Optimum Use of Existing Resources for Urban Transport Planning: A Smart Public Transport Model from Pakistan

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Abstract
Urban transport systems in low income countries are marked by fragmented infrastructure, poorly regulated traffic and rising congestion. They are also paradoxically rich in underutilized public assets. This article examines a novel model developed in Islamabad, Pakistan. It strategically repurposes existing public resources such as institutional buses, state owned fleets, human capital and Safe City surveillance infrastructure to design an integrated, smart public transport system without the burden of new large scale investments. This study investigates how system inefficiencies are perpetuated and how public transport can be reimagined as a socially inclusive, environmentally sustainable and economically feasible public good. The research utilizes mixed methods design including ethnographic fieldwork, stakeholder interviews, route density analysis and carbon emissions modeling. The findings demonstrate that through optimal reallocation and digital augmentation of existing resources, public transportation in South Asian cities can become not only viable but also transformative. This work contributes to both urban sociology and transport policy by offering an empirically grounded, replicable framework for smart urban mobility in the Global South.

Keywords: Urban transport planning; resource optimization; public-private partnerships; sustainable development; road safety.

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INTRODUCTION

This paper argues that a sociologically informed, resource-optimization approach to transport planning offers a powerful alternative to capital intensive mega infrastructure projects. Most conventional models in South Asia seek expansion of more roads, more flyovers and more concrete. However, what if the solution lies in making better use of what already exists?

Islamabad, the capital of Pakistan has experienced a drastic change in population reaching nearly 2.3 million residents according to the 2023 census. The vehicular population on roads has increased much faster than the supporting road infrastructure and economy. The number of registered vehicles rose to 9.6% by 2018 (the total number reached 23,588,263) as per Excise Department of Islamabad [1]. The Federal Excise and Taxation Department registered 72,432 private vehicles in Islamabad from July 2022 to February 2023. Out of these, 40,726 were motorcycles and utility vehicles. During the same period, 1377 vehicles in the government vehicles category were registered (which include only 12 buses). The statistics show a significant increase in private vehicle ownership, which has increased congestion and crashes on the roads [2].

The rise in private vehicle ownership has dramatically increased metropolitan pollution levels as well [3]. The pollution from these vehicles and industrial activities significantly degraded the air quality in the city. The prediction is that the demand for commuters' travel will increase significantly. Smart public transport plays a significant role in urban transportation as it reduces traffic congestion, noise and air pollution [4].

The development of the Metro Bus system in Islamabad, the rapid bus transit system mainly aims to accommodate the demand for public transport in Islamabad [5]. The system now includes multiple lines: orange, green and blue, and electric vehicles running on roads to enhance sustainability. However, despite this advancement in the transport system, inefficiencies in traveling time, schedules and route planning are causing severe issues in integration for daily commuters and hinder effective system integration [3].

Moreover, the broader public transport modes remain fragmented, as are the informal and paratransit modes, including high occupancy buses, taxis and wagon/minibuses that operate independently without coordination with the metro transport system. This disconnection severely impacts commuter convenience and network efficiency. There is an urgent need to develop a door to door, synchronized, innovative public transport system that needs a comprehensive survey and planning [6]. An innovative, connected approach is significant in linking the gaps between different modes and ensuring seamless urban mobility for Islamabad's residents.

According to United Nation United Nations[7] more than half of the country's population will be living in urban areas by 2050. As the cities expand, so do the cars, congestion, pollution and fatalities. Islamabad, a planned city, is now facing what unplanned cities face regarding traffic chaos, vehicular density and social exclusion in mobility. Oddly enough, amidst this urban disorder lies a curious abundance: idle buses, fragmented transport data, government owned fleets used for limited hours and digital surveillance infrastructure that is only partially deployed for traffic management [8].

Drawing on the Grand Challenge Fund (GCF) project titled *Optimum Use of Existing Resources: A Prototype Model on Road Safety*, conducted at Quaid-i-Azam University Islamabad, this paper examines how existing vehicles, drivers, surveillance systems and institutional capacity can be reorganized into a smart, inclusive and sustainable transport model. The project's empirical base includes traffic density mapping, interviews with transport authorities, observational data from Islamabad and Rawalpindi and carbon emission calculations.

From a sociological perspective, this approach aligns with structural functionalism [9], where each subsystem like licensing, traffic management, vehicle use and surveillance should ideally function in equilibrium. However, in Pakistan, these subsystems operate in silos, often duplicating or underutilizing resources. The project thus seeks to create what Luhmann[10] might describe as systemic coupling: integration across functional domains using digital, institutional and behavioral mechanisms.

In the field of urban sociology, transport is not just about movement. It is about access, inclusion, safety and equality. Transport systems, when poorly designed, reinforce class divisions, gender vulnerabilities and spatial exclusion. As Cervero[11] noted, informal transport often fills the gap where the state withdraws, but without regulation, it

adds to the chaos. Pakistan's urban transport landscape that splits between elite car owners and struggling public users, exemplifies this dysfunction. Therefore, this paper address key questions: Can smart urban transport be built not with billions in funding, but with intelligent reallocation of what is already available? And can such a model advance not only efficiency, but also social justice and environmental sustainability?

The following sections present a review of existing literature, followed by the methodology of the GCF-744 project, analysis of results and a concluding reflection on the implications for theory and practice.

LITERATURE REVIEW

An efficient public transport system not only fulfils the mobility needs of people but also helps to reduce the negative externalities such as road accidents and congestion indirectly by reducing private vehicles. Numerous studies have explored the relationship between road accidents and public transportation. For example, Bauernschuster, et al.[12] evaluated the short term impact of one day strikes of public transit on road accidents, traffic, pollution and health outcomes in the cities of Germany. The study reported that due to the strikes, the accidents and injuries were significantly increased by 14% and 20%, respectively. Another study conducted by Lichtman-Sadot[13] on the effect of late night driving on road accidents in Israeli cities from 2003 to 2015. The findings showed that the introduction of late night buses was significantly associated with a 37% reduction in road accidents by young drivers, while road injuries were reduced by 24%. The effect may be attributed to reducing reckless driving and drink driving, as well as decreasing the number of private vehicles and traffic on the road.

In a broader context, Moeinaddini, et al.[14] examined the relationship between the number of road related deaths and various indicators related to mode choices for work travel, including cycling, walking, motorcycle and public transport. Researchers used more than 1,000 European cities for the analysis. The study indicated that work journeys made by motorcycle were associated with more road deaths, whereas journeys by other modes, such as public transport, were related to fewer road deaths. Despite these insights, urban transport planning in the Global South has been preoccupied with infrastructure expansion rather than system efficiency. It reflects a development paradigm that prioritizes material growth over institutional optimization [15]. However, increasingly, scholars and planners are turning toward resource-sensitive models in response to both fiscal and ecological constraints [16,17].

Building on this, a sociological perspective underscores that urban mobility is not merely technical. Patterns of social inequality, institutional inertia and structural fragmentation deeply embedded in it. Urbanization in progressing countries has led to more mobility and demand for public transport within cities [18]. Within the framework, the approach to urban transportation becomes a key element of social integration. Drawing on Bourdieu[19] concept of habitus and capital, mobility can be seen as both a material and symbolic resource. Those with access to cars, gated roads or private chauffeurs enjoy spatial capital, whereas others navigate the risks of congestion, pollution and road violence [20]. People with higher incomes have access to private transport, whereas people with low income do not have an efficient transportation system, which minimizes access to jobs, healthcare, and education [21,22].

Moreover, Cervero[11] has shown that informal transport systems (rickshaws, minibuses, vans) emerge in spaces where state planning is absent or insufficient. While they fill a critical gap, their integration into formal systems remains rare, leading to regulatory and safety challenges. In Nigeria, Shittu[23] emphasized the potential of quasi formal management of paratransit, arguing for smoother coexistence rather than eradication.

The World Bank's review [16] warned that transport infrastructure in low income countries often absorbs a disproportionate share of the development budget, without significant improvements in access or equity. Similarly, Nieuwenhuijsen[24] points to transport related emissions as a growing contributor to urban health crises, demanding low cost, high impact strategies. Pollutants like volatile organic compounds (VOC), Nitrogen Oxide (NOx), CO and CO_2. VOC and NOx from vehicular emission make smog that causes respiratory diseases whereas CO is a poisonous gas and CO_2 is a major greenhouse causing gas [25].

Smart technologies have shown promising potential in improving urban mobility. Al-Turjman, and Malekloo[26] explored how Internet of Things (IoT) based innovative parking solutions can reduce search time, lower emissions and manage congestion. Gohar, et al.[27] demonstrated the application of big data analytics for transport behavior modeling in Pakistan's urban settings. However, few studies examine how these technologies can work with pre

existing infrastructure rather than requiring entirely new investments. A smart parking system is a technology intensive system designed to enhance parking efficiency and accessibility. It utilizes cameras, sensors and other technologies to monitor and manage parking spaces. Smart parking systems are used in a variety of settings, including street parking and large scale parking lots. Smart parking is a system that uses sensors, cameras and other devices to monitor parking spaces, thereby raising accessibility and efficiency through the use of technology. The smart parking system offers drivers easy access to real time parking availability information, making it more attractive due to its advantages. Through the digital system, drivers can quickly access the correct information via smartphone applications. This feature reduces traffic congestion and allows car drivers to discover an available parking space quickly.

There is a striking absence of empirical work on institutional reuse of existing buses, drivers and surveillance that cameras could be repurposed for public benefit. The GCF-744 project addresses this vacuum directly. With over 1400 government owned buses/ vehicles lying idle during off peak hours in Islamabad's institutions, the project demonstrates the viability of their integration into a smart, affordable and sustainable urban transport model.

Moreover, despite the increasing recognition of transport's role in public health, there is little intersectional work linking road safety, carbon emissions and urban inequality in the Pakistani context. Zaman[28] argues that most drivers in Pakistan either drive without licenses or with fake ones. Still enforcement remains weak. This suggests a gap in both infrastructure and institutional trust which is a sociological problem more than a technical one.

Therefore, the present study builds on interdisciplinary insights. It has focused urban studies, environmental sociology, behavioral economics and institutional theory to propose a prototype that is not only technically sound but socially responsive. This kind of literature informed intervention, grounded in real world constraints and empirical data, remains rare in the South Asian region.

METHODOLOGY

The study draws on a mixed-methods research [29] design rooted in applied sociology and urban systems theory. Conducted under the Higher Education Commission (HEC) of Pakistan's Grand Challenge Fund (GCF-744), the project was implemented in Islamabad and Rawalpindi between 2022 and 2025. Methodologically, it integrates both quantitative measurements and qualitative insights to capture the operational, environmental and behavioral dimensions of urban transport.

Ethnographic Observations and Field Visits

Teams conducted structured and unstructured observations across major routes and intersections in Islamabad, focusing on public transport flow, usage patterns, informal paratransit behavior and road user compliance. Particular attention was paid to congestion points, redundant stops and pedestrian risk zones. These observations informed the spatial and behavioral mapping of the transport system.

Stakeholder Interviews

In-depth semi structured interviews [30] were held with key stakeholders, including:

- Officials from the Islamabad Transport Authority (ITA) and Capital Development Authority (CDA)
- Officers from Islamabad Traffic Police (ITP) and Safe City Project
- Representatives from public educational institutions owning transport fleets
- Commuters and drivers (HTV, LTV, Metrobus)

Interview themes covered licensing practices, perceptions of traffic control, readiness for digital integration, resistance to reform and feasibility of public private partnership.

Transport Route Mapping and Vehicle Density Analysis

Data was collected on existing routes, peak hour density and modal distribution using manual counts, mobile telemetry and telecom data. Particular focus was placed on identifying underutilized corridors and vehicle bottlenecks. GIS tools were employed to visualize saturation levels and determine feasible routes for smart transport intervention.

Emissions Monitoring and CO2 Modeling
CO_2 emissions were modeled using the Passenger Car Unit (PCU) method. Vehicle types, volume, average speed and fuel consumption data were compiled from field observations and secondary sources (e.g., NHMP, Safe City). Comparative emissions scenarios were modeled for:

- Current baseline (private vehicle dominance)
- Optimized scenario with institutional buses integrated via smart scheduling

Institutional Resource Inventory
A comprehensive survey was conducted of all public educational institutions in Islamabad to inventory transport fleets, staffing and maintenance capacity. The data revealed that 265 buses remained underutilized for large parts of the day. These buses, along with existing trained drivers and mechanics, were mapped for potential reallocation under the proposed model.

Behavioral Experiments and Survey
A quantitative KAP (Knowledge, Attitude, Practice) survey was administered to over 3400 commuters. Additionally, a behavioral experiment was designed using randomized control methods to test the impact of BCC (Behavior Change Communication) messages on helmet usage and lane compliance among motorcyclists. Survey and experimental data were analyzed using Statistical Package for Social Sciences (SPSS) and NVivo.

This methodological strategy allowed triangulation between system level diagnostics, human behavior and institutional structure. It is reflecting a comprehensive sociological inquiry into transport planning. The results of this multi-layered investigation are presented in the following section.

RESULTS

The project findings demonstrate that the optimum use of existing resources in urban transport planning is not only theoretically sound but also operationally feasible in the case of Islamabad. The results are categorized into five core outcomes. They are transport integration, emissions reduction, behavioral response, institutional collaboration and policy influence.

Transport System Integration and Accessibility
Field data confirmed that more than 1400 vehicles from public institutions remained idle during most of the day, creating a significant opportunity for secondary deployment. Using optimized route design supported by GIS and vehicle telemetry, the proposed smart transport model could cover approximately 90 kilometers across Islamabad with only 400 buses while ensuring a maximum 500 meter walkable radius for commuters in residential and institutional zones. This intervention alone could reduce dependency on informal modes by up to 40% in pilot sectors.

An innovative public transport system requires integrated bus stops and shelters with services such as seating and information regarding bus timings and schedules. The Capital Development Authority is responsible for overseeing the management of this system. This public transport can cut down vehicular emissions that are affecting the atmosphere. This paper argued that the hardware and software technologies required for roadside bus infrastructure. In understanding commuters' choices, psychological factors are significant in terms of designs that promote sustainable infrastructure to commuters.

Emissions and Environmental Impact
Carbon emissions modeling revealed that the current modal share of private cars and motorcycles contributes disproportionately to air pollution in Islamabad. Using the PCU based model, the integration of existing institutional buses into a smart network resulted in an estimated 18–22% reduction in daily vehicular CO_2 emissions. In peak congestion zones (e.g., Faizabad Interchange, G-9 Markaz), the localized emissions reduction could reach up to 30% due to fewer private vehicles. Air pollution concentrates at pedestrian breathing height. While drivers enjoy some filtration through vehicle ventilation systems, pedestrians inhale undiluted exhaust. PM2.5 levels along major roads routinely exceed 200 $\mu g/m^3$ which is eight times WHO guidelines. A pedestrian commuting one hour daily inhales pollution equivalent to smoking several cigarettes, creating long term health impacts beyond immediate crash risks [31].

Behavior Change and Road Safety Awareness

The most challenging issues in Pakistan are driving behavior and unsafe practices. The major contributors to road traffic accidents are over speeding, wrong way driving, lane changing without indicators, absence of helmet and seat belt use, distracted driving (use of mobile and hands free) and driving under the influence of drugs and alcohol. Another crisis is that Pakistan has outdated road traffic laws that are unable to create deterrence among road users. The literature emphasizes that law enforcement for road violations has a weak impact, failing to generate fear among road users, who consequently violate traffic rules and regulations with impunity. The legislators increase the fines. However, they still have a low impact on road safety [32]. Similarly, driver behavior in Pakistan reflects both cultural norms and systemic failures in education and enforcement. Speeding, documented in 70% of serious crashes on expanded roads, stems partly from cultural values prioritizing speed and efficiency over safety [33].

Findings from a commuter survey for this study indicated that 72% of respondents were willing to switch to public transport if reliability, frequency and safety were assured. The randomized behavior changes experiments on helmet usage showed a statistically significant increase in compliance (from 18% to 43%) among exposed groups. Lane discipline improved modestly but remained hindered by infrastructural gaps.

Furthermore, 48% of male respondents under 30 years admitted to either never acquiring a valid driver's license or obtaining it informally. According to the report by Zaman, and Sabir[34], only 1.8% of drivers had taken lessons from the traffic police for driving in the metropolitan cities of Pakistan. In contrast, the majority of drivers learned driving informally from friends and family, thus creating unawareness about traffic laws and a greater likelihood of road crashes. These behavioral trends underscore the need for a centralized innovative licensing system and targeted road safety education campaigns. Road safety campaign slogans are fundamental in creating awareness regarding safe vehicles, roads, and, ultimately, safe lives and fostering responsible driving behavior among road users. Road safety education encompasses three key characteristics: firstly, it enhances understanding and knowledge of road traffic; secondly, it develops road safety skills through targeted training (learning to drive properly) in schools; and thirdly, it promotes an assertive attitude and behavior through road safety awareness [35].

Institutional Coordination and Resource Mobilization

Interviews with transport and police officials revealed a critical governance gap. Each department held partial datasets, leading to fragmentation. The research team's engagement led to preliminary agreements between the Islamabad Transport Authority (ITA), Safe City Islamabad and public universities to share resources and align goals. This inter institutional cooperation was achieved without additional budget allocation.

Moreover, the project created a replicable framework where public universities became stakeholders in urban mobility rather than passive consumers. This shift in institutional identity is significant from a sociological standpoint. It redefines the role of academia as a civic partner in urban governance.

Policy Engagement and Legislative Gaps

The legislative review and stakeholder lobbying efforts highlighted a major policy vacuum. Despite the alarming road fatality rates of over 27,000 deaths in 2018 alone [20], there have been no criminal convictions for traffic fatalities in over seven decades. According to the study of Aslam, et al.[3] the National Highway Safety Ordinance (2000) focuses on safety measures on Pakistan's national highways; the Provincial Motor Vehicle Ordinance 1969 and Motor Vehicle Rules 1965 govern motor vehicle registration, operation, and safety standards at the provincial and national levels. These three legislative laws play a substantial role in road safety and traffic management. The Provincial Motor Vehicles Ordinance (MVO) 1965 and Motor Vehicle Rules (1969) had no criminal provisions for driving offenses that cause deaths. It prescribed certain driving behaviors such as section 94 elaborates the duties of drivers in case of accidents, injury or financial loss whereas section 108 is also the sub-section of 94, section 99 indicated reckless and negligent driving behaviors.

Pakistan appears to face challenges, including ineffective enforcement mechanisms and unclear responsibilities for road safety management. Addressing these issues require concerted efforts from policymakers, law enforcement agencies and other stakeholders to prioritize road safety and implement effective measures to reduce road crashes and fatalities. The gaps in coordination among legislators and policymakers can be addressed through the development

of a stronger legislative framework where actions align with planned policies. Pakistan needs to create and involve multiple departments or ministries to cooperate and minimize the blame game so the enforcement of road offenses could improve and strengthen Pakistan's legal procedure and justice system for road victims. In implementing legislative frameworks, it is necessary to introduce training programs for the institutional actors in implementation to miscalculate loopholes in laws due to state actors [3].

Being a part of the project's, the lobbying component, in collaboration with the National Institute for Regional Studies (NIRS), resulted in a draft policy brief recommending updates in licensing laws, lane enforcement and vehicle inspection systems. Public discourse on road safety also increased through media outreach, seminars and university led awareness drives. The engagement model used in this project (combining empirical research with public mobilization) demonstrated a strong potential to bridge the divide between academic research and policy implementation.

Taken together, these findings underscore that road safety, environmental sustainability and social inclusion are not isolated outcomes. When urban transport is reimagined through a sociological lens and existing resources are intelligently repurposed, we arrive at a system that not only moves people but empowers them.

DISCUSSION AND CONCLUSION

This study reveals that urban transport challenges in the Global South which is often perceived as crises of infrastructure, are in many respects, crises of imagination, coordination and institutional inertia. The case of Islamabad, through the lens of the GCF-744 project, shows that meaningful reform does not necessarily require vast new investments. Rather, it demands the intelligent, coordinated and equitable repurposing of what is already available.

The project demonstrated that over 1400 idle vehicles owned by educational institutions, if systematically deployed and digitally managed, could alleviate major commuter gaps in Pakistan's capital. Likewise, carbon emissions (often treated as an intractable urban externality) can be measurably reduced through modal shifts grounded in public sector resource reuse. Equally compelling were the behavioral insights: citizens are not inherently resistant to public transport; they are resistant to dysfunction, delay and danger.

From a sociological standpoint, the project affirms that urban systems are not just technical assemblages but socially embedded fields, shaped by power, habitus and institutional norms. What this intervention achieved was not merely logistical. It activated dormant relationships between state bodies, academic institutions and civil society. It positioned public universities as co-producers of urban order. It reframed the commuter not as a passive subject of policy but as a participant in the reorganization of the city.

Moreover, the project disrupts the dominant paradigm of mega-infrastructure as the only route to modernization. Instead, it offers a counter logic rooted in sufficiency, interdependence and sustainability. By proposing a smart transport model that thrives on existing resources, this work makes a theoretical contribution to both urban sociology and development studies.

Finally, this project is a call to reorient urban governance around the principles of integration, transparency and empirical responsiveness. Road safety, environmental justice and equitable mobility should not be policy afterthoughts rather they must be foundational. If Pakistan and countries like it are to meet their Sustainable Development Goal (SDG) targets and improve quality of life in their cities, the optimum use of existing resources must become not just a strategy but a philosophy.

The following section offers targeted recommendations for institutional uptake, scaling and future scholarly engagement.

LIMITATIONS, FUTURE DIRECTIONS AND RECOMMENDATIONS

There are few limitations of the study as well. This study only focused on the Islamabad, Capital of Pakistan. There are other major cities in Pakistan as well including Karachi and Lahore which could be the part of research as

well. Moreover, this study focused on mixed methodology approach. Future similar studies can focus on qualitative methodology in similar studies. In the end, this study analyzed data by using Smart PLS. It is proposed to use AMOS or Smart PLS 4 for the quantitative section of the similar studies in future.

Based on the findings of this study, the following policy, institutional and research recommendations are proposed to advance the optimum use of existing resources for urban transport planning in Pakistan and comparable contexts:

Institutional Coordination and Governance

a) Establish interdepartmental transport planning councils at the municipal level involving transport authorities, educational institutions, ICT Police, Safe City operations and local universities.
b) Mandate data-sharing protocols among institutions managing licensing, road safety, surveillance and public vehicle fleets.

Smart Public Transport Integration

a) Formalize the inclusion of idle institutional buses into the city's public transport fleet under the administration of the Islamabad Transport Authority (ITA).
b) Create dedicated lanes for these integrated buses, synchronized with existing BRT routes and equipped with signal prioritization sensors.
c) Develop a unified digital platform and commuter app for route planning, bus schedules, smart ticketing and public feedback mechanisms.

Environmental and Emissions Policy

a) Institutionalize vehicular emissions monitoring using the low-cost sensor networks proposed in the project.
b) Introduce congestion pricing or carbon disincentives for high-emission private vehicles, reinvesting revenue into smart public transport infrastructure.

Road Safety and Behavior Modification

a) Launch Behavior Change Communication (BCC) campaigns targeting helmet use, lane discipline and pedestrian safety, especially in collaboration with universities.
b) Implement school-based curriculum reform integrating road safety, urban citizenship and sustainable transport education.

Licensing Reform and Surveillance

a) Digitize and centralize the driving licensing system, linking biometric identity (NADRA) with road performance histories and penalty records.
b) Extend Safe City surveillance coverage to mid-tier intersections and link it with real-time analytics for behavior prediction and violation management.

Funding and Private Public Partnership (PPP) Models

a) Encourage Build-Operate-Transfer (BOT) models that integrate public institutions and private partners in route management, app development and bus maintenance.
b) Explore micro-financing schemes for informal operators (e.g., rickshaws, minibuses) to align with safety and emission standards.

Research and Replication

a) Conduct longitudinal studies in other metropolitan areas (e.g., Lahore, Peshawar, Karachi) to assess the replicability and scalability of the Islamabad model.
b) Encourage interdisciplinary doctoral and postdoctoral research on transport sociology, smart cities and governance innovation under South Asian conditions.

These recommendations should not be interpreted as technocratic checklists, but as sociologically informed proposals for system change. They recognize the embeddedness of urban mobility within institutional culture, political will and public participation. Only through coordinated, inclusive and empirically grounded efforts can we move toward an urban future where resources are not just used but optimized.

Theoretical and Managerial Implications

Present study offers theoretical and managerial implications. From the lens of theoretical implications, present study is among very few studies that have discussed urban development from the perspective of Islamabad and linked it with road safety of the citizens. From the perspective of managerial contribution, this study provides guidelines to the policy makers of the cities by which they can save lives of the citizens. The findings of the studies can be used by the researchers for their future studies as well.

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