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Critical Analysis of Parking Systems and Their Economic Impact in Tanzania

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ABSTRACT

In nearly all large urban places on earth, parking has become an expensive resource in recent years, and its restricted supply is the simultaneous cause of urban traffic congestion and air pollution. The typical method for obtaining a parking spot in Tanzania is manual, in which the motorist typically discovers a spot in the city or on the street as a result of his or her experience or good fortune. This method requires a significant amount of time and effort, and in a city with a high car density, it could potentially lead to a situation where the motorist fails to find any parking spaces, thereby consuming a significant amount of time and fuel. Based on the additional features they may offer, the Innovative Scalable Smart Parking System (ISSPS), a component of the Intelligent Transportation System (ITS), gives rise to various parking facilities. The ISSPS should be able to work with many parking facility-related aspects in addition to managing the internal operations of the parking facility. This study critically analysed the Smart Parking System (SPS) requirements and their economic impact in Tanzania by conducting a survey in three cities (Dar es Salaam, Mwanza, and Arusha). Purposive sampling methods were used to select the three cities due to their huge populations of motorists. Four hundred (400) respondents randomly selected from the three cities were involved using a structured questionnaire. The questionnaire was administered physically and online. Survey results prompted the conclusion that a secure, knowledgeable, effective, and dependable parking system is absolutely necessary for searching for vacant parking spaces, directing drivers to available spaces, negotiating parking rates, and managing parking spaces in an appropriate manner. The study reveals that inefficient parking systems contribute to significant economic losses through increased fuel consumption, increased time spending, increased air pollution, and negative impacts on urban mobility. The paper also discusses potential solutions and policy recommendations, including the adoption of modern parking technologies; improved urban planning; and enhanced regulatory measures to optimise parking management and alleviate congestion. This analysis underscores the need for a comprehensive reform of parking systems in Tanzania to support economic development, enhance urban mobility, and improve overall quality of life in rapidly growing cities.

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1.0 Introduction

With the exponential growth of population in capitals and the spatial-physical expansion of cities in Tanzania, the demand for vehicles is increasing. The high demand for personal cars is increasing, especially in developing countries, due to the lack of systematic public transportation systems. The high demand for personal vehicles has a major impact on the inter-urban transport network and parking places. Parking is one of the important parameters in the planning of a highway transportation system. According to a study by Baseri, *et al.,* (2012), a vehicle is used for a period of 400 hours during a year, while it stays in park mode for 95% of the year.

Nowadays, most office buildings and shopping malls have built underground parking and multilevel parking to overcome the increasing number of cars. However, drivers are still finding it difficult to find an available parking slot accurately and timely. The process of looking for a parking lot is time-consuming, confusing, and wastes fuel as well. This may cause, at some point in time, someone to miss or be late for an important event.

According to Faraji & Nozar (2019), usage of personal vehicles has had a substantial negative impact on public satisfaction and has resulted in a number of environmental issues, such as traffic, congestion, and fuel waste in urban areas. The search for a parking spot adds to time and fuel waste, unnecessary traffic, accidents, pollution of the environment, and decreased vehicle safety. Enabling parking users to access quick and accurate parking space information from any location at any time could greatly mitigate these difficulties. The National Development Vision 2025 enshrines the nation's socio-economic goals, and the URT (2016) highlights the critical role that ICT development, deployment, and exploitation play in the nation's economy and society.

Information Communication Technology (ICT) can therefore successfully eliminate Tanzania's present parking lots' traditional structures and lack of automated management.

In the populating cities and districts, finding parking spaces is becoming increasingly difficult as traffic increases. Drivers have to go back and forth desperately looking for parking spaces, wasting their valuable time and fuel consumption, with an increased likelihood of causing accidents.

The Intelligent Parking Service, a part of the Intelligent Transportation System (ITS), gives rise to different parking facilities on the basis of the new functions they provide. This service not only manages the internal operations of the parking facility, but it is also designed to work with different aspects related to the parking facility. The services that the intelligent parking system should provide are:

- Parking availability information, parking reservations, and advanced navigation services mobile electronic commerce, a continuously working gate system, and collecting the parking fee electronically.
- Effective security for the safety of cars.
- Strong functions for facilitating administrators and managers in the management of the parking facility.

Information related to the availability of unoccupied lots before the driver enters the facility is provided by the parking availability information system. An empty parking lot can be reserved by the driver through the parking reservation system. The continuous entry and exit system facilitates a driver by getting rid of time-consuming processes, such as getting a ticket, and the freedom to select any payment method. The in-facility navigation system is used for finding the vacant lot and then guiding the driver to that parking space. Currently, timely and accurate parking lot information is unavailable to parking users in most Tanzanian cities. The big challenge with existing parking lots in developing countries is the lack of automated management, the unavailability of current, timely, and accurate parking lot information, and their traditional structure. Several innovative solutions (Faraji and Nozar, 2019; Mohammad, 2018; Ram, 2022; Kumar, 2023; Azshwanth *et al.,* 2019; Budiani *et al.,* 2018) have been proposed globally

to solve parking information management problems. Nevertheless, these solutions have not considered Tanzanian culture and environment, and in most cases, they are costly and dependent on foreign technical support. Thus, it is imperative to conduct research on locally re-engineered systems. Several researchers have been working to improve parking systems in recent years, and they have proposed numerous approaches by putting the concept into practice. To improve the parking system, Haller R. (2024) developed an Internet of Things (IoT)-based smart parking system. IoT tools, Bluetooth Low Energy (BLE), and mobile application development with an interface for parking space booking are part of the system development. Without wasting time looking for parking, the driver can quickly identify a spot via the mobile app and reserve it. However, the system did not have a commercial component, such as a mode of payment after bookings. Izudheen *et al.* (2023) suggested the IoT-based parking module, which is located in the parking space on site. It assists vehicles in finding parking spaces in their current location by using a smartphone application. The system makes use of infrared sensors placed in each parking area, a Wi-Fi module that assists the circuit in providing internet connectivity, and a mobile application that helps drivers find available parking spaces. However, the study did not explain how online reservations or reservations made in advance of parking can be made from a distance, nor does it incorporate a payment method. The proposed smart autonomous vehicle parking (SAVP) system improves the current collaborative IoT-cloud platform. It looks into and uses block chain and fog computing technologies to build and maintain autonomous vehicle (AV) SP systems (Shahzad *et al.,* 2022). The system provides an interior and outdoor smart parking solution, primarily for AVs searching for available parking spaces. It uses an active RFID tag for identification of cars, which is an expensive solution for developing countries. Badr *et al.* (2020) proposed a privacy-preserving block chain-based smart parking system. In this endeavour, the government-run Key Distribution Centre (KDC) is in charge of producing cryptography for public parameters, assigning keys, and initialising the entire system, including parking lots and drivers' registration. Vehicle drivers use their cell phones to connect to the block chain network in order to obtain parking spots and provide reviews for the service. Parking lot service providers (PLs) post their offers on the block chain. In order to make bookings online, they also contact PLs. The system is complex and costly, and it is difficult for a normal user to use it. A smart car parking system model for urban areas study was conducted by Atiqur (2021). The system created in this study combines an LED fitted outside the vehicle parking doorway, a Raspberry Pi 4 with Wi-Fi capability, and an ultrasonic sensor. The personnel of the relevant power monitors parking spaces. Finding a free spot in the parking lot is accomplished efficiently using the system. To avoid wasting time that would otherwise be spent looking for parking spaces, the system does not, however, accommodate online parking reservations. Additionally, the system is missing the commercial element, specifically the payment method. The smart car parking system Using IoT proposed by Priya *et al.* (2023) creates a methodical parking system for customers using Honeywell sensors and controllers. Lamps are used to identify unoccupied car parking spaces, guiding users to an empty spot and removing the need for them to look for one. The central system can virtually store the occupied parking spaces on the cloud, directing approaching cars to available spaces. While the system assists drivers in finding available parking spaces, it does not support online reservations for reserved spots. Moreover, the payment method is not indicated by the system. The Smart Car Parking System project proposed by Joshi (2020) was developed as a useful method of locating open spots and controlling the volume of cars entering and leaving intricate multi-story parking facilities by utilising infrared sensors to identify a car and subsequently sending out feedback. The literature described shows that a lot of effort has been made globally to address the issue of parking. These solutions, however, are often expensive and reliant on outside technical assistance, and they have not taken developing

countries' cultures and environments into account. This study's critical analysis was conducted to identify the current parking setup and deficiencies as well as the needs for automated parking systems in Tanzania.

2.0 Methodology

The study collected primary data focused on the number of times people drive in the city, usage of car parking facilities and their availability, the time, distance, and fuel spent on searching for a parking slot, features to accommodate in a smart car parking system, and payment method. The data was gathered between August 2023 and September 2023 in three regions, namely Mwanza, Arusha, and Dar es Salaam. The three cities were chosen because of the large number of automobiles and the large population, and they have been mentioned by researchers as having high traffic congestion. The data were gathered using a mixed sampling technique. The random sampling was used to choose specific respondents and purposive selection (non-probability) to choose the three cities.

Since the entire population of parking users is unknown, the estimated sample size for the study was calculated using Kothari's (2004) formula for the infinite (unknown) population, as indicated in equation (1).

$$n = \frac{z^2 p * q}{e^2} \qquad (1)$$

Where,

z – The value of the standard variant at a given confidence level

p – Standard Deviation

e – Margin error

q = 1-P

Given that the study's planned confidence level was 95%, the resulting Z-score, standard deviation, and margin error was 1.96, 0.5, and 0.05, respectively. Substituting this value in the provided formula resulted sample size of 384.

The study employed documentary evaluations and a structured questionnaire that was physically delivered to respondents and via Google Form. To ensure the clarity of structured questionnaire pilot testing, a questionnaire was distributed to both car owners and parking owners (Creswell, 2014). Direct invitations (emails) and online methods (social media and online forums) were used to recruit participants, and they were given exclusive access to the result. A total of 460 questionnaires, both from Google Forms and physical hard copies, were received back. During data collection, some of the respondents were skipping critical questions; a redesign was conducted to make important questions mandatory. Data cleaning was the first step in the data analysis process, and it involved ensuring that the questionnaires were accurate and comprehensively answered. During the data cleaning process, sixty-five (65) questionnaires were deleted following a comprehensive check since the respondents weren't from the three cities sampled by the study. Python Pandas libraries were used for the analysis, and graphs and charts were used to present the results.

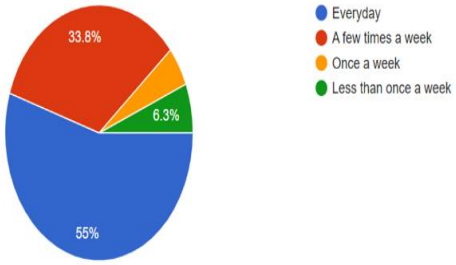
3.0 Results and Discussions

3.1 The Number of Times People Drive in the City

The study sought to understand the frequency with which people drove their cars in the cities. Drivers were asked how frequently they drove in the city. Finding out how many cars require parking each day was crucial for this study. According to the report, among the 400 respondents involved in the study, 55% (220) said they drive their cars every day, and 33.8% (135) of respondents said that they drive their cars a few times a week. Figure 1 clearly indicates the respondent's responses. Reed (2020) showed that traffic congestion is more common in urban regions. This suggests that in order to optimise parking systems in cities, focused effort should be taken into consideration.

Figure 1

The Number of Times Respondents Drive in the City



3.2 Using of Car Parking Facilities and Place to Find Them

The study was also interested in understanding how often respondents used parking facilities and their locations. The result indicates that out of 400 respondents, 54.5% (218) use parking facilities daily, 19.5% (78) use them rarely, 23% (92) use them weekly, and 3% (12) use them monthly. Figure 2 summarises how frequently respondents use car parking facilities. Additionally, the data reveals that the majority of respondents, 74.75% (299), find parking in publicly accessible locations, 17.75% (71) reported finding parking in privately accessible locations, and the remaining drivers find parking in various other locations, as depicted in table 1, Matiunina *et al.* (2023) revealed that parking lots and garages are often used by urban cars, particularly in business and commercial districts, multiple times a week. This suggests that parking lots are greatly needed and that efficient methods should be employed to guarantee that the parking lots are used to their full potential.

Figure 2

Percentage on how Respondents Use Car Parking Facilities

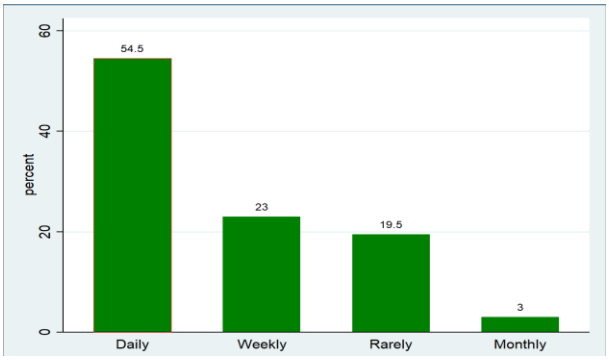


Table 1

Where do the driver find car parking?

Where do you find parking?	Freq.
Free office parking	1
I don't pay as I use powered mobility	1
Institutions	1
Mixed: private and public	1
Not payable	1
Private and public	1
Office Parking	4
Office and non-payable	10
Private free	1
Private payable	71
Private unpaid	1
Public payable	299
Road reserves	1
Unpayable	1

3.3 Time, Distance and Fuel Spend on Searching for Parking Slot

The study was interested to know the amount of time, distance, and gasoline used when looking for a parking spot since it has significant impacts on both national and individual economies. A higher number of these parameters signifies the amount of money and time lost by searching for a parking space. The study results reveal that out of 400 respondents, 49.25% (197) respondents take 5–10 minutes, 15.25% (61) respondents take 10–15 minutes, 9.25% (61) take more than 15 minutes, and 26.25% (105) take less than 5 minutes to find a parking space, as indicated in table 2. These results show a significant amount of time wasted during parking space searches as a result of a lack of parking management systems. It was discovered

that amongst 400 respondents, 53.5% (214) of respondents travel a distance of less than 500 meters, 35.5% (142) respondents travel a distance of less than 1 kilometre, 8.75% (35) respondents travel a distance of 1-2 kilometres, and 2.25% (9) respondents travel a distance of more than 2 kilometres to secure a parking space, as summarised in table 3. These findings show a significant distance travelled for finding parking spaces, which may lead to unnecessary traffic jams and air pollution. The study indicated 2.5% (10) respondents spend more than 3 litres of fuel, 1.75% (7) respondents spend 3 litres of fuel, 23.75% (95) respondents spend 1-2 litres of fuel, and 72% (288) respondents spend less than one litre of fuel on every search for a parking space. The findings are summarised in Table 4. A minimum of Tshs 3,780,000/- is wasted annually per car for a waste case scenario. These results highlight a significant issue related to the absence of information management in the parking system, which requires a solution.

Table 2
Time Spend in Searching Parking Table

How much time spend	Freq.
0-15 minutes	61
5-10 minutes	197
Less than 5 minutes	105
More than 15 minutes	37

Table 3
Distance Spend in Searching Parking

How much distance spend	Freq.
1-2 km	35
Less than 1 km	142
Less than 500m	214
More than 2km	9

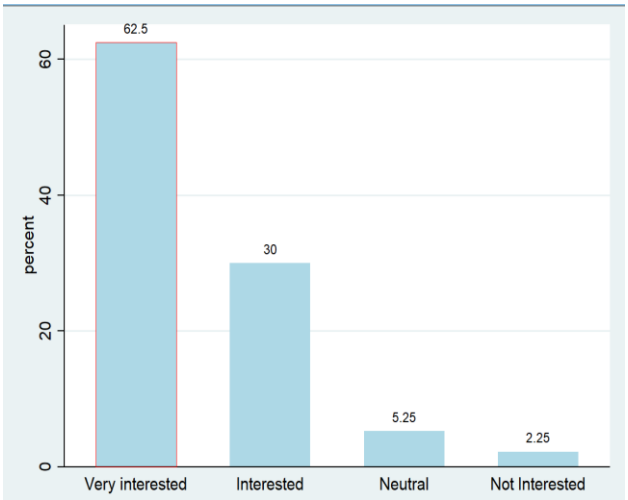
Table 4
Fuel Spend when Searching for Parking

How much fuel spend	Freq.
1-2 Litre	95
3 Litre	7
Less than 1 Litre	288
More than 3 Litre	10

3.4 Smart Parking System Features

Smart parking is one of the solutions to overcome the problem of parking in big and growing cities. The respondents were asked if they are interested in a smart car parking system to simplify parking space location and reservation. Study results indicated that the majority of the respondents, 62.5% (250), responded that they were very interested, and 30% (120) of the respondents responded that they were interested in smart parking solutions. However, 5.25% (21) respondents were neutral, and 2.25% (9) responded that they are not interested. The results are summarised by figure 3.

Figure 3
Interest in Smart Parking System (SPS)



The high level of interest in Smart Parking Systems (62.5%) indicates a strong demand for technological solutions that enhance parking management. This demand presents opportunities for economic growth, urban development, environmental benefits, and improved consumer experiences while also necessitating thoughtful planning and investment from stakeholders. Businesses involved in parking management, technology development, and urban planning should consider investing in or developing smart parking solutions to meet this demand.

Figure 4
Important Feature to be Included in Smart Parking System

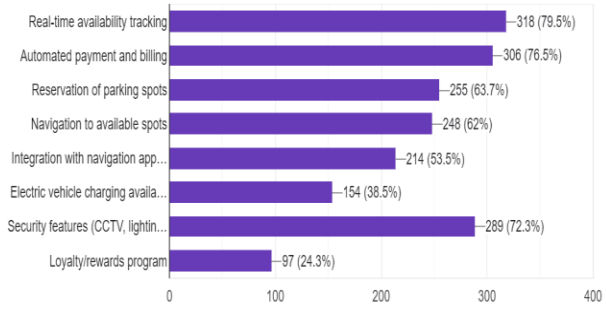
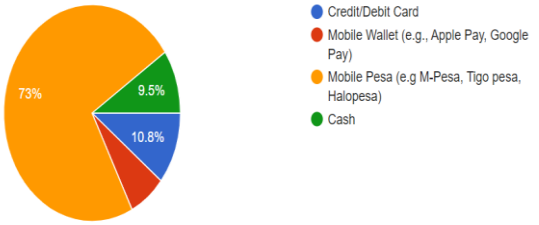


Figure 5
Payment Method



The study also asked respondents to suggest essential features of smart parking that they would find appealing. The recommended features are real-time availability tracking, automated payment and billing, reservation of parking space, navigation to available parking space, integration with navigation application, electric vehicle charging facilities, security features (CCTV, lightening protector), and a loyalty/reward program as depicted in figure 4.

3.5 Payment Method

There are several payment methods existing in developed as well as developing countries. However, its applicability varies between countries depending on technology and culture. This study intended to understand the payment methods respondents are willing to use with the smart parking system. The majority of respondents, 73% (292), suggested using mobile money, such as M-Pesa, Tigopesa, T-Pesa, and Halopesa; 10.8% (43) suggested use of credit/debit cards; 9.5% (38) suggested use of cash; and 6.7% (27) suggested mobile wallets (e.g., Apple Pay, Google Pay), as shown in figure 5. The results signify the well-known and familiar mode of payment (mobile money), which has been in place in Tanzania for a number of years, and many people are using it. Smith (2019) shows that the use of contactless payment methods in smart parking systems—such as credit/debit cards and mobile payment services—is growing. With these techniques, drivers can swiftly make transactions at payment terminals by tapping their cards or smartphones.

3.6 Limitation of the Study

The data were collected in three potential cities where there is high traffic. The findings will work perfectly in the cities with similar characteristics.

4.0 Conclusion and Future Works

The study underscored a pressing need for significant reforms and modernisation. The current state of parking infrastructure in Tanzanian cities, particularly in urban centres like Dar es Salaam, Arusha, and Mbeya, is marked by inefficiencies that exacerbate congestion, hinder economic activities, and diminish the overall quality of life. This analysis reveals that the existing parking systems are inadequate to meet the growing demands of urban populations and businesses, leading to a series of negative economic and social consequences.

4.1 Economic Impact and Operational Inefficiencies

Inefficient parking systems contribute to considerable economic costs, including increased operational expenses for businesses, reduced consumer spending, and lost productivity. The inability to find parking easily leads to wasted time and fuel, which translates into higher costs for both individuals and businesses. The congestion caused by inefficient parking further strains urban infrastructure and impedes the smooth functioning of city economies. This inefficiency impacts not only businesses but also local governments, which face increased pressure to manage traffic and maintain infrastructure amid growing urbanisation.

4.2 Potential of Smart Parking Systems

The analysis highlights that there is significant public interest in adopting smart parking systems, with 62.5% of respondents expressing a willingness to use such technology. This high level of interest reflects a clear demand for modern, efficient parking solutions that can alleviate the current challenges. Smart parking systems offer numerous benefits, including real-time information on parking availability, reduced congestion, and more efficient use of parking spaces. Implementing these systems could lead to substantial economic benefits, such as reduced operational costs, increased revenue for businesses, and improved urban mobility. Adding SPS technologies to existing infrastructure might cause problems with compatibility, and the high cost of setting up the SPS system might make it hard to get funding from stakeholders. These are just a few of the challenges that may arise during SPS implementation.

4.3 Recommendations for Policy and Practice

To address the identified challenges and harness the potential benefits of smart parking systems, the following recommendations are proposed:

4.4 Investment in Infrastructure

Significant investment is needed to develop and upgrade parking infrastructure. This includes integrating smart technologies and expanding parking facilities to accommodate growing urban populations.

4.5 Adoption of Smart Technologies

Municipalities and businesses should prioritise the adoption of smart parking solutions. This involves implementing technologies that provide real-time data, enhance user convenience, and streamline parking management.

4.6 Policy Support

Policymakers should create a supportive regulatory framework that encourages the adoption of smart parking systems. This may include incentives for technology deployment, guidelines for system integration, and funding for pilot projects.

4.7 Public Awareness and Engagement

Increasing public awareness about the benefits of smart parking systems is crucial. Engaging with the community through educational campaigns and demonstrations can foster greater acceptance and adoption of these technologies.

4.8 Sustainable Practices

Emphasising sustainability in parking management practices can contribute to broader environmental goals. Smart parking systems can reduce emissions and optimise resources, aligning with Tanzania's sustainability objectives.

4.9 Future Work

The transition to more efficient parking systems presents a transformative opportunity for Tanzanian cities. By embracing smart parking technologies and implementing effective policies, Tanzania can mitigate current parking issues, stimulate economic growth, and enhance urban living conditions. As cities continue to expand and evolve, addressing parking inefficiencies through innovative solutions will be crucial for sustaining economic development and improving the quality of life for residents.

In conclusion, the critical analysis of parking systems and their economic impact in Tanzania reveals both the challenges and opportunities facing urban areas. Addressing these issues with strategic investments and modern technologies will be key to fostering economic growth, enhancing urban mobility, and creating more vibrant and efficient cities.

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assistance during this study's execution i5.0 Conflict cities.

7.0 Conflict of Interest

The authors declare no conflict of interest.

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