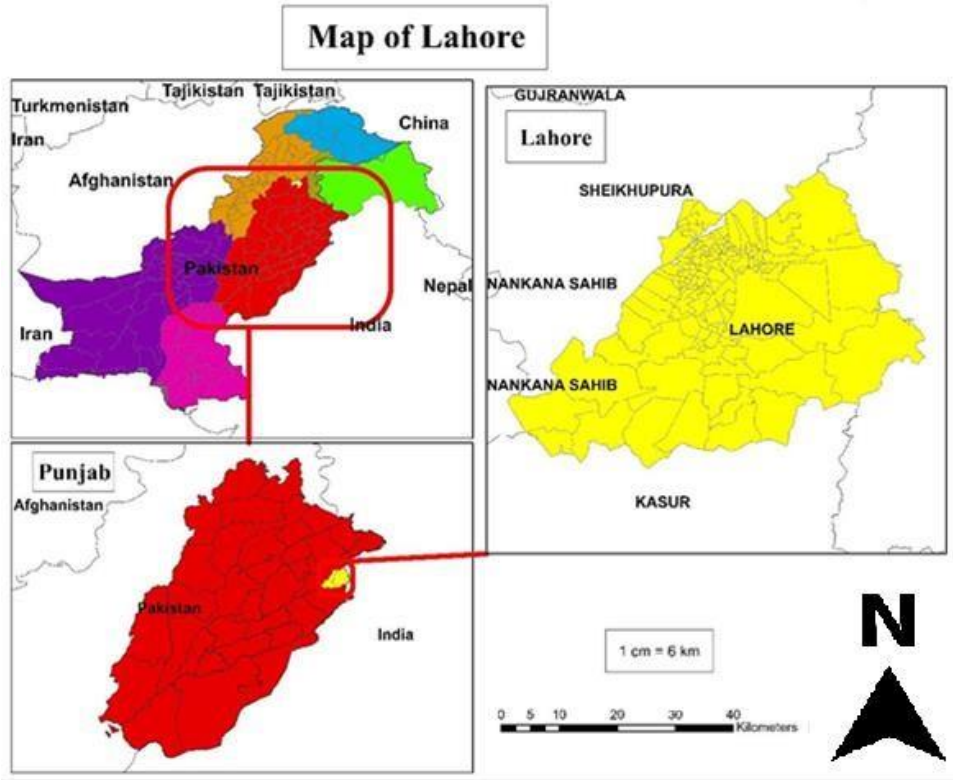

Figure 1. Location map of Lahore district

GPS Survey

GPS device was used to collect locations of industries to compute various algorithms e.g., proximity buffer analysis.

Statistical analyses

SPSS was used to determine a variety of algorithms including correlation and variance etc. Pie charts were prepared and used to inform of pie charts for build-up area, vegetation, water body and barren land to show the distinct portion of these areas. Location maps and risk assessment maps were made which include industrial and clinical location maps for risk assessment of industries. The risk assessment maps were prepared for buffer analysis to understand the vulnerability of the residential areas.

Result and discussion.

Identification of Industries

Figure 2,3 show that the study area consists of three types of industries including Iron & Steel, Chemical & Fertilizer and Plastic Industry. It was essential to examine the trend of expansion of these industries which was in the north-west side of Lahore and expanding continuously in the same direction.

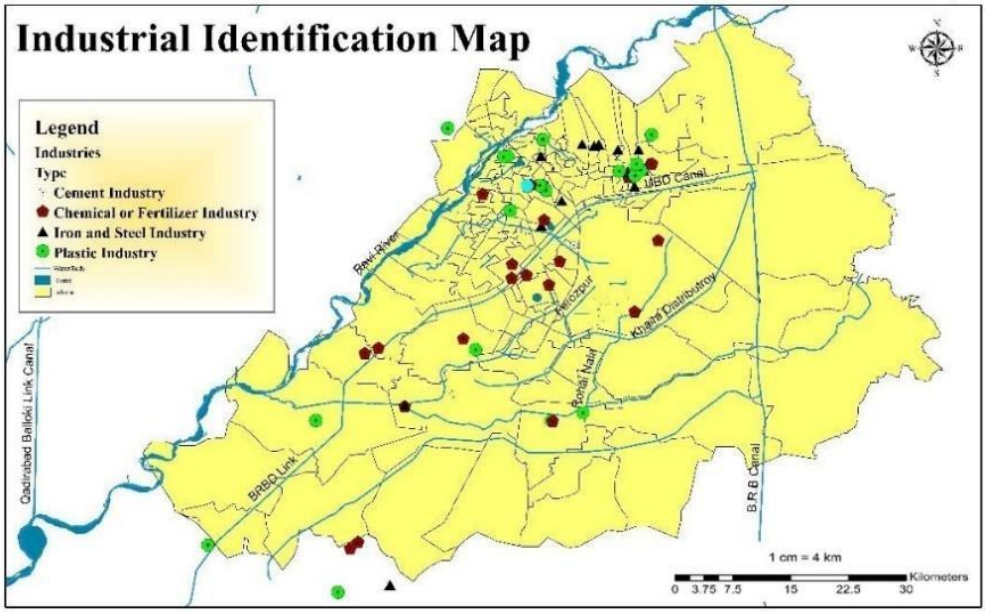

Figure 2. Map of Industries in Lahore

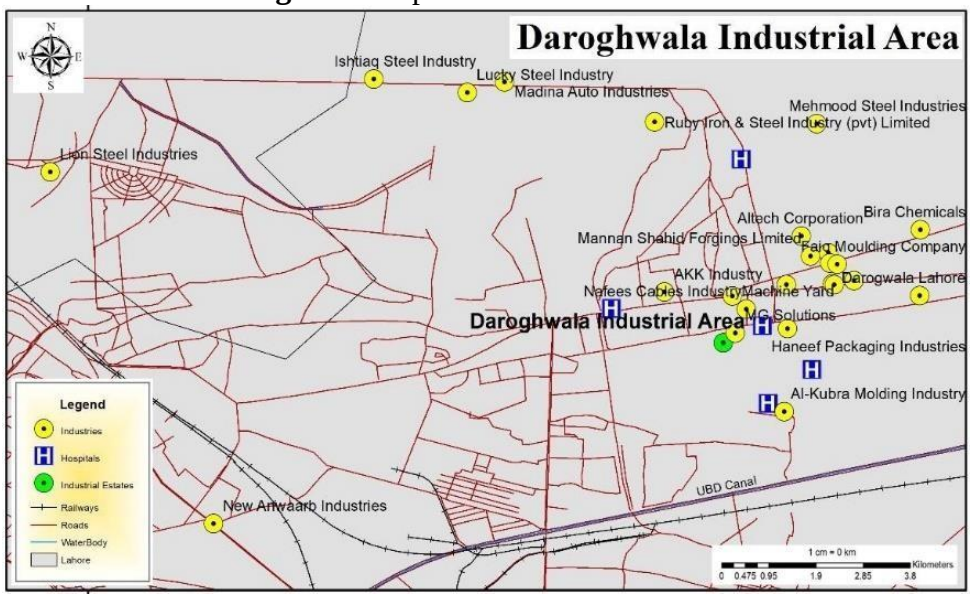

Figure 3. Map of Industries in Daroghwala

In Lahore city, the estimated total amount of waste generation was 5300 tons per day. The waste includes different types like Combustible waste, Non-Combustible waste, Plastic waste, Biodegradable waste and hazardous waste as shown in Figure 4

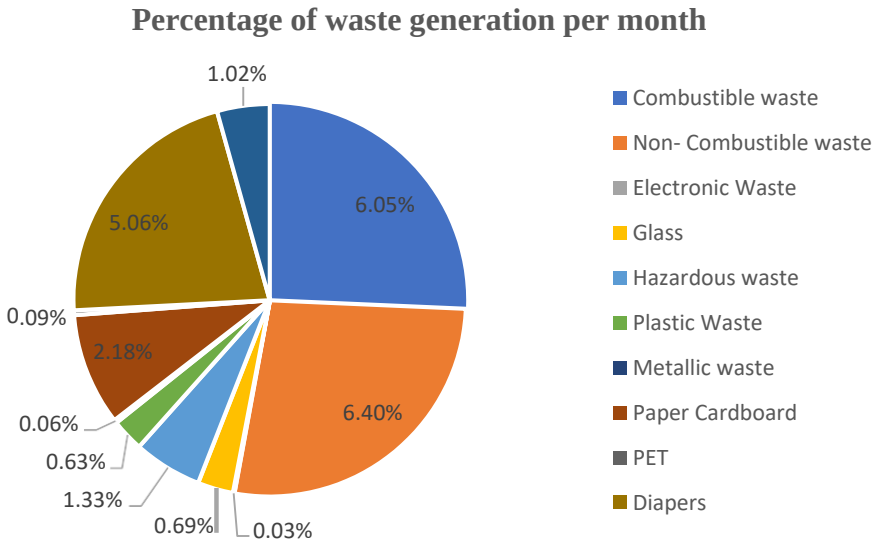

Figure 4. Percentage of Waste Generation

There are three types of industries which are identified in this research which include plastic industry, iron or steel industries and chemical or fertilizer industries. These industries use different Raw materials to produce end products. These industries generate hazardous waste products which are harmful for both the nature and human health. Along with the production of commercial, social and economical products, industries are also a source of pollutants which are released as by products. There are some industrial products with their hazardous waste as given in table 1.

Table 1. Industrial products and their hazardous waste

Products	Hazardous Waste
Medicines	Organic Solvents and residues, Heavy metals (Mercury and Zinc)
Metals	Heavy Metals, Fluorides, Cyanides, Acids and Alkaline cleaners, Solvents, Pigments etc.
Paint	Heavy Metals, Pigments, Solvents, Organic, Residues
Leather	Heavy Metals, Organic Solvents
Oil, Petroleum Products	Oils, Phenols, Organic Compounds, Heavy
Pesticides	Organic Chlorine Compounds, Organic
Plastics	Organic Chlorine Compounds
Textiles	Heavy Metals, Dyes, Organic, Chlorine

Table 1 show that the industries has both beneficial and nonbeneficial effects towards environment. Chemical industries produce medicines, paints, and different pesticides. These products are necessary for the protection of health, metals, and farms respectively. But the improper disposal of chemical wastes into rivers and canals are causing water pollution which in turn is threat to aquatic life.

Plastic polymers

The Plastic Toxicity is very dangerous for our health. The Polymers of plastic have their own impacts on human health. Polymers, their compounds (monomers and additives)

and degradation products were categorized into five qualitative groups of hazards for human life and the environment in evaluating the risk assessment of plastics (very low to very high hazard).

Characteristics of hazardous waste

EPA (Environmental Protection Agency) defined the characteristics of hazardous waste which includes Ignitibility, Corrosively, Reactivity, or Toxicity.

Ignitable Wastes

1. Liquids waste (having a flash point below 140F)
   - Alcohol solutions (which contain more than 24% alcohol by volume)
   - High-performance liquid chromatography (HPLC) liquids (which often contain highly flammable solvents such as Acetonitrile)
   - Glass-cleaning solvent rinses
2. Combustible solid waste.
   - metal powders
   - activated charcoal
3. Ignitable compressed gases
   - Gas cylinders for lab burners (butane, propane, etc.)
4. Oxidizers
   - nitrate compounds
   - peroxide compound
   - perchlorate compounds

Corrosive Wastes

Any liquid having a pH less than 2 or higher than 12.5

- Inorganic acids (hydrochloric, phosphoric, nitric, sulfuric, etc.)
- Organic acids (formic, acetic, lactic, etc.)
- Alkaline compounds (hydroxides, amines, etc.)

Reactive Wastes

1. Compounds which are normally unstable and readily undergo violent change without detonating.
   - diethyl zinc
   - organometallic gases
2. Compounds which will violently react with water
   - anhydrous metal salts
   - alkali metals
   - metal powders, shavings, or turnings
3. Compounds which form potentially explosive mixtures with water
   - calcium carbide
   - metal hydrides
   - chloro-silanes

Toxic Waste

Table 2. EPA Toxicity Characteristic List

Toxic Heavy Metals	Common Organic Chemicals
Arsenic (5 ppm)	Benzene (0.5 ppm)
Barium (100 ppm)	Carbon Tetrachloride (0.5 ppm)
Cadmium (1 ppm)	Chloro-benzene (100 ppm)
Chromium (5 ppm)	Chloroform (6 ppm)
Lead (5 ppm)	o-Cresol (200 ppm)
Mercury (0.2 ppm)	m-Cresol (200 ppm)
Selenium (1 ppm)	p-Cresol (200 ppm)
Silver (5 ppm)	Cresols (200 ppm)

Different kinds of harmful gases such as fluorides, carbon monoxide and dust are released into air from grinders and other iron and steel production industries are pulverized during the processing of phosphate rock. The blend/reactor creates gases containing silicon tetra fluoride and hydrogen fluoride. There are two major air pollutants in a sulphuric acid factory, Sulphur dioxide and acid mist. When roasting pyrite ore, iron, steel grinder is also an air pollution particulate with heavy metals such as cadmium, mercury and plum. Phosphoric acid plants produce hydrofluoric acid-containing fumes and fluoride silicone tetra Glaser. The air emissions also cause smog which is a mixture of fog and air emissions caused by combustion in industries and burning of crops. This smog causes respiratory diseases also cause irritation to eyes and skin. Lahore has been affected by this smog from last 3 years. The air quality is getting declined day by day because of industrial and transport emissions and burning of crops.

Table 3. Different sectors and their air emission percentages

Sectors	Average Percentage of Nov. Oct. (Cumulative 2008-2017)
Transport	43%
Industries	25%
Agriculture	20%
Power	22%

Industrial Impacts

The industrial impact is determined through the industrial waste processing but due to Covid_19 the sampling method is not done. However, the impact assessment is done by using the secondary datasets. The secondary datasets were analyzed to determine the diseases caused by the industrial waste contamination in underground water resources, in fertile soil and in air. The disease analysis was done by the gathering the hospitals data. The hospitals data express the common diseases outbreaks in these industrial zones and their average increase in percentage as given in Table 4:

Table 4. Impacts on Hu an Health

Diseases	Percentage of Patients
Cancer	3%
Neurological Disease	2%
Diarrhea	28%
Nausea	15%
Infectious Disease	13%
Respiratory Disease	9%
Irritation of skin, eyes, and nose	11%
Gastrointestinal Problems	2%
HIV	4%
Hepatitis B	5%
Plague	5%
Others	3%

Table 4 shows the percentage of different diseases among people living in industrial areas as reported by hospitals situated in outskirts of industrial zone. The diseases which have been mentioned in Table 4 are all because of industrial waste which was mismanaged.

Risk Assessment of Industrial Surrounding Areas

Buffers were created within 500 meter of each industry in its surrounding as shown in Figure 5 and it was observed that all the residential area within this domain is at high risk. Because these settlements were most vulnerable to the industrial waste created or produced by these industries.

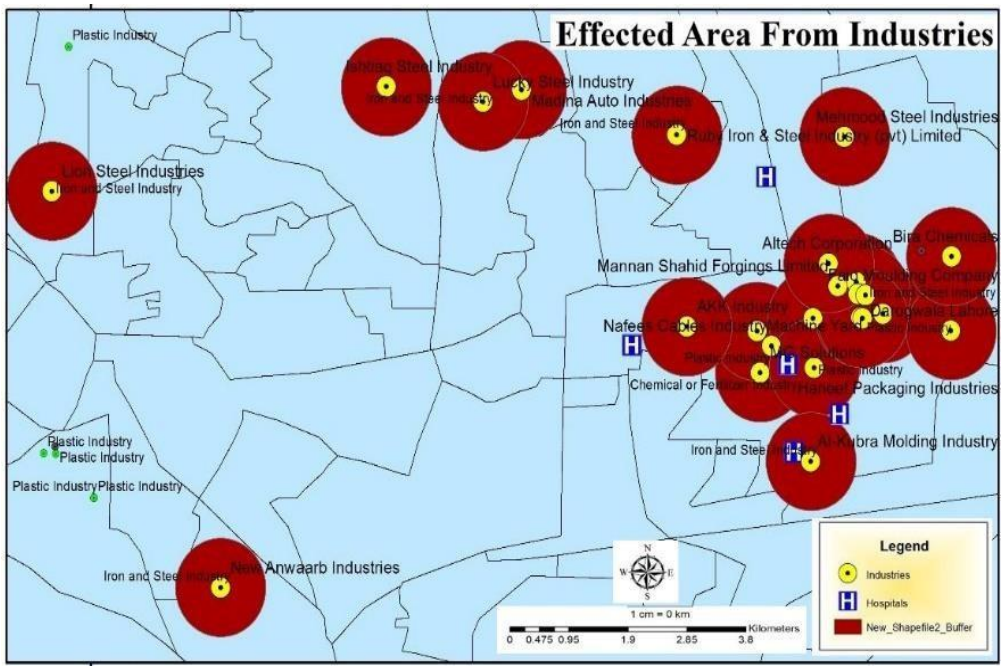

Figure 5. Map of effected areas by industries

Figure 6 is showing that the medical institute which helped the people to fight against different diseases caused by industrial effluents.

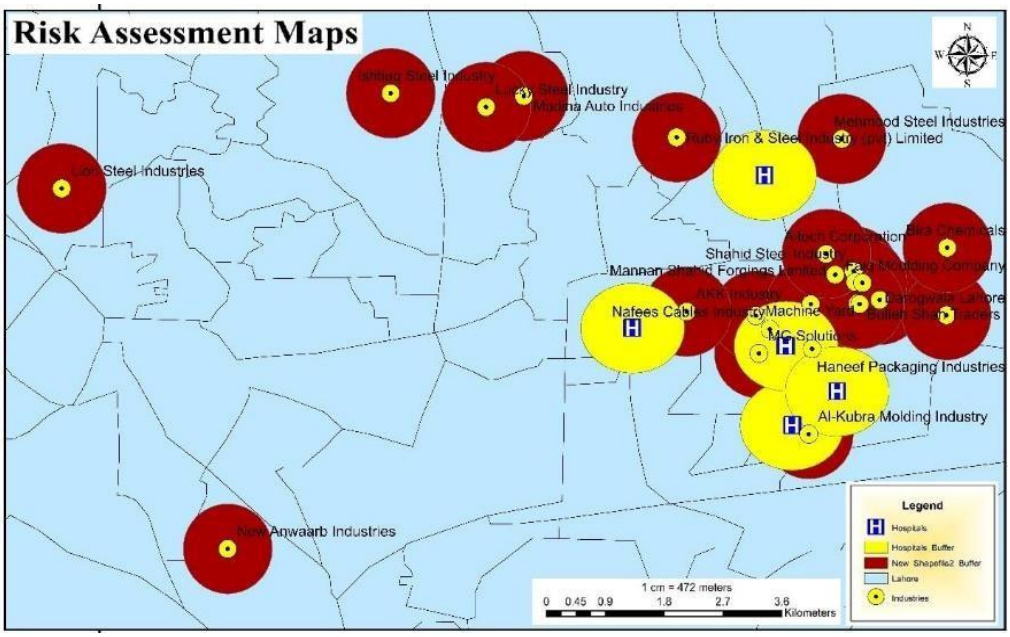

Figure 6. Risk assessment Map

Figure 6 is showing that the location of medical institute to resolve the health issues of human lives under that risk zones. The risk from industries is increasing day by day because of population growth as well as increase in pollution.

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Conflict of interest. The authors declare no conflict of interest in publishing this manuscript in IJIST.

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Estimation of Multidimensional Urban Poverty in South Asian Cities: A Case of Lahore Metropolitan Area

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Continuous monitoring of spatial variations in urban poverty is a complex multidimensional phenomenon. In urban areas of South Asian countries, various factors contribute to promote urban poverty e.g., rapid and unmanaged urbanization, high migration and inflation rates and fluctuations in land values. The poor community should be focused by policy makers to solve poverty related issues. This research was conducted in a metropolitan city Lahore in Punjab province of Pakistan which is confronting with urban poverty and need to construct a policy for poverty alleviation. Alkire-Foster approach was used to compute urban poverty by selecting poverty cut off point k=2/5 for this study. It demonstrates that 70.8% of households were poor whereas 29.8% households were living out of poverty with positive potentials. The results can be taken as a reference point to alleviate poverty in other regions of country.
Keywords: Multidimensional poverty; Metropolitan; Alkire & Foster approach; poverty cut off point and poverty indices.

Introduction.

Poverty refers to pronounced deprivations in human well-being in various dimensions [1,2]. It is considered a complex and multifaceted phenomenon [3] to evaluate for rapidly growing urban areas. Poverty has become a major challenge to the socio-economic prosperity for almost half of the world [4]. The poverty was deep rooted in rural areas, but it has become obvious and prevailing urban issue from the last few decades [4]. In urban areas of South Asian countries, various factors contribute to promote urban poverty e.g., rapid, and unmanaged urbanization, high migration and inflation rates and fluctuations in land values [5,6]. Construction and expansion of squatter settlements and slums in center and periphery of cities is the root cause of poverty in urban areas [7].

Living in poverty excludes people from opportunities and decent employment [8] consequently, affecting their psychological and societal well-beings. It is responsible for generating other social issues like street crimes, environmental pollution and availability of clean water [9, 10, 11]. Therefore, Sustainable Development Goals (SDGs) adopted by United

Nations in 2015 include eradication of poverty as the prime target to be achieved by 2030. The reforms need to be introduced to achieve the ultimate prosperity. By taking into account, the adverse impacts of poverty as well as in achieving the poverty eradication goals, substantial literature helps to analyze all hurdles on the way of prosperity and to analyze all issues more appropriately.

Paradigm Shift in Poverty Measuring Approaches

Poverty is considered as multidimensional issue and it has been widely evaluated using traditional one-dimensional approach in broader aspect i.e., income or consumption. In recent years, a growing consensus regarding the insufficiency of one-dimensional poverty measure arouse the need for multidimensional poverty measures which could reflect the poverty situation more comprehensively. Consequently, in 2007 Alkire and Foster (AF) formulated a comprehensive dual cut off method for evaluating poverty in multidimensional perspective. AF method has been widely used by researchers and policy makers because of its friendly mechanism [12, 13, 14, 15]. AF method is considered as one of the best multidimensional poverty measuring mechanism [16] [17].

Multidimensional Poverty Index (MPI) is an index developed by Alkire and Santos (2010) which follows Alkire and Foster (2007, 2011) dual cut off methodology for poverty evaluation [18]. MPI portrays the in-depth picture of poverty in multiple dimensions as well as monitoring the progress in achieving SDG i.e., aims to eliminate poverty by 2030 from everywhere. Therefore, estimation of MPI by using AF methodology has gained vast attention globally by researchers and policy makers in recent years [18, 19, 20].

The poverty has become one of the largest problems due to its influence over global population specially in South Asian countries. It is surveyed that about 1.3 billion people i.e. 23.1% of global population is multidimensional poor out of which 792 million belong to lower/middle income countries where poverty index ranges from 0 to 86.7% [21]. Pakistan lies below the line of middle income countries.

Poverty Assessment in Pakistan

As a result of commitment with UN in achieving SDGs, MPI was created first time in Pakistan in 2016 by using data from Pakistan Social and Living Standard Measurement (PSLM) surveys. About 38.8% people were found multidimensional poor with average proportion of deprivations of about 50.9% and MPI was 0.198 [22]. In Pakistan, some studies have been conducted for assessment of poverty in multidimensional perspective by adopting AF methodology. Idrees, M. (2017) [23] prepared poverty indices for Pakistan through AF approach by taking 6 dimensions that include education, health, house services, quality of house, additional services and women empowerment. Multidimensional Poverty was also estimated for Pakistan at national and provincial levels by adopting AF approach [24]. In addition MPI was generated for Punjab province at district level [25].

Moreover, different studies have been conducted to assess poverty for different cities of Pakistan. Khan A.U (2014) [26] examined the magnitude of multidimensional poverty in Rawalpindi city by incorporating education, health and living style of residents. Determinants of urban poverty have also been analyzed in Multan [27] and Sargodha city [28]. Furthermore, the magnitude and determinants of poverty have been analyzed for Christian [29].

In order to properly address this issue and achieving SDG, poverty evaluation studies may be enriched at lowest administration level of major cities like Lahore and Karachi where intra-city disparities predominantly found which in turn cause urban poverty.

Urban poverty is known as one of major issues in Lahore city where inter-city inequalities prevails in great extent. The most visible demonstration of this issue is the increase in the quantity and physical density of inner-city slums due to current urban trends. Therefore, Ravi Zone in Lahore metropolitan area is selected to assess urban poverty along with identifying its key contributors.

Materials and Methods

Investigation site.

Ravi town is one of the administrative zones in Lahore metropolitan area, located north-west of Lahore as shown in Figure 1. The latitudinal and longitudinal extent of Ravi Zone is from 74.249° – 74.307° N and 31.589° – 31.616° E respectively. The population of Ravi Zone is approximately 1368506 along with 152750 total number of households (Ravi Zone Administrative Office). River Ravi also flows across north-south of this zone. Ravi zone is segregated into three administrative zones including Shahdra, Badami Bagh and Walled city. It has total 34 Union Councils (UCs-Union councils are the smallest administrative unit within a city) out of which 14 UCs lies in Shahdra zone, 12 UCs in Badami Bagh zone whereas Walled city zone has 8 UCs.

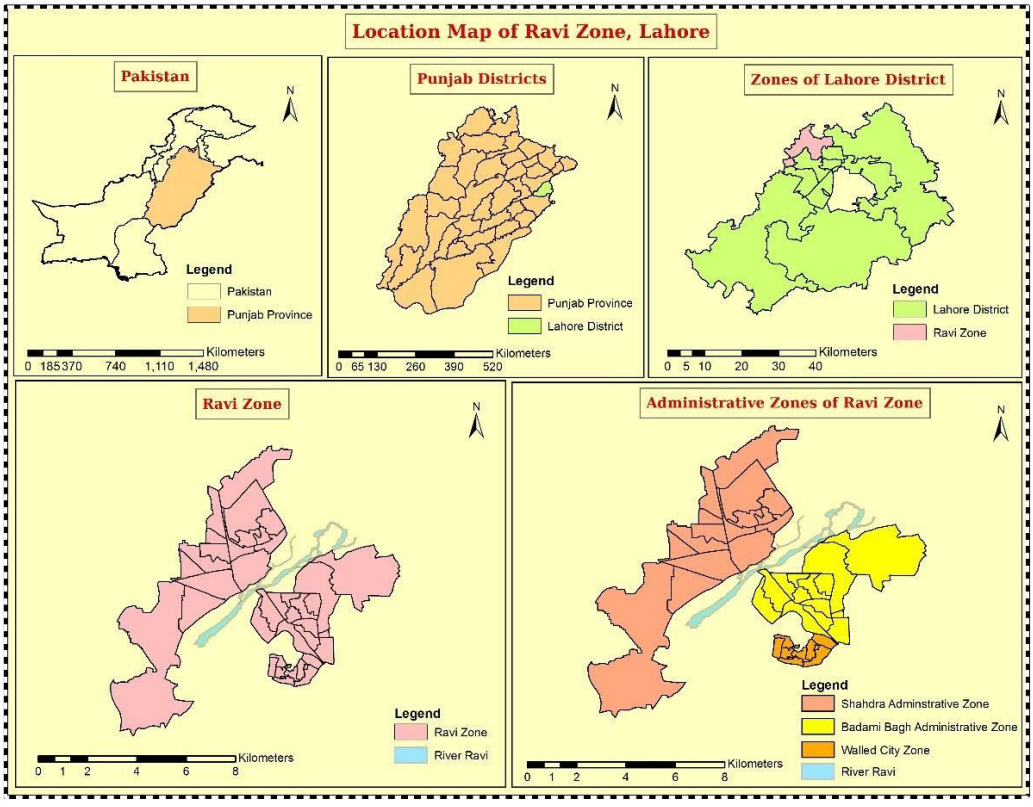

Figure 1 Study Area Map

Ravi Zone is diverse in nature as compared to other 8 zones of Lahore. The area of walled city is most densely populated, where people have substandard living conditions. In addition, Shahdra and adjoining areas that constitute the periphery of Lahore metropolitan area in north also falls under this zone. The squatter settlements are predominantly found in Ravi zone.

2.2. Material and methods

Data Collection and Instrument

The present study is based on both primary and secondary data collection and its analysis. Questionnaire was used as an instrument to collect primary data comprising both closed and open ended questions related to the factors associated with poverty (Questionnaire is attached in annexures). Secondary data was also collected from Administrative Office of Ravi Zone regarding the recent statistics about total households and population. Recent GIS based Shapefiles of Ravi Zone were collected from Urban Unit P&D Punjab Pakistan.

Sample Size and Sampling Technique

We selected a unique household as a unit of analysis and 510 sample households were selected from Ravi Zone. Two step selection procedure was used for sample collection. In the first step 510 sample households were equally distributed among all UCs. In the second step, sample households from all UCs were selected through convenience sampling. As in this study the prime focus was only on poor households. Therefore, sample household were selected through convenience sampling by keeping the assumption in mind that poor household condition is directly associated with poverty in order to make samples truly representative of research area.

2.3. Data Analysis

In this study, data analysis were performed in Microsoft Excel with the help of analytical tool i.e. Alkire and Foster (2007; 2011) approach to evaluate multidimensional poverty. The data analysis was performed in two main sections. The first section analyzed data by estimating multidimensional poverty through three poverty indices: headcount ratio (H), intensity of poverty (A) and MPI. In second section, data was analyzed by identifying the percentage contribution of each indicator to overall poverty in order to find the most prevalent factor that contribute in poverty. The detail of these sections are as under:

Evaluation of Multidimensional Poverty

The study adopted following steps for multidimensional poverty measurement as suggested by Alkire & Foster (2007; 2011).

a) Selection of dimensions and indicators
b) Define poverty cut off points for each indicator
c) Assigning weights to each dimension and indicators
d) Define second poverty cut off point (to identify poor)
e) Calculation of deprivation score for each household
f) Calculation of Incidence of Poverty (H)
g) Calculation of Intensity of Poverty (A)
h) Calculation of Multidimensional Poverty Index (MPI)

Selection of Indicators and Dimensions

Alkire and Foster (2007; 2011) measured multidimensional poverty through 3 dimensions: education, health and living standard with 10 different relative indicators. As Alkire and Foster method is flexible in the selection of dimensions and indicators so the present study assessed multidimensional poverty by using 5 dimensions including education, health, housing condition, housing services quality and employment which are further sub divided into 16 different relative indicators. In this study the selection of dimensions and indicators were primarily based on existing literature of poverty assessment studies. Moreover, the selected dimensions and indicators in this study also corresponds to SDGs which may further help policy makers to monitor the existing situation in achieving these goals by 2030. Table 1 shows the selected dimensions along with their relative indicators.

Poverty Cut off Point for each Indicator

Poverty cut off point also known as poverty line which is defined as a benchmark upon which a household is declared as deprived in the respective indicator. A household is considered as deprived in particular indicator and denoted by 1 only if the household member's achievement in that indicator falls under the given poverty cut off point otherwise considered as non-deprived and denoted by 0 (Alkire, 2007, 2011).

Table 1. Dimensions and Indicators along with their cut off points and their relation with SDGs.

Dimensions	Indicators	SDGs	Poverty cut off Points A household is considered deprived if…….
Education	1. Attainment of Primary Education	SDG4	None of its adult member aged 15 years and above has attained primary education
	2. Child Enrolment status	SDG4	At least one child of school going age (6-14 years) has not enrolled in school
Health	1. Health Status	SDG3	At least one member has serious illness and unable to perform his/her normal activities
	2. Child Mortality	SDG3	At least one child of age between 0-5 years has been died in household
Housing Condition	1. Roof Material	SGD11	Household has unimproved roof material (i.e. wooden planks, iron sheets, bamboo)
	2. Wall Material	SDG11	Household has unimproved wall material (i.e. mud, unbaked bricks)
	3. Floor Material	SDG11	Household has unfinished floor
	4. Kitchen facility	SDG11	Household has no separate kitchen facility
	5. Toilet facility	SDG6	Household either don't have toilet facility or shared toilet facility
	6. Housing Congestion	SDG11	4 and more than 4 people are living in one room
Housing Services Quality	1. Electricity	SDG7	Household has no electricity
	2. Cooking Fuel	SDG7	Household uses animal dung and wood sticks for cooking purpose
	3. Access to save drinking water	SDG6	Household does not have access to safe drinking water
	4. Household Assets	SDG11	Household owns less than 50% of household assets
Employment	1. Employment status	SDG8	Whether Household head is unemployed or employed as temporary, occasional and causal worker
	2. Quality of Employment	SDG11	Household head is unskilled wage labor in informal sector

Assigning Weights to Dimension and Indicator

The equal weights were assigned to all dimensions and their relevant indicators. Different weights can also be assigned to dimensions and indicators based on their relative importance but it is very difficult and involves valuable judgement by experts. So the present study assign equal weights to all dimensions and their respective indicators with the help of equal weighting principle as suggested by Alkire and Foster (2007; 2011).

Table 2. Weights Assigned to Each Dimension and Indicator

Dimension	Relative Weights	Indicators	Relative Weight
Education	0.2	1. Attainment of Primary Education	0.1
		2. Child Enrolment status	0.1
Health	0.2	1. Health Status	0.1
		2. Child Mortality	0.1
Housing Condition	0.2	1. Roof Material	0.0333
		2. Wall Material	0.0333
		3. Floor Material	0.0333
		4. Kitchen facility	0.0333
		5. Toilet facility	0.0333
		6. Housing Congestion	0.0333
Housing Services Quality	0.2	1. Electricity	0.05
		2. Cooking Fuel	0.05
		3. Access to save drinking water	0.05
		4. Household Assets	0.05
Employment	0.2	1. Employment status	0.1
		2. Type of Employment/Quality of Employment	0.1
5 Dimensions	1.00	16 Indicators	1.00

Selection of Second Poverty cut of point

Second poverty cut off point (k) is used to identify the MPI-poor households. Three different approaches are introduced for the identification of poor or deprived households: union, intermediate and intersection approach (Alkire & Foster, 2007, 2011). In union approach household is declared as poor if the household is deprived in any one out of all dimension whereas in intersection approach household is considered as poor if he/she is deprived in all selected dimensions. Identification of poor by using these two extreme approaches can provide misleading statistics. Therefore, intermediate approach has been widely used in literature for the identification of poor. As the present study have total five dimensions therefore, k can be set as: 1/5, 2/5, 3/5, 4/5 and 5/5.

Calculation of Deprivation Score

Deprivation score (c_i) of each household is calculated to identify MPI-poor household. Household is considered as MPI-poor if the deprivation score of each household is greater than or equal to the selected poverty cut off point.

Deprivation score of each household is calculated using the following formula:

$$Ci = Sum\ of\ indicator\ deprivation \times weight\ of\ indicator$$

Calculation of Head Count Ratio (H)

Headcount ratio is also known as incidence of poverty (H) which provides the proportion of MPI-poor households at the selected poverty cut off point. It is calculated with the help of following formula:

$$H = \frac{Number\ of\ multidimensional\ poor\ households}{Total\ numer\ of\ houses}$$

Calculation of Intensity of Poverty (A)

Intensity of poverty also known as average deprivation which estimates the average proportion of deprivations among MPI-poor households in weighted sum of indicators. It is calculated through following formula:

$$A = \frac{(Deprivation\ Score\ of\ Deprived\ Household \times HH\ size)}{Number\ of\ deprived\ houses}$$

Calculation of Multidimensional Poverty Index

Multidimensional Poverty Index (MPI) also known as Adjusted Headcount Ratio (M_0), which reflects the breadth of poverty i.e. percentage of MPI-poor along with proportion of average deprivations which they experience. It is calculated by:

$$MPI = Headcount\ Ratio\ (H) \times Intensity\ of\ Poverty(A)$$

Percentage Contribution of each indicator

In order to find out the most prevalent indicator that contribute in overall poverty, contribution of each indicator was also calculated by following formula:

$$Contribution\ of Indicator = \frac{(W_i \times CHR_i)}{MPI} \times 100$$

Where W_i = weight of that indicator

CHR_i = censored headcount ratio of that indicator

CHR reflects indicator-wise deprivations of only those households who are categorized as MPI-poor according at selected poverty line.

Results and Discussions.

Multidimensional Poverty Estimates for Ravi Zone

Multidimensional poverty estimates for Ravi Zone are presented at different poverty cut off points (*k*). The results empirically justifies that as the value of k increases, Headcount ratio (H) and MPI decreases whereas Intensity increases (A). The results indicate that if we set poverty cut off point (k) by using two extreme approaches i.e. union approach where k = 1/5 and intersection approach where k = 5/5 then these poverty lines will present very high and very low statistics respectively as shown in Table 3. Therefore, in our study we used intermediate approach by taking k = 2/5 as poverty cut off point which was suitable enough for poverty assessment in our case. At our selected poverty cut off point i.e. k = 2/5, 70.8% households are categorized as multidimensional poor with the average proportion of weighted deprivation is 58.0% and MPI being 0.401. The results further depict a positive condition by indicating that very few or no households seems to be deprived at 4/5 and 5/5 poverty cut off point.

Table 3. Multidimensional Poverty Estimates of Ravi Zone

Poverty cut off Points	Ravi Zone Statistics		
	H	A	MPI
k = 1/5	100%	50.6%	0.506
k = 2/5	70.8%	58.0%	0.410

k = 3/5	21.2%	68.6%	0.145
k = 4/5	0.9%	84.1%	0.007
k = 5/5	0%	0%	0.00

Source: Authors computation from Household Survey (2019)

Estimates of Poverty at Administrative Zone level

Multidimensional poverty estimates when segregated at administrative zone level then the results shows that at k = 2/5, Shahdra Zone records the highest incidence of poverty where 80% of the people are MPI-poor and remaining 20% are categorized as non-poor while in Badami Bagh 65% and in Walled City Zone 35% households are categorized as MPI-poor. MPI-poor of Shahdra zone faced the highest level of deprivations i.e. on average they are deprived in 56% of weighted indicators. In Badami Bagh and Walled City Zone the MPI-poor experience was relatively low. Likewise in case of MPI, Shahdra Zone reflects the highest breadth of poverty i.e. 0.45 whereas Badami Bagh and Walled city zone has relatively low breath of poverty with very slight difference in statistics i.e. 0.35 and 0.32 respectively.

The analysis revealed that Shahdra Zone ranked 1st in all three poverty indices as compared to other zones. Although other two zones have relatively low poverty estimates but a very slight difference is found in the statistics among these two zones.

Table 4. Multidimensional Poverty estimates at Administrative Zone Level

Administrative Zones	k= 2/5			Ranking of Zones
	H	A	MPI	
Shahdra	80%	56%	0.45	1
Badami Bagh	65%	54%	0.35	2
Walled City	60%	53%	0.32	3

Source: Authors computation from Household Survey (2019)

A) Contributors to Poverty at Administrative Zone Level

MPI was decomposed to identify the contribution of each indicator and dimension to overall poverty.

a) Contribution of each indicators to Poverty

The results indicate that in all three zones; Shahdra, Badami Bagh and Walled City, attainment of primary education contributed most to poverty among all indicators with a very slight difference in statistics i.e. 17.4%, 16.9% and 17.7% respectively. Quality of employment made the second whereas child labor status made the third highest contribution to poverty among all zones. The results are shown in Figure 2,

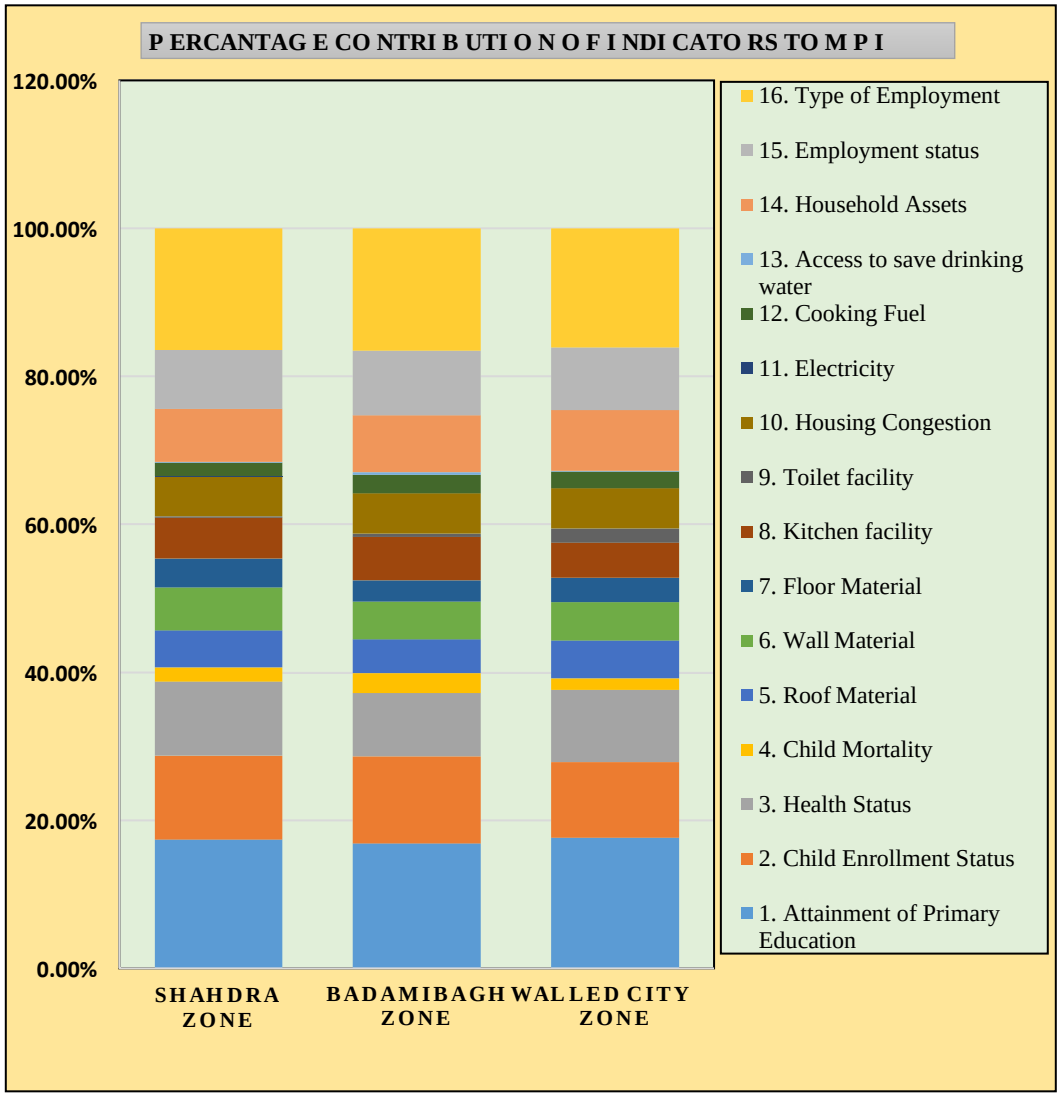

Figure 2. Contribution of each indicators to Poverty

b) Contribution of each Dimension to Poverty

The results indicate that education dimension contributed most to overall poverty among all administrative zones with a very slight difference in statistics. Employment made the second highest contribution to poverty in Badami Bagh zone of about 25.3% whereas in Shahdra and Walled City zone housing, the condition made second highest contribution i.e., 25.7% and 25.8% respectively. Employment made third highest contribution in Shahdra and walled city zones whereas in Badami Bagh Zone, housing condition made third highest contribution to poverty. Housing Services Quality had least contribution in poverty among all three zones. The results are shown in Figure 3,

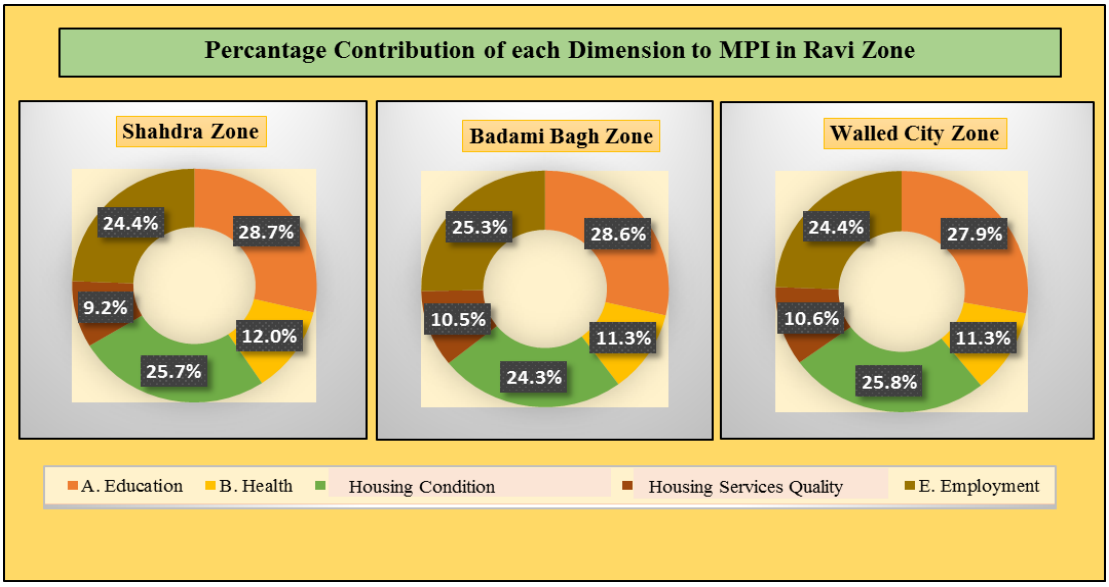

Figure 3. Contribution of each Dimension to Poverty

B) Estimates of Poverty at UC level

Estimates of multidimensional poverty at UC level were computed with the help of choropleth thematic map to illuminate inequalities across UCs. The results demonstrates that UC-wise poverty incidence is ranging from 30-95%. Accordingly, UCs are classified into five main categories: very low poverty (30-38%), low poverty (39-59%), moderate poverty (60-68%), high poverty (69-80%) and very high poverty (81-95%). The results demonstrates that Shams Abad, Chah Chambay Wala, Javaid Park, Majeed Park, Aziz Colony, Ladhey Shah, Ravi Clifton Colony, Hanif Park, Bhama Jhuggian and Bhatti Gate have very high poverty incidence among all. Whereas 3 UCs Qila Lakshaman Singh, Auqaf Colony and Badar Colony experience very low poverty incidence.

In case of intensity of poverty, UCs were again classified into five categories: very low poverty intensity (47-49%), low poverty intensity (50-52%), moderate poverty intensity (53-55%), high poverty intensity (56-58%) and very high poverty intensity (59-63%). High poverty intensity was found in 8 UCs: Javaid Park, Qazi Park, Begum Kot, Bhama Jhuggian, Hanif Park, Siddique Pura, Bhatti Gate and Shahi Qila where MPI poor on average deprived about 59-63% in weighted sum of indicators. In UCs like Siddiqia Colony, Badar Colony, Qila Lakshaman Singh, Data Nagar and Azam Market MPI-poor have very low intensity of poverty. MPI values at UC level vary from 0.15-0.55 on the basis of this range UCs were categorized into very low MPI values (0.15-0.24), low MPI values (0.25-0.32), moderate MPI values (0.33-0.41) high MPI values (0.42-0.47) and very high MPI values (0.48-0.55). Javaid Park, Majeed Park, Chah Chambay Wala, Bhama Jhuggian, Hanif Park and Bhatti Gate have very high MPI-values. On the other hand MPI values found to be very low in Badar Colony, Auqaf Colony, Qila Lakshaman Singh, Azam Market and Shah Alam Market indicating that all UCs with low MPI values lie under the Walled city and Badami Bagh Zones. The analysis revealed that 1 UC Javaid Park from Shahdra Zone, 2 UCs Hanif Park and Bhama Jhuggian from Badami Bagh Zone and only 1 UC Bhatti Gate from Walled City Zone records very high poverty indices and were categorized as highly deprived UCs. The results are shown in Figure 4.

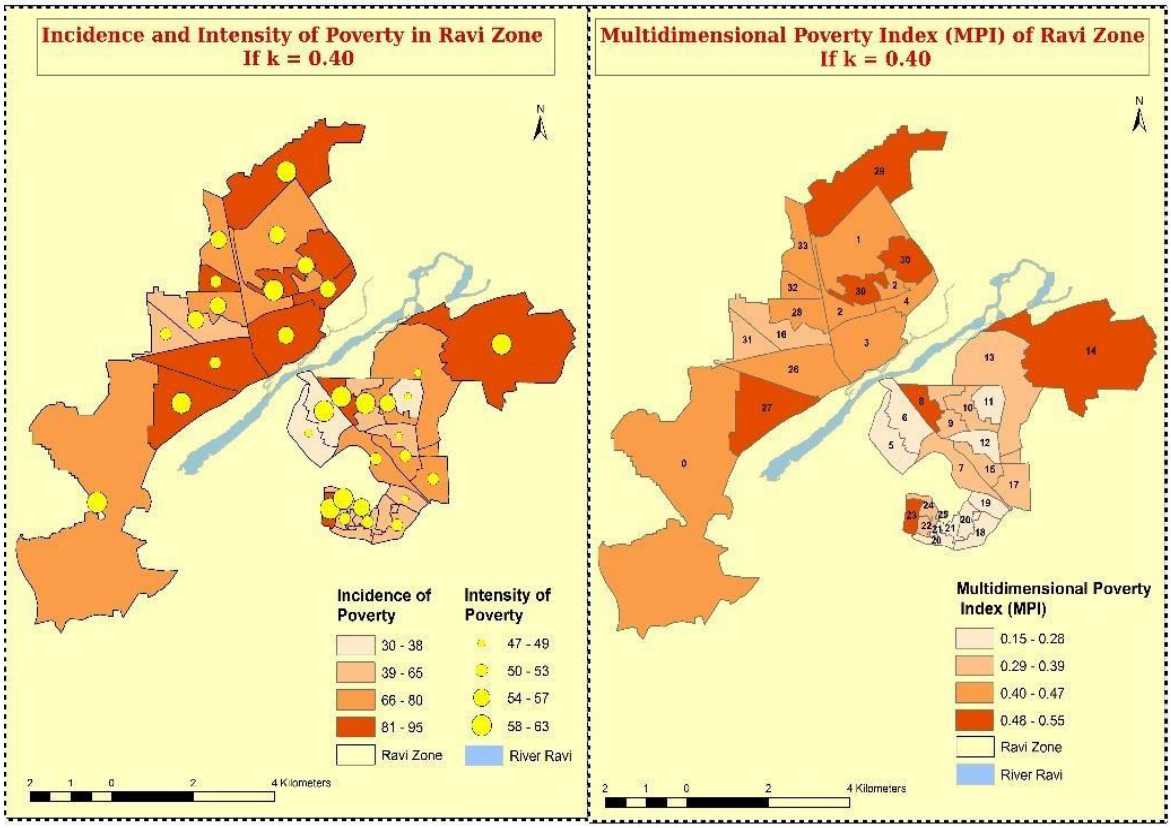

Figure 4. Multidimensional Poverty Indices at UC Level in Ravi Zone

0.Begum Kot	7. Farooq Gunj	14.Bhama Jhuggian	21.Rang Mahal	28. Lajpat Nagar
1.Qaiser Town	8. Hanif Park	15.Usman Gunj	22.Lohari Gate	29. Javaid Park
2.Qazi Park	9.Siddique Pura	16. Jia Musa	23.Bhatti Gate	30. Majeed Park
3.Ravi Clifton Colony	10.Larex Colony	17. Manzor Abad	24. Shahi Qila	31. Yousaf Park
4.Ladhay Shah	11.Badar Colony	18.Mochi Gate	25. Sotar Mandi	32. Aziz Colony
5. Qila Lakshaman Singh	12.Data Nagar	19.Azam Market	26. Shams Abad	33. Faisal Park
6. Auqaf Colony	13.Siddiqia Colony	20.Shah Alam Market	27.Chah Chambay Wala	33. Faisal Park

Main Contributors to Poverty at UC level

a) Contribution of each indicators to Poverty

The results revealed variability between two indicators: attainment of primary education and quality of employment. Attainment of primary education make the highest contribution to poverty among 19 UCs whereas in 6 UCs quality of employment contributed highest. In remaining 9 UCs, both indicators contributed equally in poverty. While child enrollment status contributed as second highest to poverty among 18 UCs. On the other hand, two indicators: electricity facility and access to save drinking makes the lowest contribution among UCs. Table5 presents percentage contribution of each indicator to poverty at UC level.

Table 5. Percentage Contribution of each Indicator to Poverty at UC Level

UCs Name	Percentage Contribution of each Indicator															
	Education Indicators		Health Indicators		Housing Condition Indicators						Housing Services Quality				Employment Indicators	
	1[1]	2[2]	1[3]	2[4]	1[5]	2[6]	3[7]	4[8]	5[9]	6[10]	1[11]	2[12]	3[13]	4[14]	1[15]	2[16]
Begum kot	16.4	9.3	12.9	3.1	4.7	5.5	4.6	3.8	0.6	3.8	0.9	1.6	0.9	5.6	11.0	15.2
Yousaf Park	19.4	16.0	6.6	4.4	5.1	5.6	4.7	6.0	0.0	6.0	0.0	0.9	0.0	5.8	4.1	15.3
Jia Musa	17.7	8.1	8.4	3.0	5.4	5.3	4.7	5.6	0.0	5.9	0.0	1.0	0.0	6.4	11.0	17.6
Shams Abad	18.6	10.4	8.4	0.0	5.9	5.8	5.9	4.9	2.0	5.4	0.0	2.4	0.0	6.3	7.9	16.1
Chah ChemayWala	14.4	10.3	14.0	1.4	4.8	5.7	5.7	5.7	0.0	4.9	0.0	4.4	0.3	6.4	5.6	16.2
Aziz Colony	19.6	12.7	10.1	0.0	5.5	6.0	2.5	6.5	0.0	5.5	0.0	0.0	0.0	8.1	6.6	16.7
Lajpat Nagar	17.4	9.1	12.9	1.3	5.4	5.8	1.9	5.4	0.0	5.5	0.0	1.6	0.0	7.8	10.3	15.6
Faisal Park	17.4	9.6	14.3	3.1	2.8	5.8	1.3	5.4	0.0	5.8	0.0	2.3	0.0	7.9	9.9	14.5
Javeed Park	16.4	12.5	12.1	1.3	4.7	5.5	3.2	5.5	0.0	4.5	0.0	3.2	0.0	7.7	6.9	16.4
Qaiser Town	18.5	11.7	9.6	1.0	3.5	6.2	2.3	5.6	0.0	5.3	0.0	1.5	0.0	7.7	8.6	18.5
Majeed Park	17.6	13.1	6.9	1.3	5.9	5.9	3.9	5.9	0.0	5.3	0.0	1.6	0.0	8.2	6.9	17.6
Qazi Park	16.9	14.6	10.2	0.0	4.4	5.6	4.2	5.6	0.0	5.6	0.0	2.3	0.0	6.3	10.0	14.4
Ravi Clifton Colony	18.1	12.7	7.1	1.5	4.9	6.0	4.6	6.0	0.0	5.8	0.0	0.0	0.0	9.0	6.3	18.1
Ladhey Shah	18.1	8.7	6.6	5.5	5.2	6.0	4.0	5.8	0.0	5.8	0.0	0.0	0.0	8.3	7.9	18.1
Qila Lakshaman Singh	20.0	8.0	12.0	0.0	4.8	5.7	2.6	6.4	0.0	5.1	0.0	5.4	0.0	4.0	5.0	21.0
Auqaf Colony	17.0	12.4	4.6	0.0	5.7	3.7	2.8	5.7	0.0	5.5	0.0	0.0	0.0	8.5	16.9	17.0
Farooq Gangh	19.4	3.8	14.5	1.1	3.9	6.5	2.6	6.5	0.5	6.5	0.0	2.0	0.0	6.9	9.0	16.7
Hanif Park	15.8	13.1	5.9	5.5	4.9	5.3	3.5	4.6	0.0	5.3	0.0	4.3	2.1	7.0	6.8	15.9
Siddique Pura	10.7	10.7	8.1	5.8	5.3	5.6	5.3	5.6	0.0	5.3	0.0	4.5	0.0	8.4	7.6	16.8
Larex Colony	17.1	17.0	7.9	0.0	4.7	5.9	1.2	5.9	0.0	6.4	0.0	0.0	0.0	8.8	11.6	13.5
Badar Colony	20.7	7.4	10.4	0.0	5.7	6.9	2.5	6.2	0.0	6.2	0.0	0.0	0.0	9.6	3.7	20.7
Data Nagar	15.4	8.9	2.7	1.9	5.9	6.7	3.3	6.7	1.7	6.7	0.0	0.0	0.0	8.7	11.5	20.0
Siddiqia Colony	18.6	16.0	10.1	0.0	4.6	6.9	2.7	6.9	0.0	5.7	0.0	0.0	0.0	4.1	6.5	17.9
Bhaman Jhuggian	16.9	13.1	4.2	3.3	4.4	5.6	5.0	5.6	0.0	5.4	0.0	6.0	0.0	7.6	7.7	15.2
Usman Gangh	17.7	13.7	10.9	1.1	4.2	2.1	2.1	6.4	1.4	5.1	0.0	0.7	0.0	9.8	10.9	14.0
Manzoorabad	17.8	11.4	10.4	5.0	4.6	0.4	1.1	6.5	0.0	4.3	0.0	3.3	0.0	9.8	8.2	17.0
Mochi Gate	19.6	8.9	14.7	5.5	4.5	3.6	3.6	3.8	0.9	3.8	0.0	1.4	1.4	6.9	7.9	13.8
Azam Market	20.6	13.5	4.3	0.7	4.0	6.9	2.2	1.1	3.2	5.4	0.0	0.0	0.0	10.3	9.6	18.1
Shah Alam Market	15.3	6.4	12.1	4.8	5.0	3.5	2.0	3.9	0.9	5.8	0.0	4.4	0.4	10.2	12.5	12.5
Rang Mehal	17.4	13.1	9.4	2.2	5.6	5.4	4.1	4.9	0.0	6.4	0.0	0.6	0.0	7.0	9.9	14.1
Lohari Gate	19.8	10.8	7.6	0.0	4.5	6.6	2.4	5.7	1.3	6.4	0.0	1.0	0.0	9.0	5.9	19.1
Bhatti Gate	16.9	7.9	9.6	0.4	5.3	5.6	3.9	5.6	3.3	5.1	0.0	5.0	0.0	8.5	5.8	16.9
Shahi Qila	16.9	13.3	8.3	0.0	5.6	5.0	2.5	5.6	2.6	5.6	0.0	3.0	0.0	4.7	10.0	16.9
Sotar Mandi	15.5	8.4	10.8	0.0	5.9	5.9	4.6	5.9	1.8	5.9	0.0	0.9	0.0	8.8	8.0	17.6

Note: Yellow color in table highlight the indicator which makes highest contribution in poverty. Blue color highlights second highest Contribution. Gery color highlights third highest contributor and Green color highlights equal contribution of indicators.

[1] Attainment of Primary Education
[2] Child Enrollment Status
[3] Health Status
[4] Child Mortality
[5] Wall Material
[6] Roof Material
[7] Floor Material
[8] Kitchen Facility
[9] Toilet Facility
[10] Housing Congestion
[11] Electricity Facility
[12] Cooking Fuel
[13] Assess to save drinking water
[14] Household Assets
[15] Employment Status
[16] Quality of Employment

Source: Authors Computation from Household Survey (2019).

b) Contribution of each Dimension to Poverty

The results demonstrate the variability among dimensions across UCs regarding highest contribution. In 24 UCs, education contributed highest whereas housing condition make highest contribution in 6 UCs although in 4 UCs employment dimension highly contributed to overall poverty. Table 6 shows the dimension-wise contribution to poverty among all UCs.

Table 6. Percentage Contribution of each Dimension to Overall Poverty

UCs Name	Percentage Contribution of each Dimension to Overall Poverty				
	Education	Health	Housing Condition	Housing Services Quality	Employment
Begum kot	26.5%	14.6%	25.2%	8.3%	25.4%
Yousaf Park	35.4%	11.0%	27.5%	6.7%	19.4%
Jia Musa	25.7%	11.4%	26.8%	7.5%	28.6%
Shams Abad	29.0%	8.4%	29.8%	8.7%	24.1%
Chah ChemayWala	24.7%	15.4%	26.9%	11.1%	21.8%
Aziz Colony	32.3%	10.1%	26.1%	8.1%	23.3%
Lajpat Nagar	26.5%	14.1%	24.0%	9.5%	26.0%
Faisal Park	27.0%	17.4%	21.0%	10.2%	24.4%
Javeed Park	29.0%	13.4%	23.4%	10.9%	23.3%
Qaiser Town	30.2%	10.6%	22.8%	9.3%	27.1%
Majeed Park	30.7%	8.2%	26.8%	9.8%	24.5%
Qazi Park	31.5%	10.2%	25.4%	8.6%	24.3%
Ravi Clifton Colony	30.7%	8.5%	27.3%	9.0%	24.4%
Ladhey Shah	26.8%	12.1%	26.8%	8.3%	25.9%
Qila Lakshaman Singh	28.0%	12.0%	24.6%	9.4%	26.0%
Auqaf Colony	29.5%	4.6%	23.3%	8.5%	34.1%
Farooq Gangh	23.3%	15.6%	26.5%	8.9%	25.8%
Hanif Park	28.9%	11.4%	23.6%	13.4%	22.7%
Siddique Pura	21.4%	13.9%	27.1%	12.9%	24.6%
Larex Colony	34.1%	7.9%	24.1%	8.8%	25.1%
Badar Colony	28.2%	9.6%	27.4%	10.4%	24.5%
Data Nagar	24.3%	4.6%	30.9%	8.7%	31.6%
Siddiqia Colony	34.5%	10.1%	26.9%	4.1%	24.4%
Bhaman Jhuggian	30.0%	7.5%	26.0%	13.6%	22.9%
Usman Gangh	31.5%	12.0%	21.3%	10.3%	24.9%
Manzoorabad	29.2%	15.4%	17.0%	13.1%	25.2%
Mochi Gate	28.4%	20.2%	20.1%	9.6%	21.7%
Azam Market	34.1%	5.0%	22.8%	10.3%	27.7%
Shah Alam Market	21.7%	16.9%	21.0%	15.1%	25.3%
Rang Mehal	30.5%	11.6%	26.3%	7.6%	24.0%
Lohari Gate	30.5%	7.6%	26.8%	10.1%	25.0%
Bhatti Gate	24.8%	10.1%	28.9%	13.5%	22.7%
Shahi Qila	30.1%	8.3%	27.0%	7.7%	26.9%
Sotar Mandi	23.8%	10.8%	29.9%	9.8%	25.7%

Note: Yellow color highlight the dimension which makes highest contribution in poverty. Blue color highlights second highest, Green color highlights third highest contributor and purple color highlights forth highest contribution.
Source: Authors Computation from Household Survey (2019).

Conclusion

It was revealed that poverty cut off points (k) affect poverty estimates. As the value of k increases, two multidimensional poverty indices: H and MPI continues to decrease whereas A increases. The study concluded that in Ravi Zone, 70.8% of households are considered as MPI-poor whereas 29.8% households are living out of poverty with positive potentials. The results revealed that in Ravi Zone, Shahdra administrative zone found to be highly deprived as compared to other two zones. In case of UCs, 4 UCs: Javaid Park, Hanif Park, Bhama Jhuggian and Bhatti Gate are categorized as highly deprived in Ravi zone.

The study further revealed that in Ravi zone, attainment of primary education followed by quality of employment and child enrollment status played a vital role in driving poverty. The results showing an alarming situation because these three indicators have a significant correlation with each other i.e., attainment of primary education determine quality of employment which in turn effects child enrollment status because people with low education which is unable to get better jobs which meet their needs so they engage their children in child labor despite of educating them. It is recommended that government and policy makers should concentrate in creating quality job opportunities for the unskilled and uneducated people.

Future Avenues

- ❖ This study can be further enhanced by assessing multidimensional poverty in all zones of Lahore at segregated administrative unit levels.
- ❖ Multidimensional poverty measuring tool can be further enhanced by adding more dimensions and indicators in it.
- ❖ The study can further assign unequal weights to different indicators and dimensions according to their relative importance.

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Annexures

Questionnaire

GC University Lahore

HOUSEHOLD LEVEL POVERTY ASSESSMENT SURVEY IN RAVI ZONE

I am MS Geography student of GC University, Lahore and aims to conduct a research on poverty assessment in Ravi Town. This survey explores the poverty status among the projected area along with the determining factors which in turn will help to establish poverty alleviation strategies. Your contribution will make this effort possible and your provided information will be kept confidential

SURVEY INFORMATION

Questionnaire no.____ **Date:**_____ **Time Interview started**_____ **Time Interview ended**_____

GPS Points:_____ **UC:**_____ **Locality within UC:**_____

Respondent's Behavior: ☐ Cooperative ☐ Reluctant/Hesitant ☐ Non-serious ☐ Refusal

Language of Interview: ☐ Urdu ☐ Punjabi ☐ Others

HOUSEHOLD INFORMATION

1. Total no of household members_____

2. Family Structure: ☐ Joint Family System ☐ Nuclear Family system ☐ Any other please specify_____

3. Residential Status: ☐ Owned ☐ Rented ☐ Mortgage property

4. Head of Household: ☐ Male Headed Household ☐ Female Headed Household

If head of household is female then specify her marital status: ☐ *Married* ☐ *Unmarried* ☐ *Widowed* ☐ *Any other*____

HOUSEHOLD CHARACTERISTICS

Note: Please give the information about each household member who lives here

A) DEMOGRAPHIC DETAILS						**B) EDUCATIONAL PROFILE**		
No	**5. Relation with Head**	**6. Gender**	**7. Age**	**8. Marital Status**	Code for 6 Female =1 Male=2 Code for 8 Single=0 Married=1 Never married=2 Widow=3 Divorced=4	**9. Educational Status**	**10. In which type of educational institution he/she is going?**	Code for 9. Illiterate=0 Primary=1 Middle=2 Matriculation=3Inter=4 Graduate=5 Higher Education=6 Code for 10. Govt. =1 Private=2 Madras=3 NGO/Trust=4
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

11. Do any school going children aged 6-14 not going to School?

☐ No ☐ Yes (State how many_____)

If your answer is yes what are the reasons for not going to School?

☐ Education is costly ☐ Child is not willing ☐ Far away

☐ Helping in domestic purpose ☐ Helping in work

☐ Parents do not permit

ECONOMIC PROFILE

12. Occupational Structure/Income source (Specify the occupation of household head)_____

Occupation	Govt. job	Private job	Own business	Labor	Working as an employ in Industry	Pension Holder	Rental Income
No of persons							
Relation/Gender							

13. No of Earning and dependent members: Earning members_____ Depending members_____

Among earning members no of: Males _____ *Females*_____

14. No of unemployed members in family other than students_____

15. Specify the reason behind unemployment_____

16. Estimated monthly income_____ **rupees**

☐ Below 10,000 ☐ 10,001-15,000 ☐ 15,001-20,000 ☐ 21,000-30,000 ☐ 31,000-40,000 ☐ 41,000-50,000
☐ Above 51,000

17. Total Expenditure of household in a month? _____**rupees**

a) On Food items_____ b) On Transportation _____ c) On bills _____

18. Do you find household income enough to meet expenditure: ☐ No ☐ Not at all ☐ Yes

19. How many household members at present receive any benefit like:

☐ Income Support_____ ☐ Widow's benefit _____ ☐ Pension _____ ☐ Others (please specify)_____

18. Are you availing any poverty alleviation measure from government/NGOs? ☐ No ☐ Yes

19. Are you aware about the poverty alleviation measures? ☐ No ☐ Yes

HEALTH STATUS

20. Is any child died in the household under 0-5 years: ☐ No ☐ Yes (State number and reason_____)

21. Is any member in this household sick/ill ☐ No ☐ Yes (State number of sick members _____ age_____)

Did they consult for their illness? ☐ No ☐ Yes

If yes which type of health provider, they visit?

☐ *Private Dispensary* ☐ *Govt. Dispensary* ☐ *Hakeem* ☐ *Homeopathic* ☐ *One who perform DUM (spiritualism)*

If no, then why they didn't take treatment?

☐ *Costly treatment* ☐ *Not Required* ☐ *Far away* ☐ *Doctor do not present* ☐ *Unsatisfactory*
☐ *Untrained staff* ☐ *Others (please specify)*_____

22. Are you satisfied with the health facilities in your area? ☐ Yes ☐ No (Please specify)_____

HOUSING AND INFRASTRUCTURE INFORMATION

A) HOUSEHOLD STRUCTURAL INFORMATION

23. Size of your plot: ☐ 1-2 marla ☐ 3-4 marla ☐ 5-6 marla ☐ 7-10 marla ☐ 10 marla and more

24. Story of building: ☐ Single Storey ☐ Double Storey ☐ Triple Storey ☐ Four story and more

25.Age of Building: ☐ < 5 years ☐ 6-10 years ☐ 11-20 years ☐ 21-30 years ☐ 31-40 years ☐ > 41 years

26. No of rooms in household: _____

27. No of family members sleeping in one room:_____

28. Main Building Material of Building	**i. Main Material for roofs**	**ii. Main Material for floor**
☐ Brick	☐ wood/bamboo	☐ Earth/Sand
☐ Concrete	☐ Iron/Cemented Sheets	☐ Wood planks
☐ Wooden	☐ RCC/RBC	☐ Cement
☐ Others_____	☐ Others_____	☐ Ceramic Tiles
		☐ Polished Wood

B) WATER SUPPLY AND SANITATION

29. Source of Drinking Water:

☐ Piped water ☐ Public tap ☐ Hand pump ☐ Water motor ☐ Filtration Plant ☐ Mineral Water ☐ Water Tank ☐ Others

Do you have any problem with water supply? ☐ No ☐ Yes

What are the problems with water supply:

☐ Water cuts (how frequent___) ☐ Not Clean ☐ Low quality (hardness) ☐ Difficult to access ☐ Others_____

30. No of hours of water access? _____

31. No of toilets available in household? _____

32. What kind of toilet facility do your household members mostly use?

☐ Facility not available ☐ Dry raised latrine ☐ Flush system (linked to sewerage) ☐ Flush (linked to septic tanks)
☐ Flush connected to open drains ☐ Pit Latrine ☐ Others

33. How are the solid waste disposed?

☐ Municipality collects regularly ☐ Disposed irregularly ☐ Disposed to predefined landfill ☐ Burning ☐ Others

C) ENERGY USE

34. In your household which type of cook stove is mainly used?

☐ LPG Cooking gas stove ☐ Piped natural gas stove ☐ Others (Please specify_____)

35. What is the main fuel used for cooking in household?

☐ Gas ☐ Kerosene oil ☐ Coal ☐ Dung cake ☐ Others

36. Do you face any gas shortage in your area? ☐ No ☐ Yes (How frequent_____)

37. Do you have electricity in your household? ☐ No ☐ Yes

38. Do you experience any problem with electricity supply? ☐ No ☐ Yes

39. What kind of problems do you experience?

☐ Electricity cuts (how frequent_____) ☐ Low Voltage ☐ Others (Please specify_____)

D) ASSESTS IN POSSESION

Assets	Quantity	Assets	Quantity

Car / Truck		Washing machine	
Motorcycle		Stove with oven	
Air conditioner		Refrigerator	
TV		Phone	

AREA INFORMATION

A) FACILITIES AVAILABILITY IN AREA

Available Facilities	**Accessibility**
Educational institutes ☐ No ☐ Yes	☐ Satisfied ☐ Not Satisfied ☐ Household children not go to area institutes
Banks ☐ No ☐ Yes	☐ Satisfied ☐ Not Satisfied
Police Station ☐ No ☐ Yes	☐ Satisfied ☐ Not Satisfied ☐ Never used
Hospitals/Clinics ☐ No ☐ Yes	☐ Satisfied ☐ Not Satisfied
Recreational Activities ☐ No ☐ Yes	☐ Satisfied ☐ Not Satisfied

40. How satisfied are you with this area as a place of living?

☐ Very Satisfied ☐ Fairly Satisfied ☐ Neither satisfied nor dissatisfied ☐ Slightly Dissatisfied ☐ Very Dissatisfied

B) CRIME RATE

41. How do you rate the crime in your area?

☐ High crime ☐ Medium crime ☐ Low crime

42. Which type of crime is mostly prevail in your locality? _____

43. Are you satisfied with the security condition of your locality? ☐ Satisfied ☐ Not Satisfied

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Monitoring the Spatial Structure of Land Values in Lahore Metropolitan Area

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Spatio-temporal variations in assessment of land values play a vital role in better urban planning and policy making. This study focuses on spatial structures of land values in Lahore metropolitan area by using different spatial and statistical techniques. The comparative analysis of land values for the years 2012 & 2018 is generated which is useful for planners, investors, and policy makers. The research is descriptive but explanatory in nature to show correlation between independent variables (real land values) and dependent variables (interpolated land values). The interpolation techniques which have the highest correlation coefficient, were used further processing. The inter category shift based on interpolation maps for comparison shows categorical shift which is useful for investors in future. The results indicate that the land values are higher in Central Business District and Gulberg Zone because of highly active business zone which increases the demand of the land which is ultimately increasing the value of land in Lahore metropolitan area.

Keywords: Land values per Marla; Central Business District Lahore; Accuracy Assessment; Correlation Coefficient and Interpolation.

Introduction

Urban land values are an important aspect of urban geography where emphasis is on spatial structures. Land values are not uniformly distributed, the variability exist over space. The land values are lower at periphery as we move away from Central Business District (CBD) [1]. Due to lack of public transportation network and great distance from main CBD, mostly people do not buy land for residence in suburb areas but only those who can afford transportation cost, live at periphery so the land values remain lower at the edges and congestion occur near center which ultimately trigger issues like environmental degradation in form of pollution [2]. To avoid such variability in land values, a proper monitoring mechanism is required for better planning and future investments [1, 2]. The spatial structures of land values are linked with the urban development where the development is more the land valuesare higher. Spatio-temporal assessment of land values is helpful for planners, policy makers and investors for better understanding and planning of future to make plans and policies to avoid issues and problems [3, 4].

Land prices are important aspect of urban area which needs to be monitored properly. To examine the variability in land prices over space, the spatio-statistical techniques are applied by incorporating real time land prices [5, 6]. The price of residential area differs from commercial areas because people acquire commercial land to perform economic activities [7, 8].

The emphasis of the study is to map spatial structures of land values in Lahore metropolitan city through GIS and statistical techniques. The study compares the data of years 2012 and 2018 using different geographical and statistical techniques (correlation coefficient).

Materials and methods

2.1 Investigation site.

Lahore is one of the largest cities of Pakistan and capital of province Punjab. It is located in northeast of Punjab which extends from 31° 15' and 31° 43' Northern latitude and 74° 10' and 74° 39' East longitude with 1772 Sq Kms total area. Lahore falls into a major climatic zone which is Sub-Tropical continental lowlands which face high summer temperature and receive late summer monsoon rainfall. It has a semi-arid type of climate. Lahore has an alluvial plain traversed by river Ravi [9].

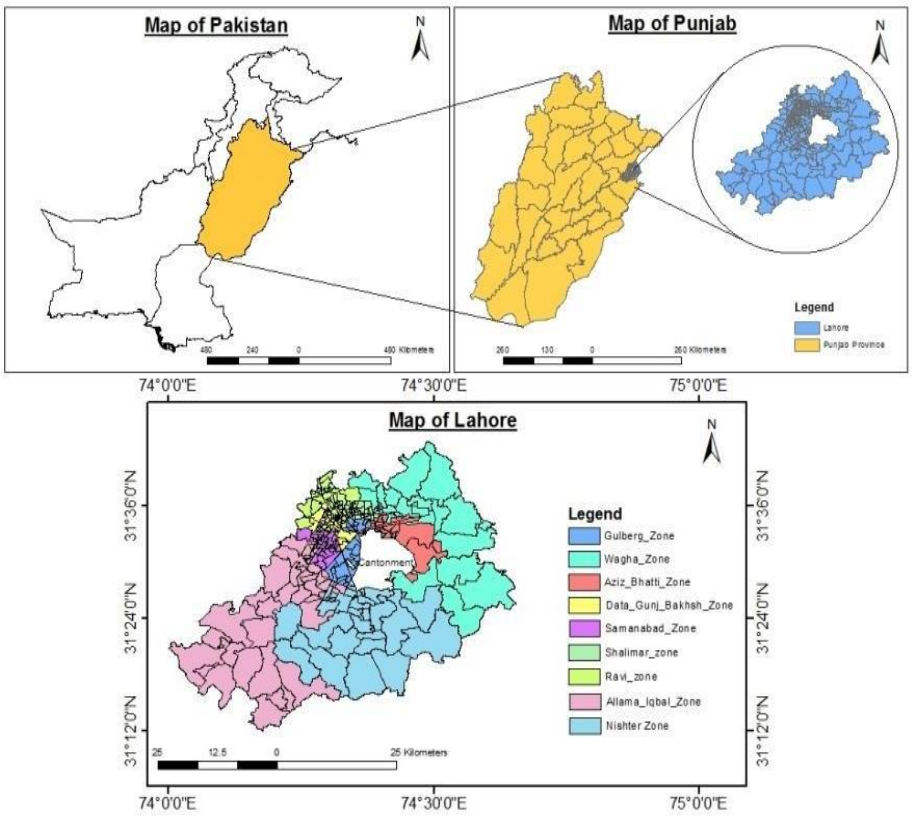

Figure 1. Study site

Lahore has one cantonment and nine zones which are Ravi, Shalimar, Gulberg, Data Gunj Bakhsh, Samanabad, Allama Iqbal, Nishter, Aziz Bhatti and Wagha. These zones are further divided in total 274 Union Councils. Lahore is the second most populous city of the country with 11 million heads [10]. The highest concentration of people found near or around

the city center. Lahore is famous for its commercial activities and is considered as active business zone which attracts many people from different parts of country [9]. The spatial extent of study site is mapped in Figure 1.

The number of localities were different for the both residential and commercial areas. Total number of residential areas in 2012 were 917 that increased to 1191 in 2018 which shows 23% increase. Total number of commercial areas in 2012 were 1004 that increased up to 1287 in 2018 which shows 22% increase [11, 12]. Most of the development was observed in southeast and southwest of Lahore and remarkable development was observed in Wagha zone in north of the city.

Table 1. No of localities of Lahore metropolitan area

Classification	2012	2018	Increase/change
No of residential areas	917	1191	23%
No of commercial areas	1004	1287	22%

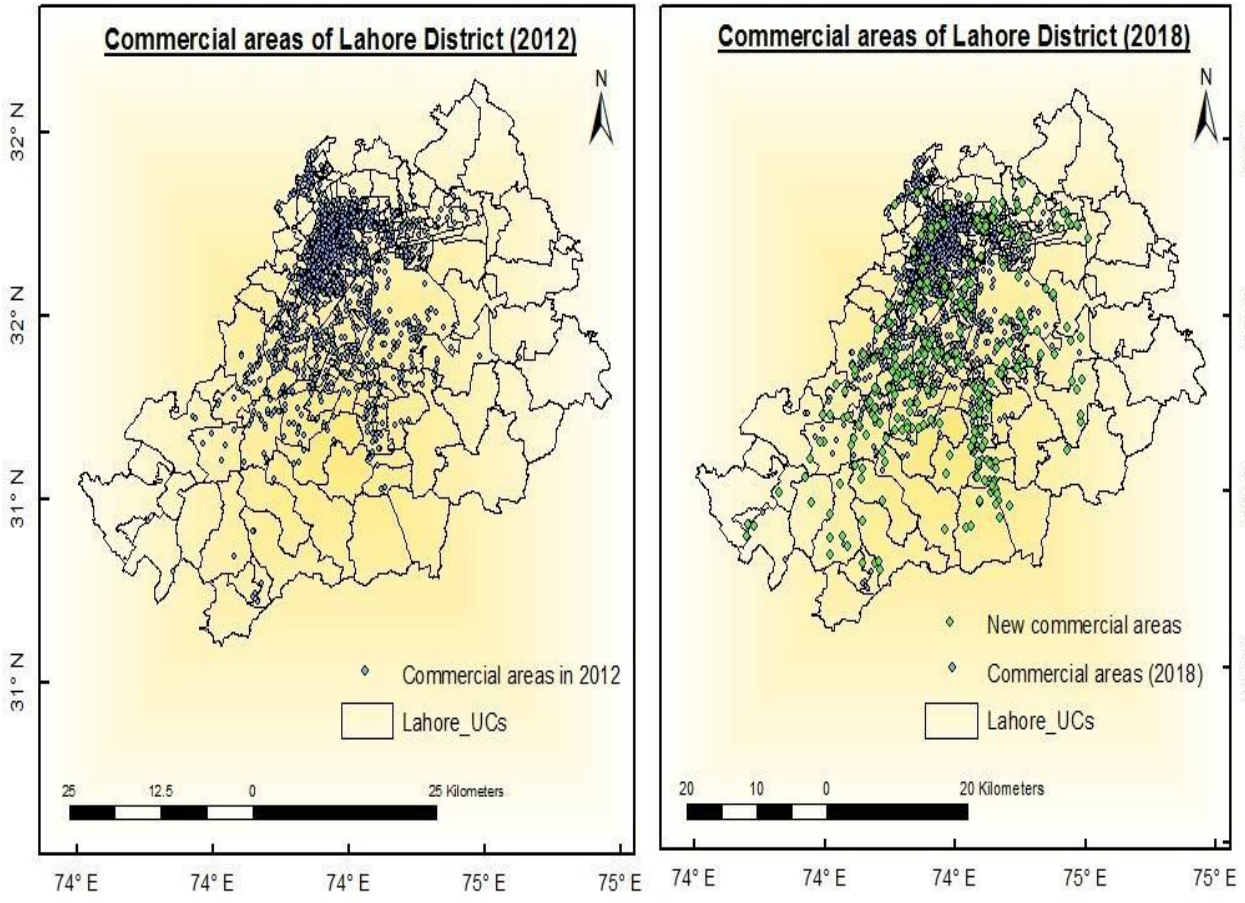

Figure 2. Residential areas of Lahore metropolitan area.

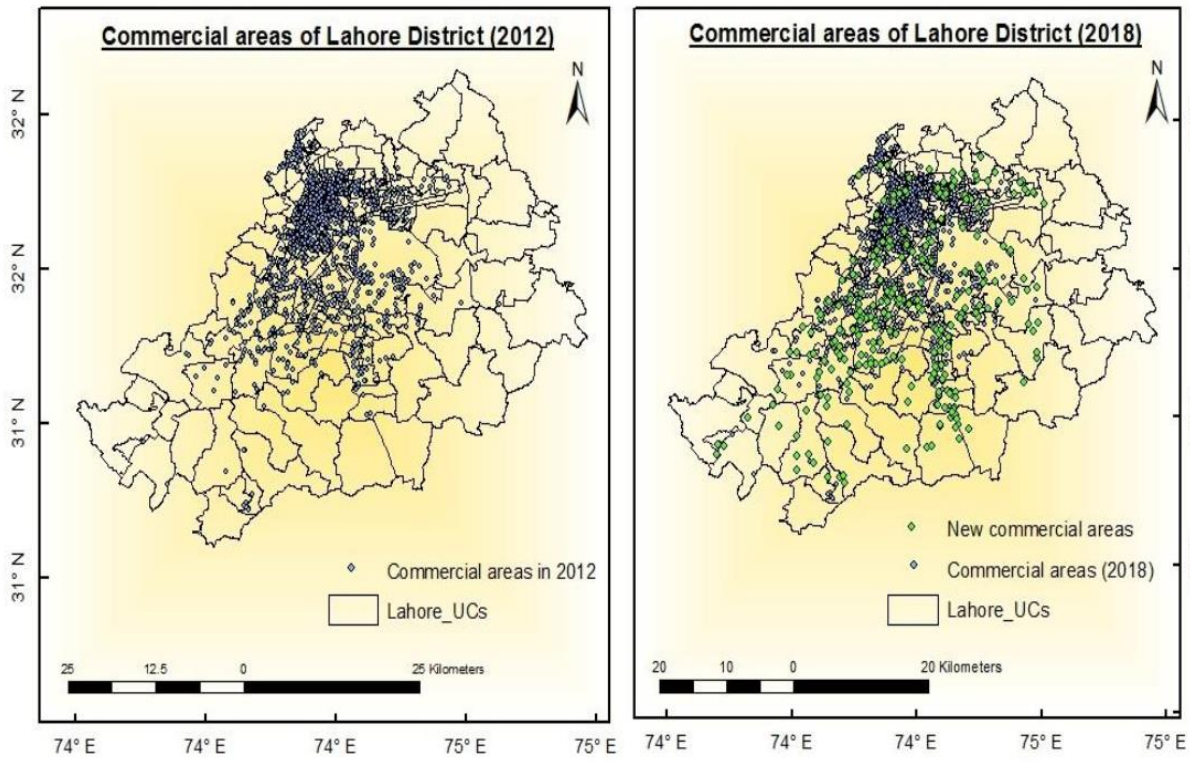

Figure 3. Commercial areas of Lahore metropolitan area.

Material and methods.

The study is based on secondary and descriptive approach. The data of land values was collected from Senior Member Board of Revenue, Lahore (SMBR) and DC office Lahore. The shape files for spatial analysis were acquired from Urban Unit Lahore. ArcGIS 10.3 version was used for spatio-statistical analysis [10, 11, 12].

After collection of land values record, the data is extracted in excel along with GPS points for further processing. Excel sheets are converted into shape files in ArcGIS 10.3 to perform spatial analysis e.g., application of interpolation techniques. The validation results were converted to excel sheet from attribute table to find correlation coefficient. To check inter category change, the counter change and growth rate was calculated.

Various interpolation techniques were used including Inverse Distance Weightage (IDW), Kriging available in ArcGIS 10.3 interface. Correlation is one of the useful statistical techniques to find association between two variables. The correlation coefficient ranges between -1 to +1, where a value of "0" shows that there exists no relation between variables. If the value is greater than 0, it means that variables are positively correlated and vice versa. In this study two variables are used which are interpolated land values (dependent variable) and true land values (Independent variable).

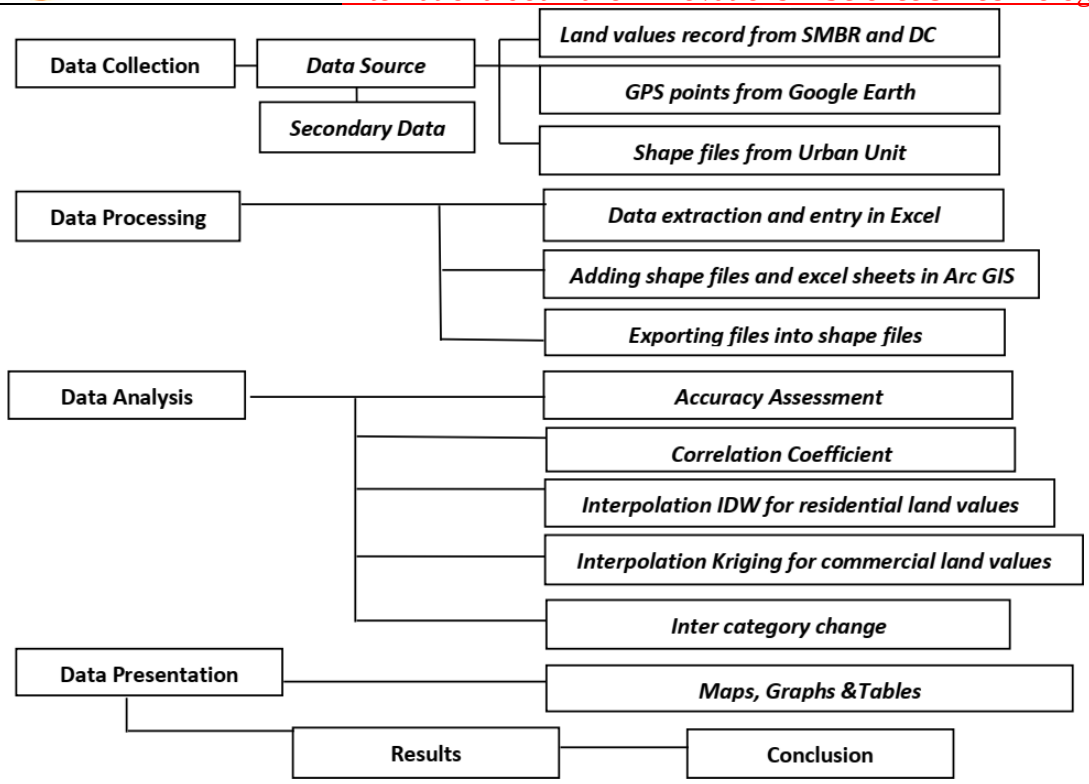

Figure 4. Flow of Methodology

IDW is used for residential land values and Kriging is used for commercial land values on the basis of correlation results. For comparison of land values for the years 2012 and 2018, the inter category change of areas in map were also calculated by using counter check and applying growth rate formula to check the change over time in percentage. The inter category shift is further helpful for investors and planners. To present data in meaningful form, different maps, and tables were generated in excel and ArcGIS.

Results and discussion.

Validation results of IDW & Kriging were further used to find correlation between interpolated values and true values. In case of residential land values, the more accurate result of correlation coefficient is found for IDW technique which has positive coefficient of 0.74222 values that shows moderate relation in variables for the year 2012 and found positive coefficient 0.742276 for the year 2018. However, for Kriging technique, the correlation coefficient was 0.61057 for the year 2012 and 0.616911 for the year 2018.

R^2 in scatter plot known as Coefficient of Determination which shows how well trendline, more closer to 1 value indicates that trendline better fit. Scatter plot in figure 5 shows the relation of interpolated values with true values of 2012 by trend line which indicates the positive association of variables with 0.555 R^2 and scatter plot for 2018 indicates the positive association of variables with 0.551 R^2. The result shows that IDW technique is more correlated in case of residential land values and was further used to show spatial structure.

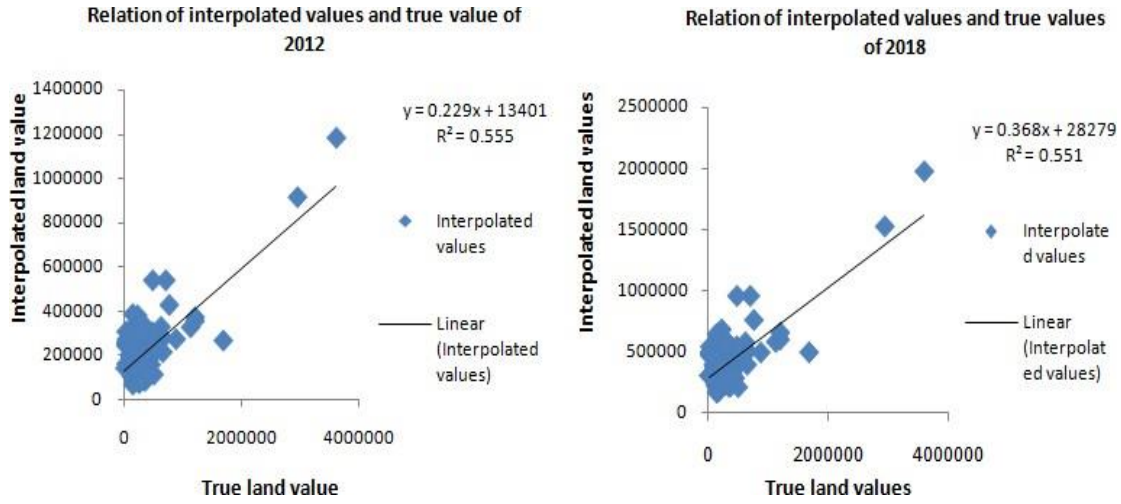

Figure 5. Scatter plot of validation result for Interpolation IDW techniques of residential areas.

In case of commercial land values, the result of correlation coefficient was more efficient for Kriging technique which shows a positive coefficient with 0.725266 for the year 2012 and also a positive correlation coefficient 0.72298 for the year 2018. The IDW generated correlation value was 0.634233 for 2012 and 0.636146 for 2018. It shows that Krigging technique is more correlated in case of commercial land values.

Scatter plot was used to highlight the relationship of interpolated values with true values of 2012 by trend line which indicates the positive association of variables with R^2 = 0.528 and in 2018 result shows the positive association of variables with R^2 = 0.522. It shows that Krigging technique was more correlated in case of commercial land values and was further used to show spatial structure.

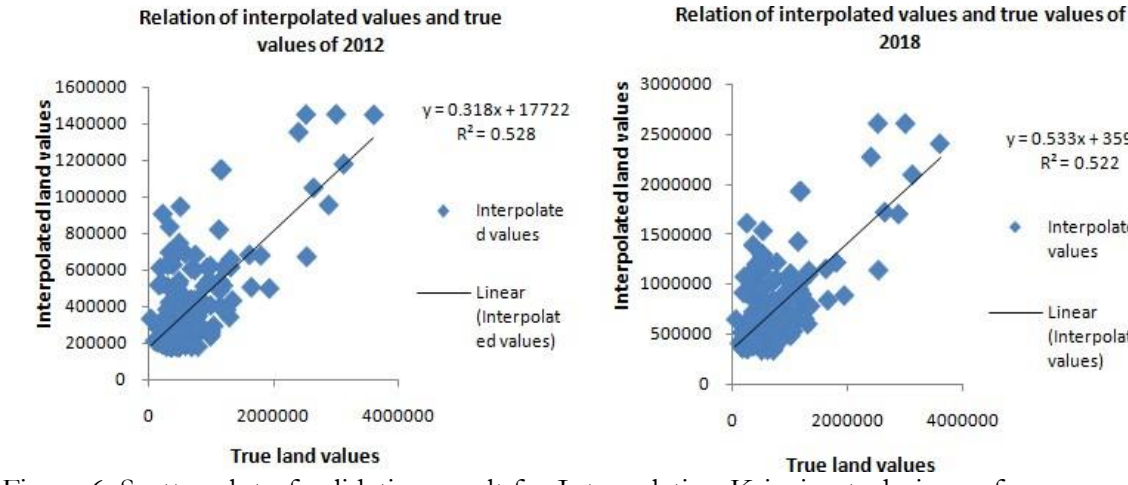

Figure 6. Scatter plot of validation result for Interpolation Krigging technique of commercial areas.

The highest residential land value found in city center which is known as walled city

because it is the main CBD of Lahore. According to bid rent theory, the land values are highest in the CBD as we move away these values start declining. The changes are mentioned in Figure 7

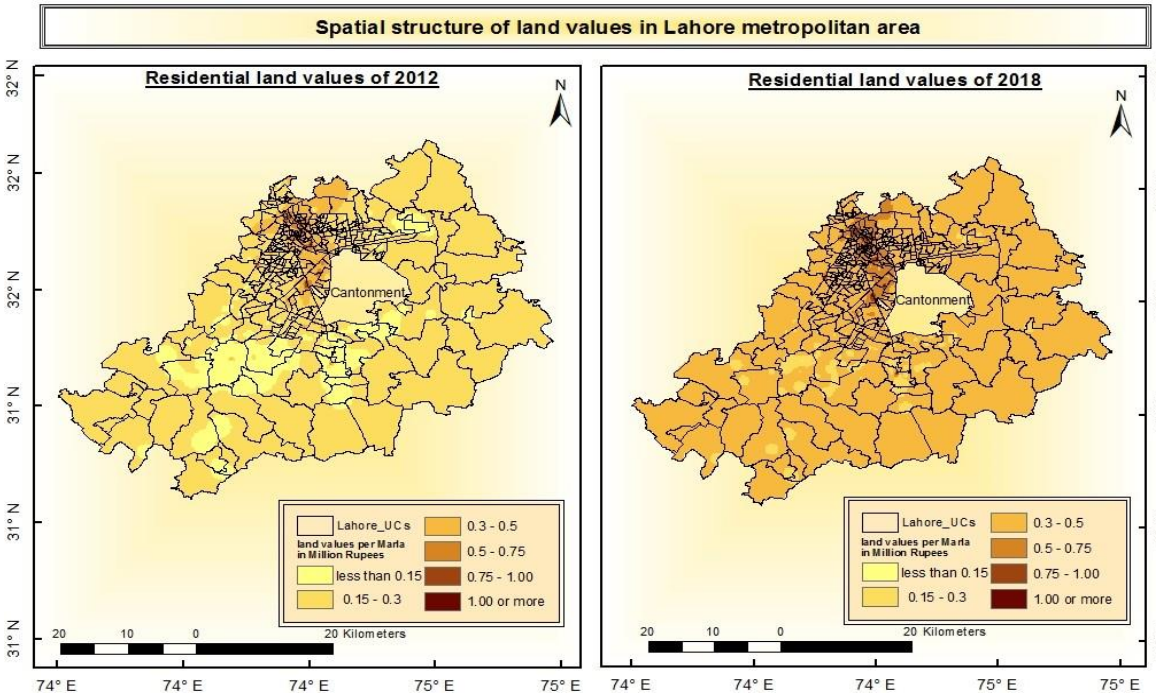

Figure 7. Spatial structure of residential land values in Lahore metropolitan area.

Residential land values were observed ranging from 0.15 to 1 million rupees per Marla with lowest amount found near periphery in 2012. Comparative result in map shows that in 2012 most of land area was under the range of 0.15 to 0.3 million rupees and in city center, the prices were from 0.3 to 1 million rupees. But in 2018, most of the land area of city was found under the range of 0.3 million rupees to 0.5 million rupees and in city center it was from 0.5 million rupees to more than 1 million rupees.

Inter category shift was calculated to compare the values of 2012 and 2018. In case of residential land values, the highest shift of areas was found in three ranges. The highest shift was observed in category of the third range 0.75 to 1 million rupees where there were only 5 regions existing in 2012 which exceeded to 34 showing 85% growth rate. The lowest growth rate was found within the range of 1 million or more which is showing the growth rate of about 49% and negative rate observes over the ranges of less than 0.15 to 0.3 million.

Table 2. Inter category shift of residential land values from 2012 to 2018.

Per Marla land values in million rupees	Number of areas in 2012	Number of areas in 2018	Growth rate
Less than 0.15	255	12	-95%

0.15 – 0.3	498	212	-57%
0.3 – 0.5	107	483	78%
0.5 – 0.75	19	120	84%
0.75 – 1	5	34	85%
1 or more	24	47	49%

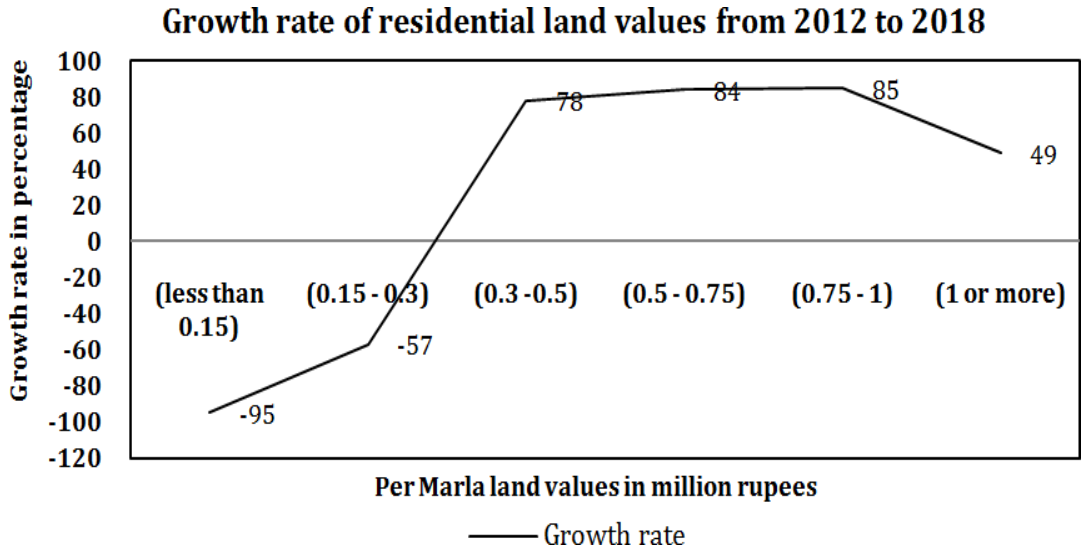

Figure 8. Inter category change in residential land values from 2012 to 2018.

Average residential land values of different zones show that the highest land values were in Ravi zone and Gulberg Zone which were 0.4 million rupees in 2012 and 0.7 million rupees in 2018 for commercial areas. The lowest average land value were found in Wagha zone which was 0.1 million rupees in 2012 and 0.2 million rupees in 2018. The result of average land values shows that the increase in land values from 2012 to 2018 was gradual in all over the zones.

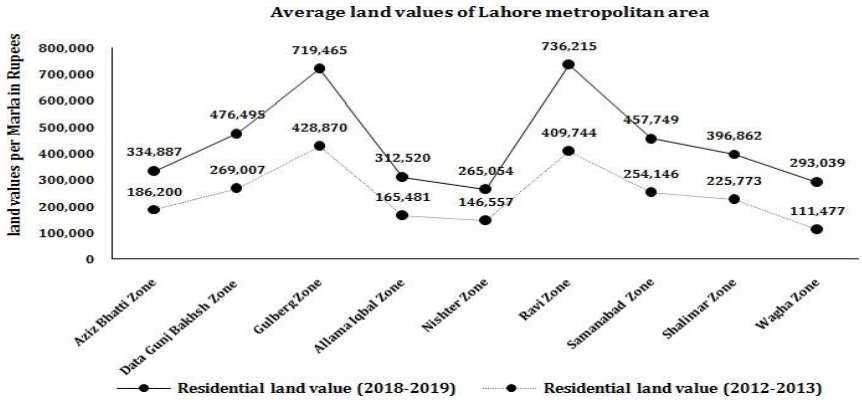

Figure 9. Average residential land values of Lahore Zones from 2012 to 2018.

The highest commercial land value were found in city center which was the main CBD of Lahore. Commercial land values ranged from less than 0.25 million rupees to more than 1 million rupees per Marla. The lowest amount was observed in outer parts of Lahore mostly in Wagha and Nishter town. Comparative result shows that in 2012, most of the area was under the range of less than 0.25 million rupees to 0.5 million rupees and the highest amount was found in Ravi and Gulberg zone which had more than 1 million rupees. In comparison to 2018, most of the area was observed under the range of 0.25 million rupees to 0.75 million rupees and the highest commercial land values were found in four zones of Lahore which are Gulberg zone, Ravi zone, Samanabad zone and Data Gunj Bakhsh zone where the land values were more than 1 million rupees.

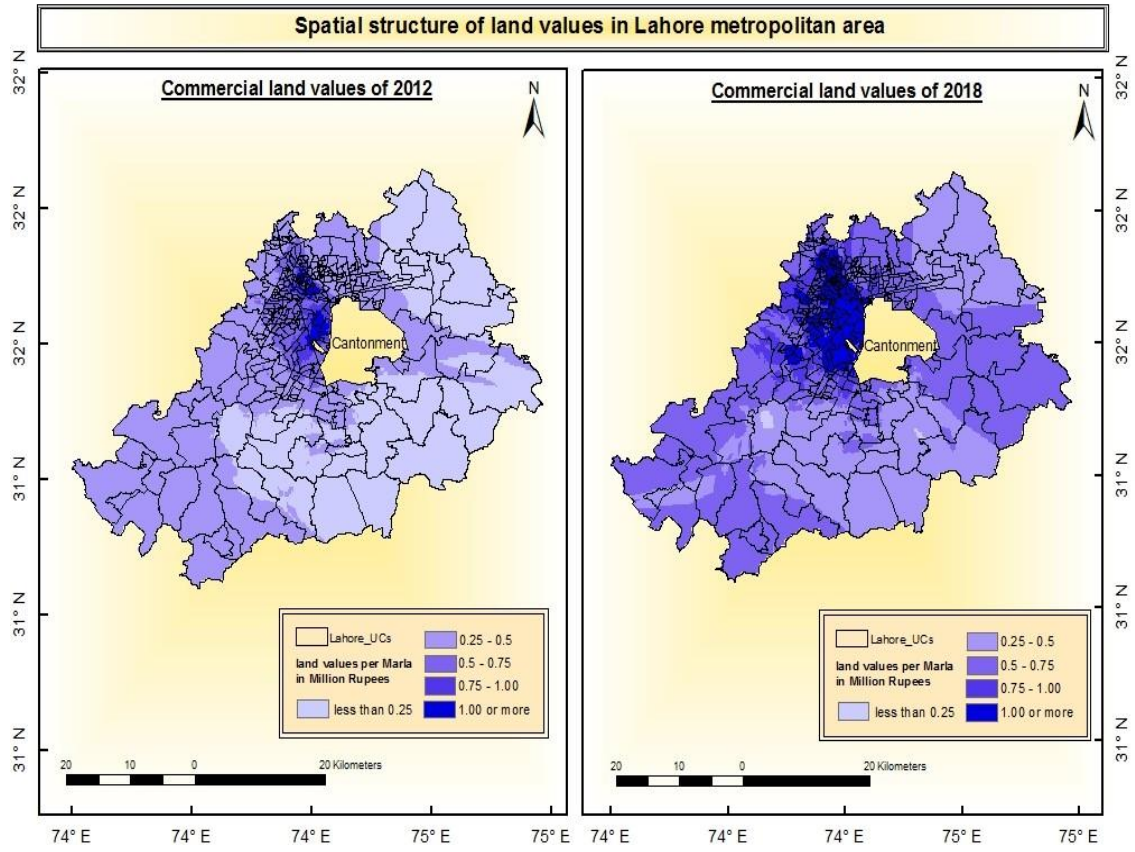

Figure 10. Spatial structure of commercial land values in Lahore metropolitan area.

The change in land values determines the rate of shift from 2012 to 2018. In case of commercial land values, the highest shift of areas was found in two ranges. First is 0.75 million rupees to 1 million rupees in which there were only 66 areas in 2012 and increased to 197 in 2018 having 66% growth rate. The second range was from 1 million rupees or more in which there were 108 areas in 2012 that increased to 344 areas which shows 69% growth. The lowest growth was found in the range of 0.5 million rupees to 0.75 million rupees which shows 4% growth and a negative rate was observes over the ranges of less than 0.25 million to 0.5 million rupees.

Table 3. Inter category shift of commercial land values from 2012 to 2018.

Per Marla land values in million rupees	Number of areas in 2012	Number of areas in 2018	Growth rate
Less than 0.25	159	12	-92%
0.25 – 0.5	395	164	-58%
0.5 – 0.75	272	283	4%
0.75 – 1	66	197	66%
1 or more	108	344	69%

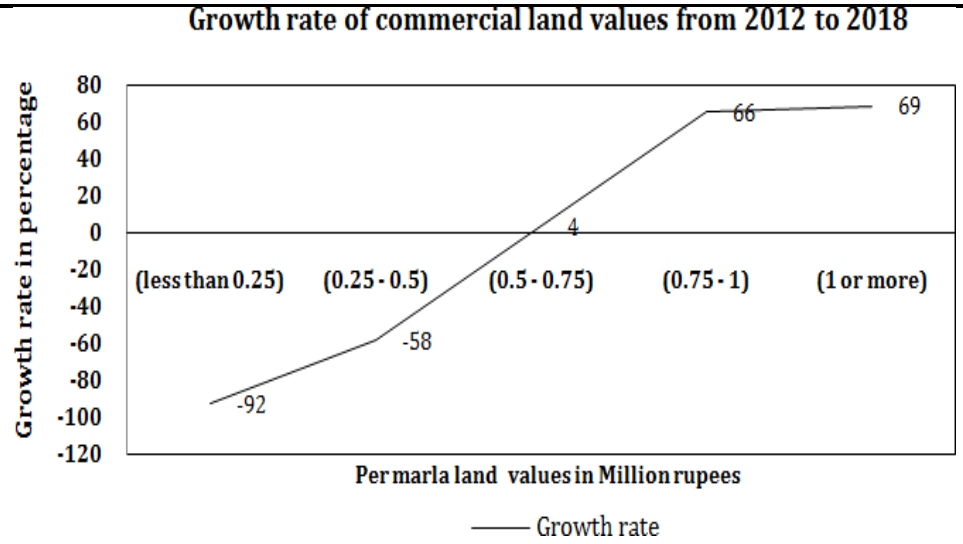

Figure 11. Inter category change in commercial land values from 2012 to 2018.

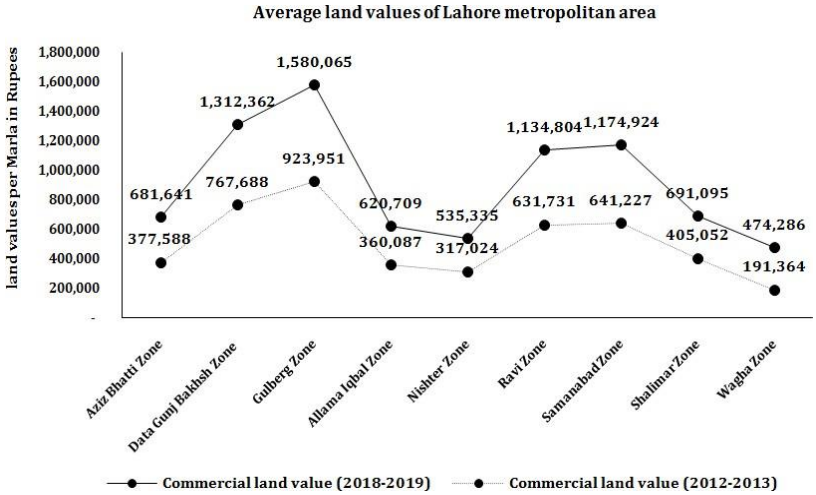

Figure 12. Average commercial land values of Lahore Zones from 2012 to 2018.

Average commercial land values of different zones show that the highest land values were in

Gulberg Zone ranging between 0.9 million rupees in 2012 to 1.5 million rupees in 2018. The residential area was converted to commercial area. The lowest average land values were found in Wagha zone ranging between 0.1 million rupees in 2012 which increased to 0.4 million rupees in 2018 because of the less development in this zone.

Conclusion.

This paper demonstrates the spatial structure of land values in Lahore metropolitan area by using different geographical and statistical techniques which will assist help planners, investors, and policy makers to manage a region in a better way. The results concludes that commercial land values were high for the four zones Ravi zone, Gulberg zone, Data Gunj Bakhsh zone and Samanabad zone because of the increasing commercial activities and development in Lahore. The land values were increased in the mid of city center and a considerable change was observed while applying spatial and statistical techniques.

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Assessment and Mapping of Vulnerable Roads to Accidents Through Geospatial Techniques

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In Pakistan, about 36000 people were killed in road accidents in the year 2019. This study focuses on hazard assessment through geo-spatial techniques using both quantitative and qualitative research methodologies.An attempt wasmadetodemarcatethemost vulnerableroadstoaccidents for theyears 2015 to 2019 through geospatial techniques. The data used in this research was collected through real time field observation using questionnaire-based survey. The results show that the ratio of reported accidents was higher in 2019 which was 53,979, in comparison to the number of accidents occurred in 2015 which were 19,073. It caused 478 casualities in 2019 in comparison to 308 in 2015. We found various reasons behind these accidents at both administration and individual levels e.g., about 67% increase was observed in number of vehicles from 2015 to 2019 whereas only 14% driving licenses were issues against this number. The most vulnerable roads where most of accidents occurred were Ferozepur Road, Ring Road, Mall Road and Jail Road whereas, in Iqbal Town, the roads were Canal Road, Multan Road, College Road and Raiwind Road. Geospatial techniques proved efficient for mapping the vulnerable roads to accidents.

Keywords: Road Traffic Accident (RTA), Two Wheelers, Vulnerable Roads, Hazards, Driving licenses**.**

Introduction

Road traffic accident is a term specified by Economic Commission for Europe (ECE); i.e., traffic accidents which occur in a way that cause deaths or injuries, where at least one vehicle is involved [1]. Accidents can be categorized in four types, i.e., fatal, non-fatal, slight, and property damage [2]. The fatal accident leads to the death of more than one person and the other type of accident is non-fatal which leads to serious injuries including fractures, unconsciousness, inner cuts, scratches and grazes etc. Third type of accident is concerned with damages and the fourth type of accident is related to property/infrastructures damages[3].

Around 1.35 million people were killed in road accidents globally in 2019 according to WHO[4] and 50 millions are disabled or injured. Approximately 3000 people die in the traffic accidents every day [4]. Traffic accidents have become a fundamental cause of death for young people of age group (15-19) years due to immaturity and nonawareness of traffic laws. Accidents are projected to be the 5th leading cause of death for all age groups globally by the year 2030 [5]. A total 1 % to 3 % of Gross National Product (GNP) is lost globally, particularly in low and middle-income countries, approximating to 500B$. About 90% of total Road Traffic Accident (RTA) leads to causalities which mostly occur in middle and low-income countries. Accidental deaths have been decline by 30% in developed countries due to awareness and implication of traffic laws [5].

Themagnitudesofhigh-riskroadaccidentsaregreaterinmiddleandlow-incomecountries [4]. World Health Organization (WHO) published a special report about road accident in Pakistan which described that 27,871 causalities occurred in the year 2019 and the death rate was computed as 15.42 per 100,000 of population [4]. Pakistan occupies number 104 in accident hazards in the

world [4]. In Pakistan, it is estimated that around 40000 people die in accidents every year, and many other face serious injuries [6]. According to Rescue 1122 department, two-thirds of people driving on roads, die every year due to road traffic crashes RTCs in major and minor road accidents. According to recent survey reports, around 15-17 per 1000 persons die per year in Pakistan [7]. A researcher revealed that most of the accidental injuries were recorded to the age group ranging between 16 and 30 years [8].

Accordingto 2019 Statistics Report, 443 peoplelosttheirlives, 54,240 peoplewereinjured and 53,979 road accidents occurred in Lahore[9]. Reasons behindmost ofaccidents werecareless driving, over-speeding and nonawareness of traffic laws. Actual facts regarding accidents differ from rescue 1122 reports because most of victims hide their identity from media [9]. Mostly lower class and backward localities are observed under accidents which result to indulge many families further into poverty by the loss of their bread and butter[10].

The main objective of this study was to analyze the major causes of increasing number of accidents reported each day in the study site. It also aim at investigating the reasons behind these accidents and to suggest appropriate solutions for preventions from these unpleasant events.

Material and Methods

Investigation site

This research was carried out in the Lahore's two major towns, Data Ganj Bakhsh town and Iqbal town. Data Ganj Bakhsh is situated in the center of Lahore. This town is spatially located at 31°34' N latitude & 74°18' E longitude. Iqbal town is a residential/commercial area of Lahore, situated in the south west of Lahore region with spatial location 31°30'N latitude and 75°17'E longitude.

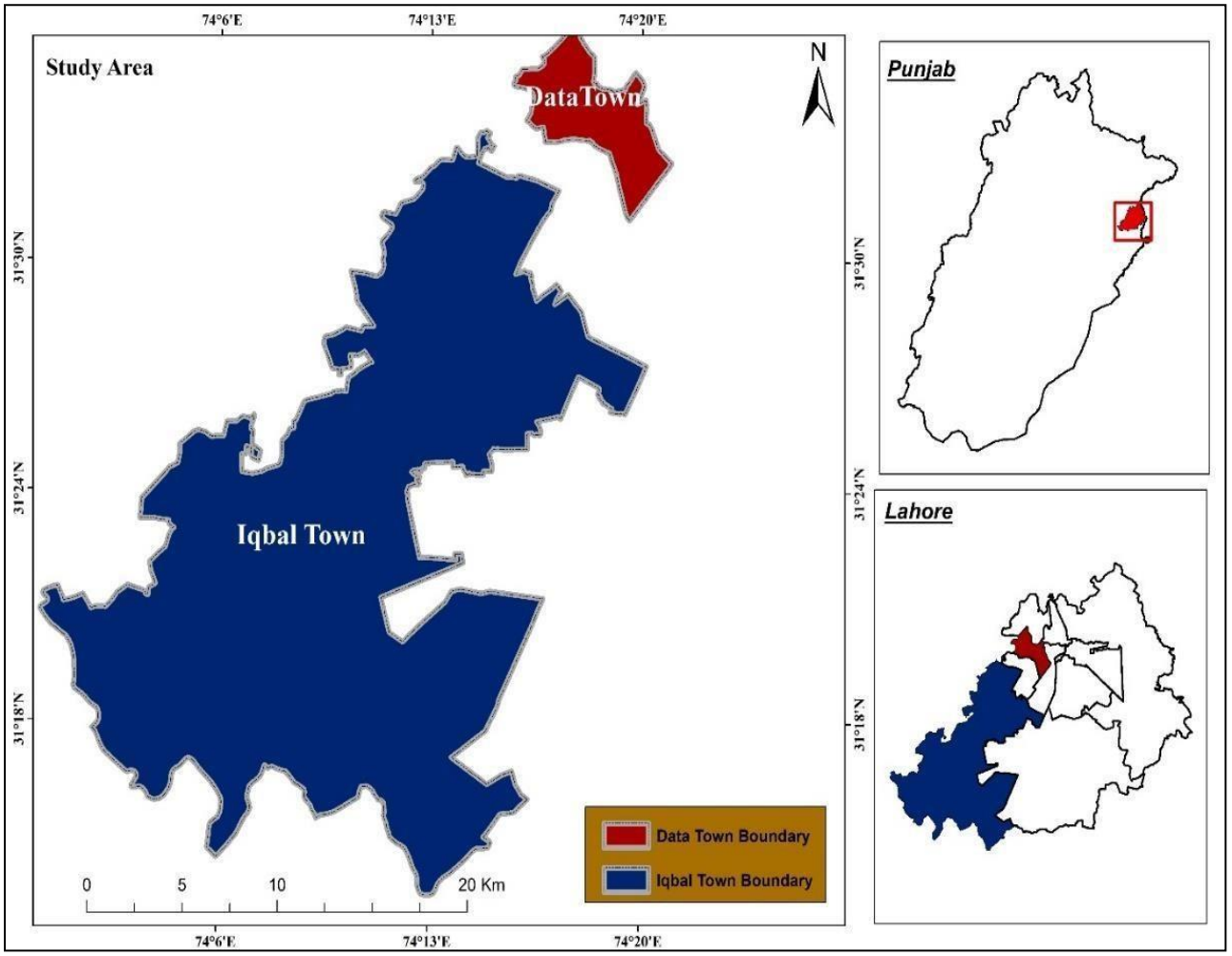

Figure 1: Study Area, Data Ganj Bakhsh & Iqbal Town

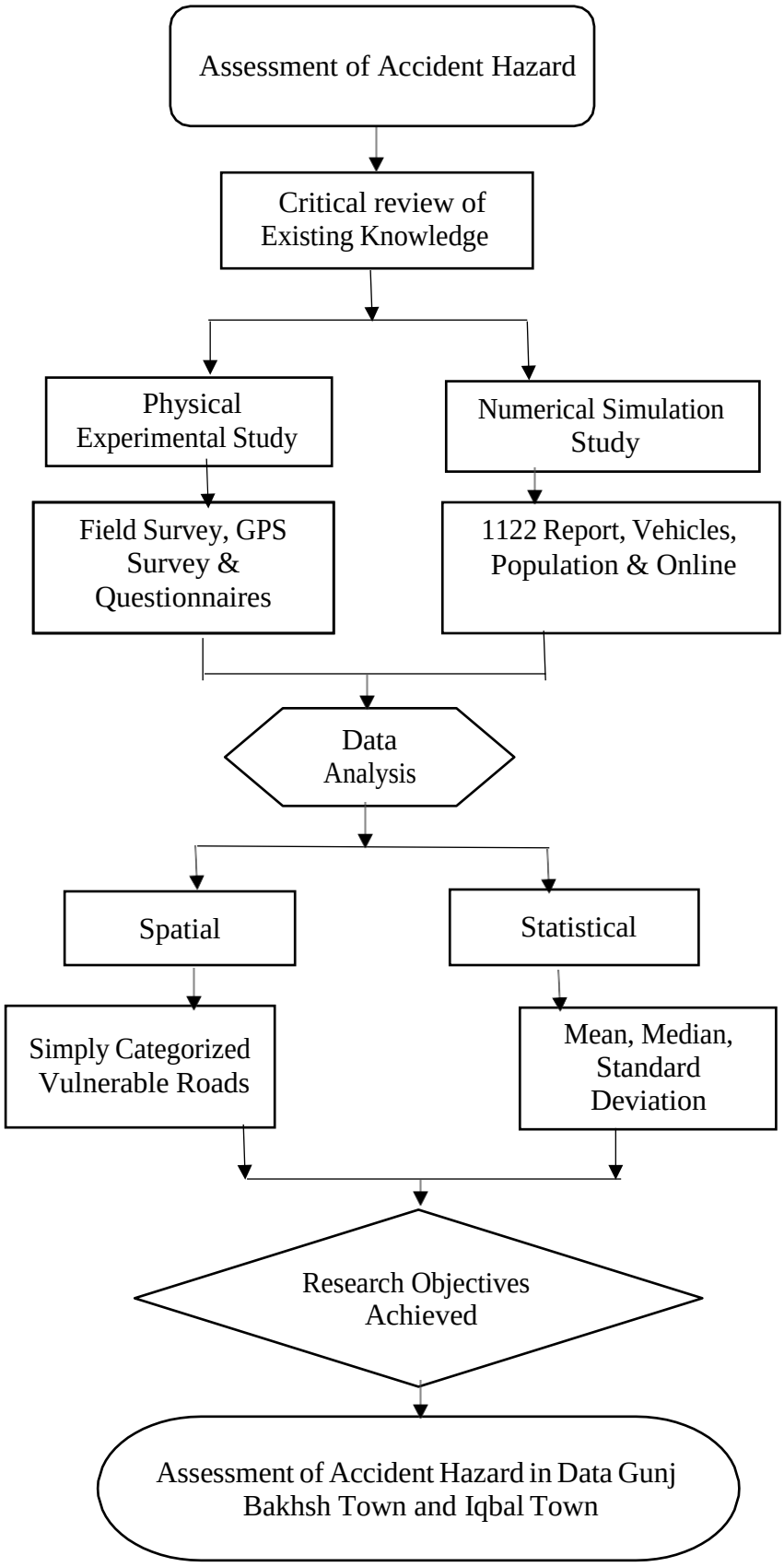

Figure 2: Flow of Methodology

In this study, the primary source of data was questionnaire-based field survey conducted within the study site. The secondary source of data was number of major and minor accidents reported in various hospitals and police stations from 2015 to 2019. Data of vehicle registration

was obtained from excise and taxation office. In data analysis, multiscale vulnerability was conducted of accidents in Data Ganj Bakhsh and Iqbal Town.

Results and Discussion.

The roads vulnerable to accidents were mapped by distinguishing their categories in Figure 3.

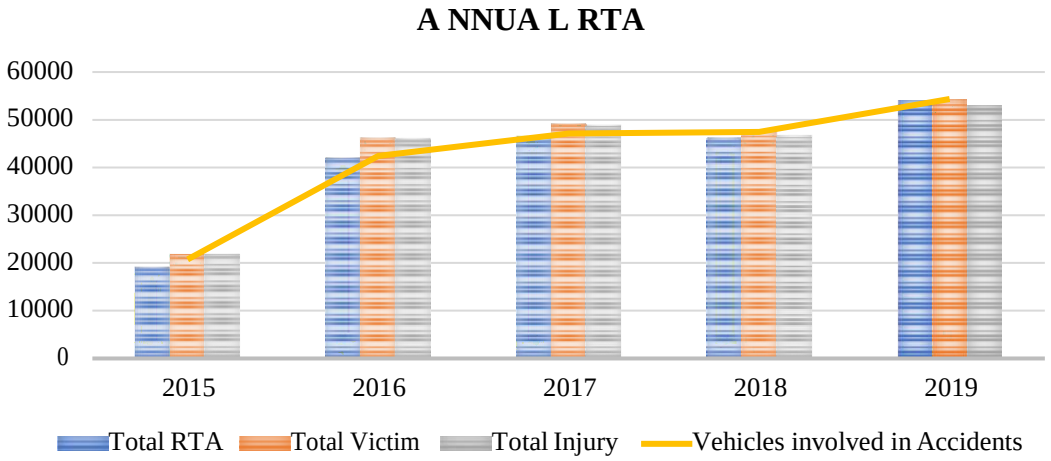

Figure 3: Yearly growth of Road Traffic Accidents (2015-2019)
source: Rescue 1122 control office

Figure 3 shows that the highest number of accidents occurred in 2019 while lowest were observed in 2015. It means that the accidents were increased with respect to space and time. In 2019, there were 53,979 number of the accidents, 54,240 number of victims, 52,856 number of injuries and 54,345 vehicles involved in accidents. While in 2015, there were 19,073 number of accidents, 21,794 number of victims, 21,719 number of injuries and 20,721 number of vehicles involved in accidents. The trend of yearly increase in road traffic accidents within last five years was observed 3 time more in 2019 as compare to 2015. In 2015, Rescue 1122 department was with lack of equipment, technology, ambulances and skilled workers that's why the number of cases was also limited**.**

Table 1. Annual increase in Road Traffic Accidents (RTA)

Yearly RTA	2015	2016	2017	2018	2019
Total RTA	19073	41811	46268	46060	53979
Total Victim	21794	46014	49025	47234	54240
Total Injury	21719	45789	48642	46394	52856
Vehicles involved in Accidents	20721	42410	47123	47423	54345

Data source: Rescue 1122 control office

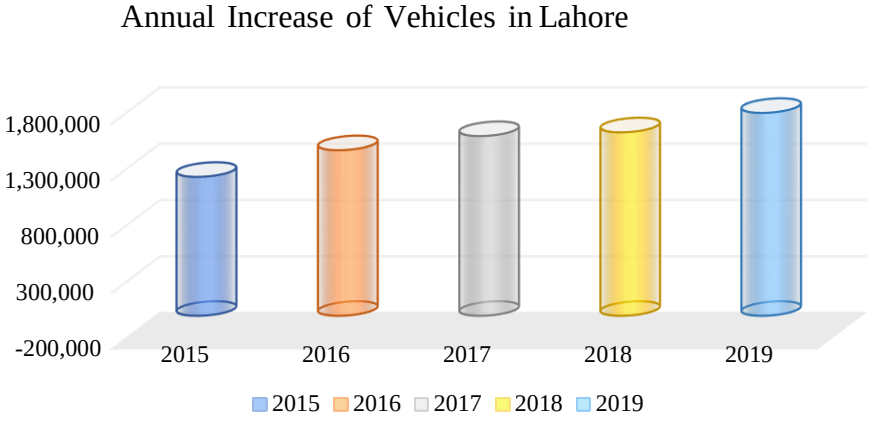

Figure4: Yearlyincreaseofvehiclesin Lahore(*Source: Excise& Taxation Officeof Punjab)*

Figure 4 shows that 1.83 million vehicles were registered in 2019 comparison to 1.23 million in 2015. The percentage of increase in vehicle's registration was about 14.81% within 5 years from 2014 to 2019. It may be dramatic increase in the vehicles due to bank financing and rapid growth rate of population in Lahore metropolitan. This vehicle's population was mainly increased by migrants of rural areas and the increase in population is directly linked with transportation facilities.

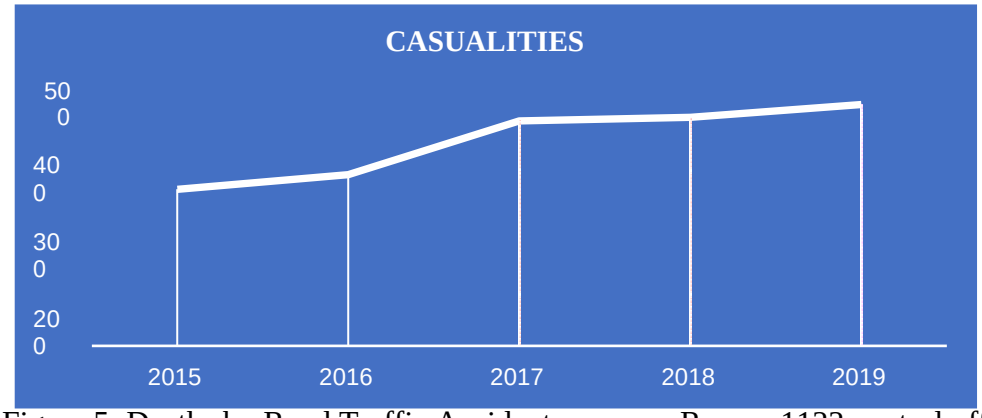

Figure 5: Deaths by Road Traffic Accidents, source: Rescue 1122 control office

Figure 5 shows a comparison of deaths occurred in 2015 and 2019. In 2015, there were 308 people died in road accidents as compared to 478 in 2019. It was about 32% increase to deaths in comparison to previous years.

Table. 2 Total Deaths in Road Traffic Accidents (2015-2019)

Years	2015		2016		2017		2018		2019	
Dead	308	7%	337	15%	443	22%	450	24%	478	32%

Data source: Rescue 1122 control office

Causes and Hotspot Areas of Accident Hazards

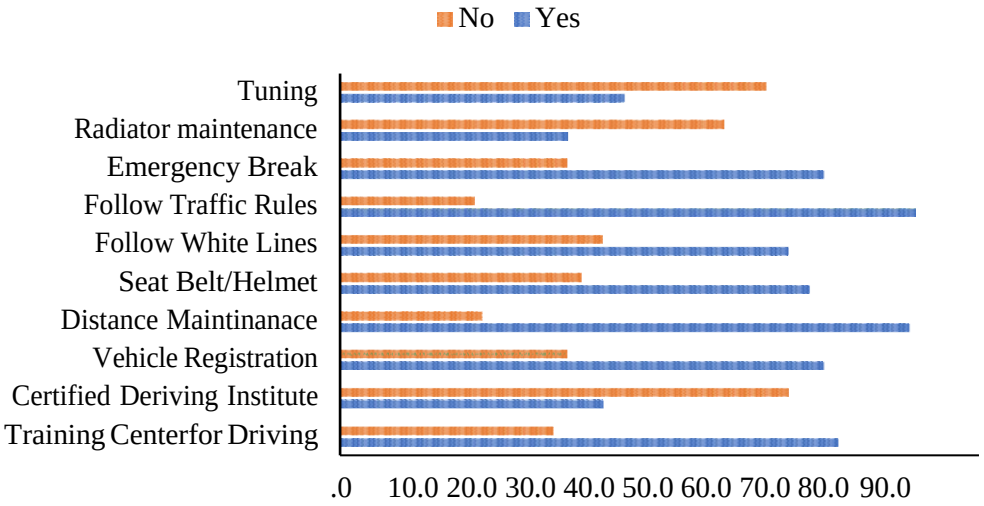

Figure 6: Awareness about various traffic related issues

Questionnaire results are drawn in Figure 6, which is showing that 31% of respondents wereawareofallmattersrelatedtovehicle'smaintenance.About29%ofrespondentswerefamiliar about tuning, 23% were aware of the radiator's maintenance and only 7% knew about the maintenance of smoky vehicles.

About 81% of respondents areawareoftraffic rules andregulations. Whereas the rest 19% of respondents were involved in signal breaking and various types of other violations.

About 70% respondents were trained from various training centers before getting driving license. On theotherhand, rest 30% nevervisitedany institution duetonon-availability oftraining institutes and claimed that they know everything.

About 63% of respondents got driving license without any test from a recognized institution. They seem to use links or unfair means to get a license which was quite alarming situation. Only 37% of respondents were found properly certified from institutions. About 68% vehicles were registered properly on owner's names and rest 32% of respondents did not bother to transfer vehicles in their names properly. They even did not carry their documents with them.

The awareness of maintaining a safe distance is important in driving. About 80% respondents claimed that they maintain a safe distance while driving and they know about the severity and prefer to maintain distance in order to avoid blocking/accident. Whereas, the rest 20% respondents were unaware of this kind of safety measures.

About 66% of respondents claimed that they were familiar with the use of helmet/seat belts. They knew that such negligence results in major accidents. Whereas, the rest 34% of the respondents were not familiar with wearing of helmet/seat belts and they never considered it compulsory.

Awareness of White Road Lines

About 63% of respondents claimed that they follow white lines and broken lines during driving. They had proper knowledge about lanes and variations in speed according to lane. They knew about the importance of lane in smooth driving which leads to eliminate accidents. The people who did not follow these lines were 37%. They claimed that they never use or follow paved lines and drive in a zigzag manner without following any rules.

Awareness About Emergency Break

About 68% of respondents claimed that they know how to stop their vehicle in an emergencysituation. Theywereawareofcontrollingtheirvehiclesin orderto prevent furtherloss. Whereas, the rest 32% of respondents claimed that they cannot handle their vehicles and are not able to stop in any kind of emergency.

Major Roads Vulnerable to Accidents

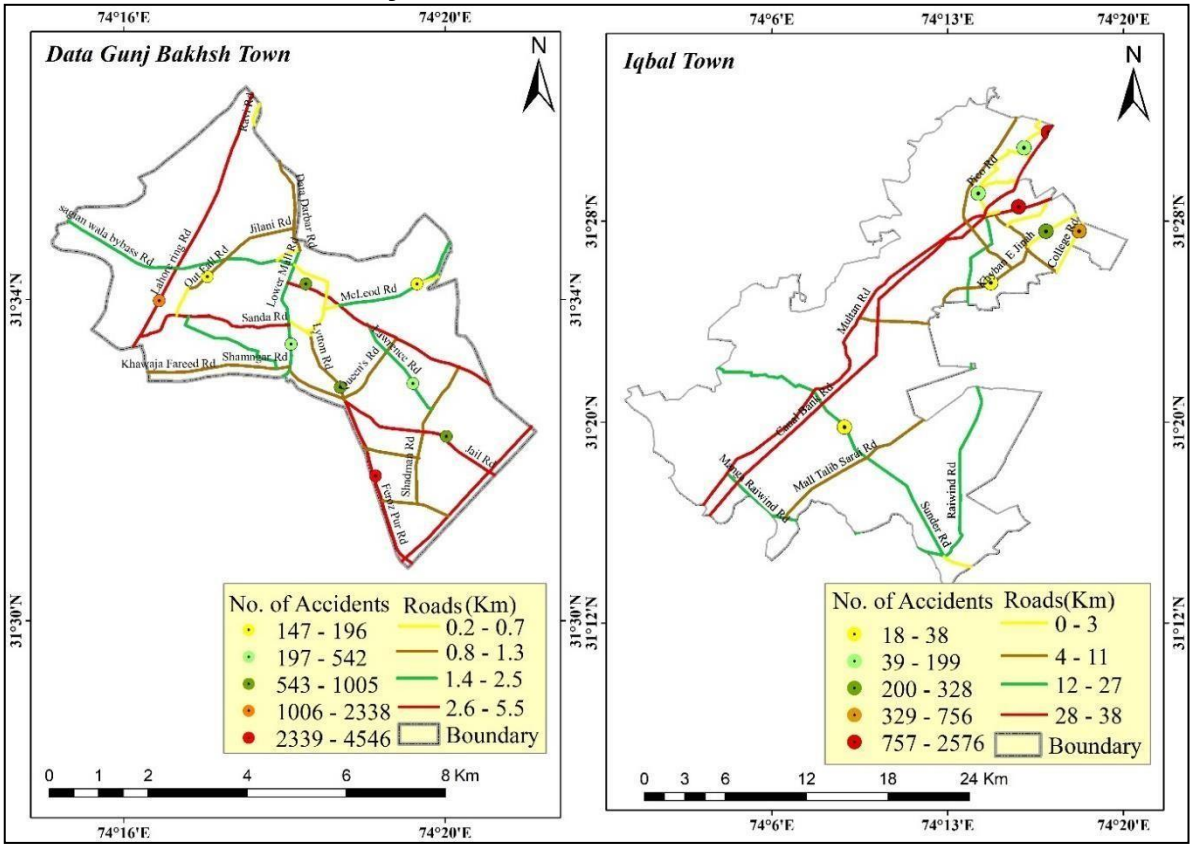

Figure 7: Vulnerable zone along major roads Data Gunj Bakhsh Town and Iqbal Town

Figure 7 is showing the spatial distribution of road network in the study site. The roads were categories on the basis of road length/width in kilometer/meters respectively. As per length, some roads were called major and some were minor roads. The major roads were observed with

large number of accidents in comparison to minor roads as shown in Figure 7. The main reason of increasing number of accidents was mainly carelessness of individuals. People show immature behaviour while driving by competing their buddies on major roads and try to leave them behind while chasing each other. The overall situation results in over speeding which leads to sever accidents. About 80% people have proper awareness of traffic laws but they violate and the law enforcement agencies seems to get fail for imposition of these rules to residents.

Conclusion.

This study reveal that traffic accidents have been increased in most populated areas of Lahore due to increase in population. The situation is getting drastic day by day but it is not due to capability/capacity of road infrastructure or unawareness of people, but a lack of controlling/ law enforcement was observed. Intentional violations of traffic laws by people occur but law enforcementagenciesseemtobehelplessforimposingtrafficlaws. Governmentneedtointroduce strong technical/technological equipment on roads to avoid violations of traffic laws. Challan system must be monitored and license cancellation must be imposed to culprits.

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Conflict of interest. Authors have no conflict of interest for publishing this manuscript in IJIST.

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