The Scientific Journal of Cihan University – Sulaimaniya **PP: 387-406**
Volume (7), Issue (2), December 2023
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

The Smart Parking Implementation as a Solution for On-Street Parking: A Case Study of Sulaimani City

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Abstract:

Traffic congestion presents a typical issue in every metropolitan area. Causing on-street parking that refers to the practice of parking vehicles along the sides of roads or streets. It is a common method of parking in urban and suburban areas where designated parking spaces may be limited. On-street parking can provide convenience to drivers by allowing them to park closer to their destinations.

However, it can also contribute to traffic congestion and reduce the available space for moving vehicles. Effective management and regulation of on-street parking are crucial to ensure proper traffic flow and equitable access to parking spaces for all users. The utilization of intelligent parking systems, when conceived and put into action, has the potential to decrease the wastage of time, fuel, and environmental pollution. The main objective of this study is to examine the characteristics of on-street parking, with the intention of implementing smart parking solutions. This case study focuses on Sulaimani City as an example. This study has concentrated on three congested street: Salim Street, Ibrahi Pasha Street and Orzdy Street. Accordingly, field data was gathered through the in-out method, focusing on an examination of parking characteristics and types. Data collection was conducted through manual means. . Moreover, additional date were collected for the visitors whom used the current car parking at AM, and PM periods and at peak hours for a normal day. The study result shows the fact that the highest number of cars are parked and moving in two hours underscores the significance of the demand for long-duration parking options in the area. Implementing a comprehensive smart parking system in Sulaimani city, incorporating sensor-based technology and mobile applications, along with strategically increasing off-street parking availability, will alleviate on-street congestion. This approach aims to cater to the demand for long-duration parking options, ultimately reducing traffic-related issues, optimizing parking space utilization, and contributing to a more sustainable urban environment. This observation supports the idea of introducing smart parking solutions and increasing off-street parking availability, as many drivers require parking solutions that cater to extended stays associated with various daily activities.

Key words: Smart Parking, On-Street Parking, Sulaimai City, Parking Income.

DOI: http://dx.doi.org/10.25098/7.2.38

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Volume (7), Issue (2), December 2023
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

الملخص:

يعتبر الازدحام المروري مشكلة شائعة في معظم المناطق الحضريةواحدى الاسباب هي وقوف السيارات على جوانب الطرق أو الشوارع. وهي طريقة شائعة لوقوف السيارات في المناطق الحضرية والضواحي عندما تكون المساحات المخصصة لوقوف السيارات محدودة. يمكن أن يوفر وقوف السيارات في الشوارع الراحة للسائقين من خلال السماح لهم بالوقوف بالقرب من المكان المقصود ومع ذلك، يمكن أن يسهم أيضًا في ازدحام المرور وتقليل المساحة المتاحة للمركبات المتحركة. إدارة وتنظيم وقوف السيارات في الشوارع أمر ضروري لضمان تدفق المرور السليم والوصول العادل لجميع المستخدمين. استخدام أنظمة وقوف السيارات الذكية ذو قدرة على التقليل من هدر الوقت والوقود وتلوث البيئة. الهدف الرئيسي من هذه الدراسة هو اختبار خصائص وقوف السيارات في الشوارع، بنية ايجاد وتنفيذ حلول ذكية لوقوف السيارات. تركز هذه الدراسة على مدينة السليمانية. وقد تركزت هذه الدراسة على ثلاث شوارع مزدحمة: شارع سالم، شارع إبراهيم باشا، وشارع أورزدي. وبناءً على ذلك، تم جمع البيانات الميدانية ، مع التركيز على اختبارخصائص وأنواع وقوف السيارات. تم جمع البيانات من خلال المسح الميداني بالإضافة إلى ذلك، تم جمع بيانات إضافية للزوار الذين استخدموا مواقف السيارات الحالية في فترات الصباح والمساء وفي ساعات الذروة ليوم عادي. تظهر نتيجة الدراسة حقيقة أن أعلى عدد من السيارات يتم وقوفها والتحرك في ساعتين وهذا يبرز أهمية توفير مواقف السيارات طويلة الأمد في المنطقة. ستخفف تنفيذ الانظمة الذكية لوقوف السيارات في مدينة السليمانية من ازدحام الشوارع ، بما في ذلك تكنولوجيا استنساخ الحساسات وتطبيقات الهواتف المحمولة. تهدف هذه الطريقة إلى تلبية الطلب على خيارات وقوف السيارات طويلة الأمد، مما يقلل في النهاية من المشاكل المرورية ذات الصلة، ويحسن استخدام المساحة لوقوف السيارات، ويسهم في بيئة حضرية أكثر استدامة. تدعم هذه الدراسة فكرة إدخال حلول مواقف السيارات الذكية وزيادة توفر مواقف السيارات في الأماكن الملائمة، حيث يحتاج العديد من السائقين إلى حلول لوقوف السيارات التي تلبي احتياجات الإقامة الطويلة المرتبطة بالأنشطة اليومية المتنوعة.

الكلمات المفتاحية: مواقف السيارات الذكية، مواقف السيارات في الشوارع، مدينة السليمانية، إيرادات وقوف السيارات.

پوختە:

قەرەباڵغی هاتوچۆ کێشەیەکی باوی زۆربەی ناوچە شارییەکانە و یەکێک لە هۆکارەکانیش وەستانی ئۆتۆمبێلە لە تەنیشت ڕێگاکان یان شەقامەکان. شێوازێکی بەناوبانگی وەستانی ئۆتۆمبێلە لە ناوچە شارییەکان و دەرەوەی شارەکان کاتێک شوێنی وەستانی ئۆتۆمبێل سنووردارە. وەستانی ئۆتۆمبێل لەسەر شەقامەکان دەتوانێت ئاسانکاری بۆ شۆفێران دابین بکات بە ڕێگەدان بە وەستانی ئۆتۆمبێل لە نزیک شوێنی مەبەست لێیان، بەڵام دەتوانێت یارمەتیدەر بێت لە قەرەباڵغی هاتوچۆ و کەمکردنەوەی شوێنی بەردەست بۆ ئۆتۆمبێلە جوڵاوەکان. بەڕێوەبردن و ڕێکخستنی وەستانی ئۆتۆمبێل لەسەر شەقامەکان زۆر گرنگە بۆ دڵنیابوون لە هاتوچۆی دروست و دەستڕاگەیشتنێکی یەکسان بۆ هەموو بەکارهێنەران. بەکارهێنانی سیستەمی زیرەکی وەستانی ئۆتۆمبێل توانای کەمکردنەوەی بەفیڕۆدانی کات و سووتەمەنی و پیسبوونی ژینگەی هەیە. ئامانجی سەرەکی ئەم توێژینەوەیە تاقیکردنەوەی تایبەتمەندییەکانی وەستانی ئۆتۆمبێل لەسەر شەقامەکانە، بە مەبەستی دۆزینەوە و جێبەجێکردنی چارەسەری زیرەکی وەستانی ئۆتۆمبێل. ئەم توێژینەوەیە تیشک دەخاتە سەر شاری سلێمانی. ئەم توێژینەوەیە لەسەر سێ شەقامی قەرەباڵغ بوو: شەقامی سالم، شەقامی ئیبراهیم پاشا، شەقامی ئۆرزدی. بەم پێیە داتای مەیدانی کۆکرایەوە، کە تیایدا تیشک خراوەتە سەر تاقیکردنەوەی تایبەتمەندی و جۆرەکانی وەستانی ئۆتۆمبێل. زانیارییەکان لە ڕێگەی ڕاپرسییەکی مەیدانییەوە کۆکرانەوە، سەرەڕای ئەوەش، زانیاری زیاتر بۆ ئەو سەردانکەرانە کۆکرانەوە کە شوێنی وەستانی ئۆتۆمبێلەکانی ئێستایان لە بەیانیان و ئێواران و لوتکەی ڕۆژێکی ئاساییدا بەکارهێناوە. دەرئەنجامی لێکۆڵینەوەکە ئەو ڕاستییە دەردەخات کە زۆرترین ژمارەی ئۆتۆمبێل لەماوەی دوو کاتژمێردا وەستاون و دەجوڵێن و ئەمەش گرنگی دابینکردنی وەستانی ئۆتۆمبێلی درێژخایەن لە ناوچەکەدا دەردەخات. جێبەجێکردنی سیستەمی وەستانی ئۆتۆمبێلی زیرەک لە شاری سلێمانی قەرەباڵغی شەقامەکان کەمدەکاتەوە، لەوانەش تەکنەلۆجیای کلۆنکردنی هەستەوەرەکان و ئەپلیکەیشنی مۆبایل. ئەم شێوازە ئامانجی دابینکردنی خواست لەسەر بژاردەی وەستانی ئۆتۆمبێلە بۆ ماوەیەکی درێژخایەن، کە لە کۆتاییدا کێشەکانی پەیوەست بە هاتوچۆ کەمدەکاتەوە، بەکارهێنانی شوێنی وەستانی ئۆتۆمبێل باشتر دەکات، و بەشداری لە ژینگەیەکی شارستانی بەردەوامتر. ئەم توێژینەوەیە پشتگیری لە بیرۆکەی ناساندنی چارەسەری زیرەکی وەستانی ئۆتۆمبێل و زیادکردنی بەردەستبوونی وەستانی ئۆتۆمبێل لە شوێنە گونجاوەکاندا دەکات، چونکە زۆرێک لە شۆفێران پێویستیان بە چارەسەری وەستانی ئۆتۆمبێل هەیە کە پێداویستییەکانی مانەوەی درێژخایەن پەیوەست بە چالاکییە جۆراوجۆرەکانی ڕۆژانە دابین بکات.

DOI: http://dx.doi.org/10.25098/7.2.38

The Scientific Journal of Cihan University – Sulaimaniya **PP: 387-406**
Volume (7), Issue (2), December 2023
ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

کلیلە وشە: وەستانی ئۆتۆمبێلی زیرەک، وەستانی ئۆتۆمبێل لەسەر شەقامەکان، شاری سلێمانی، داهاتی وەستانی ئۆتۆمبێل.

1. Introduction:

In recent years, the rapid expansion and growth of cities have posed a significant problem among them, the increasing need for parking spaces [1, 2]. As more people own cars and urban areas become more crowded, the requirement for accessible and well-organized parking facilities has become a crucial issue [1, 3]. This essay explores the reasons behind the surge in the demand for parking spaces and discusses the implications and potential solutions for addressing this issue [4, 5]. As economies grow and living standards improve, more individuals and families are able to afford private vehicles [4, 6]. This flow in car ownership puts massive pressure on existing parking infrastructure [5]. Moreover; the rapid growth of urban populations has limited space in urban areas compounds the challenge of accommodating the increasing number of vehicles, leading to congestion and inadequate parking availability [7, 8].

In addition; the development of commercial centers, shopping malls, and residential complexes contributes to the need for parking spaces [7, 9]. These establishments attract large numbers of visitors and residents, straining the already limited parking resources [1]. In another hand; Insufficient and inefficient public transportation systems in many cities compel individuals to rely on private vehicles for their daily commutes [10]. This reliance further exacerbates the demand for parking spaces [10]. Consequently, traffic congestion and insufficient parking availability leads to cars turning in search of parking spots, contributing to traffic congestion and increased pollution [4, 6]. This negates efforts to create smooth traffic flow and sustainable urban environments [5]. Finally; in term of environmental impact that affected by rising in vehicle numbers and resulting congestion contribute to increased emissions, negatively affecting air quality and exacerbating environmental concerns [2, 11].

The increasing need for parking facilities is an intricate issue rooted in urbanization, population growth, and shifting mobility trends [4]. Addressing this challenge requires a comprehensive approach that combines innovative technologies, urban planning strategies, and sustainable transportation solutions [4, 5]. By acknowledging the importance of efficient parking systems in our modern cities, we can pave the way for smoother traffic flow, reduced environmental impact, and enhanced quality of life for urban dwellers [4, 12]. This research will specifically focus on the quantity and locations of parking spaces, as the scarcity of available parking spots leads to traffic complications, notably vehicles parking on main roads, consequently causing congestion. This, in turn, becomes a key factor contributing to other traffic issues encountered by the city.

The objective of the Smart Parking System is to efficiently guide vehicles to available parking spaces, minimizing both time and effort. This arises due to the disparity between parking space availability and demand, coupled with the proliferation of vehicle ownership in commercial, administrative, and service areas, as well as in residential regions. This situation is further compounded by a lack of adequate public transportation, disorderly parking practices, and instances of vehicles being illegally parked, all of which contribute to traffic congestion.

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The shortage of parking spaces within the city leads to wasted time and effort for individuals, while also contributing to traffic congestion. The presence of disorderly parking, particularly unauthorized vehicles, further compounds the issue. The primary objective of this study is to formulate an implementation plan for a Smart Parking System designed to effectively manage parking spaces in Sulaimani city. To achieve this objective, a series of steps were undertaken. Firstly, the parking challenges faced by drivers on the study area were identified. Subsequently, the study delved into evaluating the potential impact of introducing the Smart Parking System as a solution to these parking issues. Lastly, a practical application of the Smart Parking System was installed on the study area.

2. Literature Review:

In the early 20th century, a parking system was developed to address the need for car storage facilities[6]. Consequently, in the present context, extensive research efforts are primarily directed towards unraveling and comprehending the various factors that wield influence over the formulation and implementation of parking policies[13]. Researchers aim to gain a deeper understanding of the intricate interplay between these factors and the strategies employed in managing parking within urban environments. This exploration seeks to enhance the efficiency, accessibility, and sustainability of parking solutions, contributing to the overall management of urban mobility and congestion [8, 14-16].

A prior study conducted in China explored parking lot characteristics in Shanghai's city center, particularly in market and food areas, revealing high parking space saturation. This led to the proposal of parking improvement strategies tailored to the city's context. An investigation in Najaf's city center, specifically in Al-Rawan and Al-Iskan areas, utilized manual counts, drones, and video cameras to study street parking attributes. Findings highlighted that over 80% of cars in both areas waited for more than 30 minutes [17]. In Bat Yam, a study assessed parking patterns using a high-resolution spatial display of parking supply and demand. The study concluded that parking time approaches zero within 50 meters and reaches 4.5 minutes within a 200-meter distance[18, 19].

Addressing the high demand for on-street and off-street parking in Hilla's city center, suggestions included allocating small spaces for parking to reduce street-parked vehicle-related traffic accidents. Research in Delhi's business district revealed a parking peak of 3.25 for vehicles and 6.21 for bicycles, indicating significant congestion[20]. Geographic information systems in Sanandaj, Iran, determined suitable parking spaces covering 14.16% of the study area[21].

2.1 Parking characteristics:

Factors impacting parking spot choice include the distance from parking to exits, sunlight protection, safety, and proximity to entrances[22]. Urban planning often overlooks parking, contributing to urban traffic congestion; addressing this requires integrated solutions in planning, design, and management levels[23]. City planning must incorporate parking space considerations[24].

The initial phase of the study necessitates the determination of parking space numbers and the collection of relevant data to establish various characteristics associated with on-street parking. These

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characteristics are commonly referred to as parking statistics or attributes. In general, the following criteria are employed for assessing car parks [16, 17, 25, 26]:

1. **Parking Volume:** This refers to the total number of cars parked simultaneously, disregarding the recurrence of vehicles. The focus is on tracking the actual count of vehicles entering the designated area.
2. **Parking Accumulation:** It denotes the quantity of parked cars in a given study area at a specific moment. Plotting this data as an accumulation-vs-time curve illustrates the fluctuation in parking accumulation throughout the day.
3. **Parking Load (Space-Hour):** The parking load represents the area under the accumulation curve. Alternatively, it can be computed by multiplying the number of parked vehicles at each interval by the interval's time value. Mathematically, it can be expressed as: Parking Load = Time Interval (hours) * Σ Parked Vehicles at Each Time Interval
4. **Average Parking Duration:** This metric indicates the duration for which a car remains parked in a space. When expressed as an average, it offers insights into how frequently parking spaces become available. It is calculated by dividing the total vehicle hours by the quantity of parked cars.
5. **Parking Turnover:** Parking turnover measures how frequently a parking space is used. It is determined by dividing the total volume of parking during a specific time period by the number of parking spaces available.
6. **Parking Index (Occupancy/Efficiency):** The parking index gauges the efficiency of parking utilization. It quantifies the ratio of the total accessible space to the number of occupied bays over time. This provides a comprehensive assessment of parking space efficiency and can be calculated using the formula: Parking Index = (Parked Load / Parking Capacity) * 100

These metrics collectively offer a comprehensive understanding of parking dynamics, usage patterns, and efficiency levels within a given area. By analyzing and interpreting these characteristics, urban planners and researchers can formulate informed strategies for optimizing parking spaces and mitigating associated challenges[27-30].

2.2 The Concept of Smart Parking and Its Transformative Impact on Urban Mobility:

Smart parking refers to an innovative parking management system characterized by the integration of technology to optimize parking space utilization and enhance the overall parking experience. Key characteristics of smart parking include the use of sensor technology to monitor space occupancy in real-time, the implementation of mobile applications for user convenience and navigation, and the potential for automated payment systems. These systems are designed to improve efficiency, reduce traffic congestion, and contribute to a more sustainable urban environment. The benefits of smart parking can be summarized as follows:

a- This facilitates drivers to park in proximity to their destinations, thereby providing heightened convenience[31] .
b- It ensures equitable distribution of parking opportunities among all drivers[32].
c- Effectively managed on-street parking, where users pay for their occupied time, can serve as a substantial revenue stream for urban areas [17, 26].

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d- Enhancing the aesthetics and vibrancy of the community [12, 33].
e- Modern parking meters can collect valuable data about parking behavior, which can be used to optimize parking policies and urban planning decisions [6, 12, 34, 35].

2.3 Smart on Street Parking System:

On-street parking machines, commonly referred to as parking meters, function through a relatively uncomplicated mechanism. Although the exact operation may differ based on the technology employed, a fundamental explanation of how they work is as follows [6, 36, 37]:

1. **Payment Insertion:** Traditionally, parking meters operated on a coin-based system. When a driver located an available parking space with an associated meter, they would insert coins into the meter. The amount of time purchased for parking depended on the value of the coins inserted. More coins translated to a longer parking duration.
2. **Time Tracking:** Upon completing the payment process, a mechanical or electronic timer would commence counting down. This timer would keep track of the remaining parking time, and the meter's display would indicate the amount of time left for the driver's reference.
3. **Expiration Alert:** When the purchased parking time elapsed, the meter would emit a visual signal, often through methods like flashing lights or a change in the color of the display. This signal served as an alert for parking enforcement personnel, indicating that the vehicle had exceeded its paid parking duration. Consequently, fines or penalties could be imposed for non-compliance with the parking regulations.

2.4 Enhancements to the smart parking model:

1. **Digital Payment:** In contemporary setups, modern parking machines have embraced digital payment methods, encompassing credit/debit cards and mobile payments. This evolution allows for greater convenience, offering users the option to pay using electronic means, either alongside or in lieu of physical coins [6, 12, 34].
2. **Wireless Connectivity:** Many contemporary parking meters possess wireless communication capabilities, enabling seamless interaction with a central system. This real-time connection facilitates the monitoring of parking occupancy and payments, enabling dynamic pricing models that adjust parking costs based on demand fluctuations[38].
3. **Integrated Mobile Apps:** Advanced parking systems have integrated with mobile applications, providing drivers with an array of functionalities. These apps empower users to locate available parking spots, make payment for parking, and even remotely extend parking time if they anticipate a delayed return to their vehicle [31, 39].
4. **License Plate Recognition:** Some cutting-edge systems incorporate license plate recognition technology. This innovative approach eliminates the need for drivers to display physical tickets on their dashboards. Instead, the system associates the payment with the vehicle's license plate number, streamlining the process, enhancing security, and simplifying enforcement efforts [32, 39-41].

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3. Methodology:

To comprehensively examine the impact of on-street parking, the initial step involves the collection of relevant data. This data serves as the foundation for conducting an in-depth analysis, enabling us to assess the effectiveness and efficiency of street parking within the designated study area. In general; the city of Sulaimani has experienced notable growth, expansion, and a considerable rise in population. As the central hub and vibrant core of the city, the city roads need to adapt to this progress and expansion[42]. Nonetheless, the challenges that this area faces put considerable pressure on its infrastructure, leading to noticeable planning complexities. These circumstances necessitate a thorough examination, evaluation, and continuous development of strategies and interventions. The central area of Sulaimani city threatens a remarkable problem that reverberates across its entire urban fabric. This challenge primarily stems from its role as a magnet attracting both local inhabitants and external migrants [42]. The aggravation of these issues is attributed to land misuse, traffic congestion, inadequate infrastructure, neglect of architectural and recreational aspects, and a lack of clear demarcation. Among the prominent challenges experienced by the city is traffic-related concerns.

This study has concentrated on three congested main street: Salim Street, Ibrahi Pasha Street and Orzdy Street. Three specific streets have been chosen due to their significant attractiveness to citizens, primarily stemming from their central positioning and the presence of vibrant commercial avenues that provide abundant on-street parking. Consequently, the scrutiny of parking patterns within this vicinity emerges as a critical benchmark for evaluating the overall traffic efficiency in the area. Salim Street stands out as a primary access characterized by extensive on-street parking availability. This street is positioned along the central axis of the city and holds a significant stature as one of the crucial streets within Sulaimani, particularly within the Saholaka district. Furthermore, the presence of diverse shops and expansive commercial hubs contributes significantly to the elevated importance of this street (see Figure 1 which illustrates location of three studied Street).

Ibrahim Pasha and Orzdy Streets present a distinctive challenge due to their double lane parking setup, which imposes limitations on the overall capacity of these streets. Located within the central business district (CBD), these streets rank among Sulaymani's most congested area. The primary demographic frequenting these streets consists of customers. It's important to highlight that parking options are confined to on-site spaces, with no provision for parking within the buildings.

These streets hold a crucial role within the city's central infrastructure, their significance further emphasized by the presence of medical clinics and specialized hospitals. Moreover, the obvious presence of diverse shops and expansive commercial centers adds to the considerable importance attributed to these streets. (See Figure 1 and 2 that show studied Streets photos).

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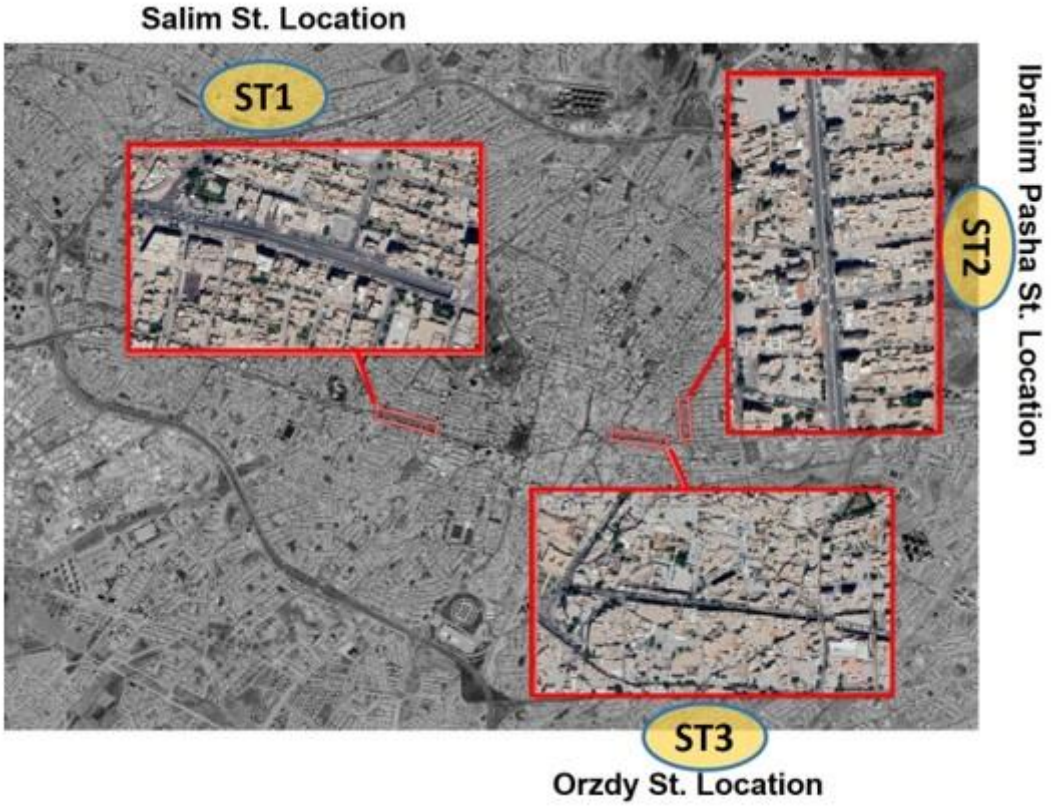

Figure 1: Illustrates location of Selected Three Streets
Source: Drawn by authors depending on Google Earth.

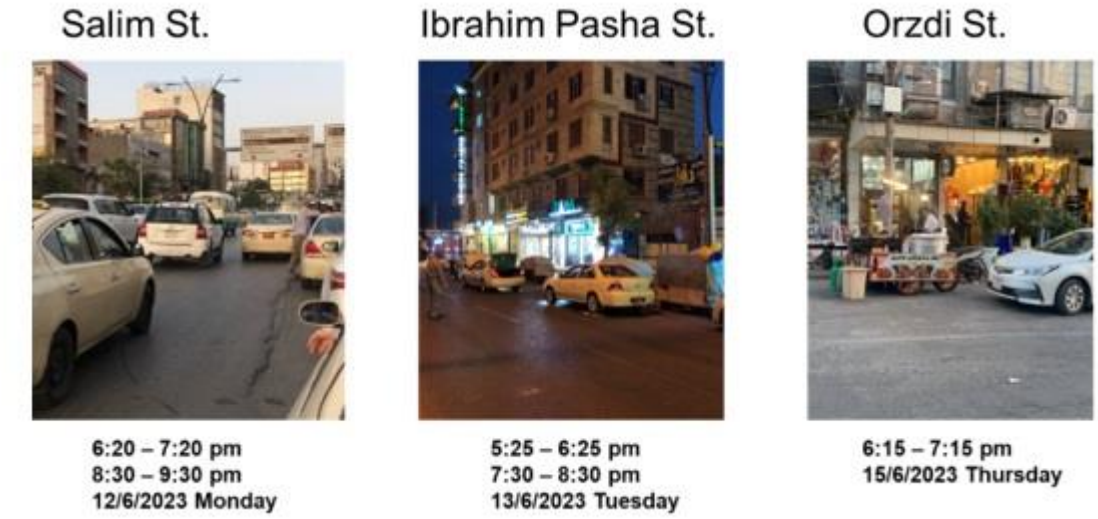

Figure 2: Photos of Three Studied Streets in Different Time.
Source: Photos have captured by authors.

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ISSN 2520-7377 (Online), ISSN 2520-5102 (Print)

4. Data Collection

First of all, the system relies on the knowledge of real-time parking information, based on which it makes and upgrades allocations for drivers. The data of this study were collected for the purpose of finding the characteristics concerning parking patterns in the study area that involve three main streets in Sulaimani city: Salim Street (ST1), Ibrahim Pasha Street (ST2), and Orzdy Street (ST3). Data collection encompassed different time periods and days of the week. The survey utilized the "in-out" method, which involved selecting three specific spots where vehicles were allowed to stop.

During the survey, the initial count of vehicles present on the street was recorded, and subsequently, the number of vehicles parking or leaving the street was documented at specific time intervals. This meticulous approach provided a comprehensive understanding of the evolving parking dynamics within the study area.

Figure 3: The Location of Salim Street and On-Street Parking **(ST1).**
Source: Drawn by authors.

DOI: http://dx.doi.org/10.25098/7.2.38

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Figure 4: The Location of Ibrahim Pasha Street and On-Street Parking **(ST2).**
Source: Drawn by authors.

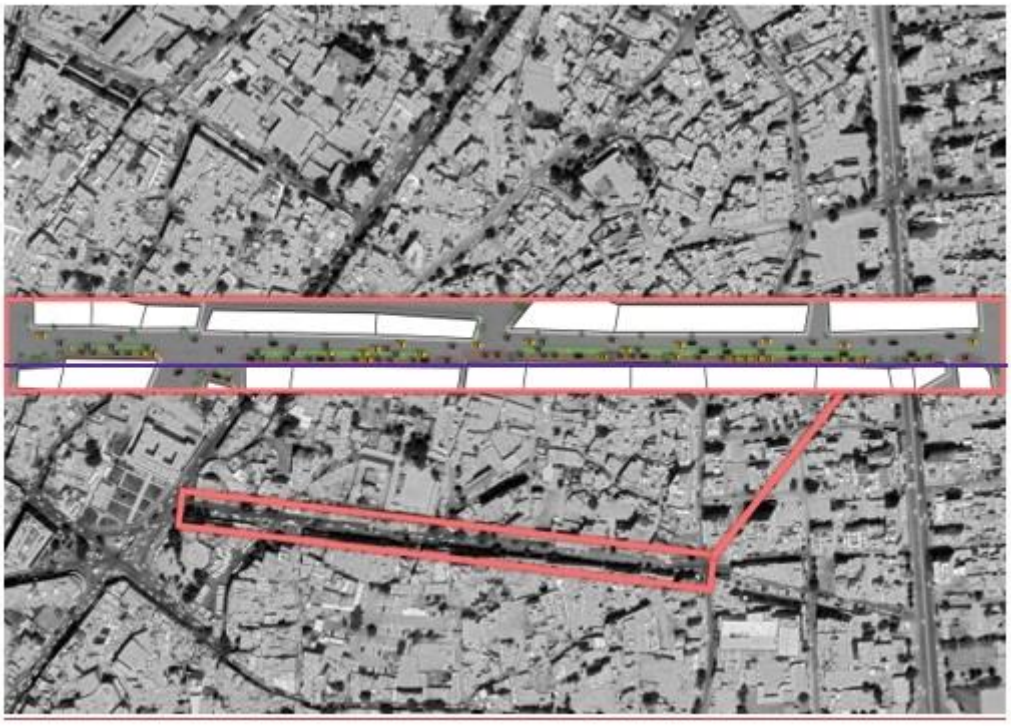

Figure 5: The Location of Orzdy Street and On-Street Parking **(ST3).**
Source: Drawn by authors

DOI: http://dx.doi.org/10.25098/7.2.38

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5. Result and Discussion:

From the data collected in the study area (ST1, ST2, ST3) in Sulaimani city center, several important inferences can be drawn based on the comparison between the number of vehicles parked on the street and the actual number of demand parking area. According to the provided information, the total number of vehicles parked on the street is twice of required number of vehicles parking in the designated parking area. This finding suggests a significant imbalance between on-street parking and actual parking demand.

The tables referenced, Table (1), (2), (3), (4), and Table (5), likely contain detailed characteristics and statistics related to on-street parking during the morning and evening on Salim Street, Ibrahim Pasha Street, and Orzdy Street. These characteristics could include data points such as:

A) Total Vehicles Parked on the Street: The number of vehicles that were found parked on each of the specified streets during the evening period.
B) Total Vehicles Moving in parking area: The number of vehicles that were looking for parking or leaving the parking in designated parking area during the same time frame.
C) Comparison Ratio: The ratio of vehicles parked on the street to those who need parking, as
D) indicated by the statement that the parking demand is twice the parking supply.
E) Parking Utilization: The percentage of parking spaces on the street that are being utilized compared to the total demand parking.
F) Parking Demand: An estimate of the demand for parking spaces in the city center, considering the higher number of vehicles parked on the street.
G) Parking Management Issues: The data might reveal underlying problems related to parking management, availability of parking spaces, and the convenience of using on-parking Street compared to street parking demand.
H) Traffic Flow and Congestion: If the street parking significantly exceeds parking lot utilization, it could lead to traffic congestion, reduced road capacity, and inconvenience for both drivers and pedestrians.
I) Urban Planning Implications: The findings could indicate a need for better urban planning strategies to allocate parking spaces effectively and enhance the overall transportation infrastructure in the city center.

In conclusion, from the interpretation of the data the finding suggests a significant imbalance between on-street parking and actual parking demand. This has implications for traffic management, urban planning, and the overall convenience of commuters. Further details from Figure (6), (7), and (8) could provide insights into specific characteristics and trends of on-street parking on the specified streets during the evening hours.

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Table 1: Salim Street Lane A

Time	Parked	Parking Cars			Moving cars			Remained Parked Cars
		Lane 1	**Lane 2**	**Total**	**Lane 1**	**Lane 2**	**Total`**	
6:20 - 6:30	20	10	1	11	9	0	9	22
6:30 - 6:40	22	6	0	6	5	1	6	22
6:40 - 6:50	22	7	0	7	5	0	5	24
6:50 -7:00	24	7	1	8	12	0	12	20
7:00 -7:10	20	10	1	11	10	1	11	20
7:10 -7:20	20	8	0	8	7	0	7	21
8:30-8:40	28	7	1	8	5	1	6	30
8:40-8:50	30	4	1	5	4	2	6	29
8:50-9:00	29	5	1	6	5	0	5	30
9:00-9:10	30	8	1	9	4	1	5	34
9:10-9:20	34	6	2	8	2	3	5	37
9:20-9:30	37	5	1	6	5	1	6	37
Total				**93**			**83**	

Table 2: Salim Street Lane B

Time	**Parked**	**Parking cars**			**Moving Cars**			**Remained Parked Cars**
		Lane 1	**Lane 2**	**Total**	**Lane 1**	**Lane 2**	**Total**	
6:20 - 6:30	44	0	10	10	0	5	5	49
6:30 - 6:40	49	1	11	12	0	8	8	53
6:40 - 6:50	53	0	11	11	2	6	8	56
6:50 -7:00	56	0	8	8	0	7	7	57
7:00 -7:10	57	1	8	9	2	7	9	57
7:10 -7:20	57	3	13	16	1	7	8	65
8:30-8:40	38	3	13	16	1	10	11	43
8:40-8:50	43	0	13	13	1	15	16	40
8:50-9:00	40	2	15	17	2	12	14	43
9:00-9:10	43	1	6	7	1	8	9	41
9:10-9:20	41	2	11	13	2	10	12	42
9:20-9:30	42	3	11	14	2	17	19	37
				146			**126**	

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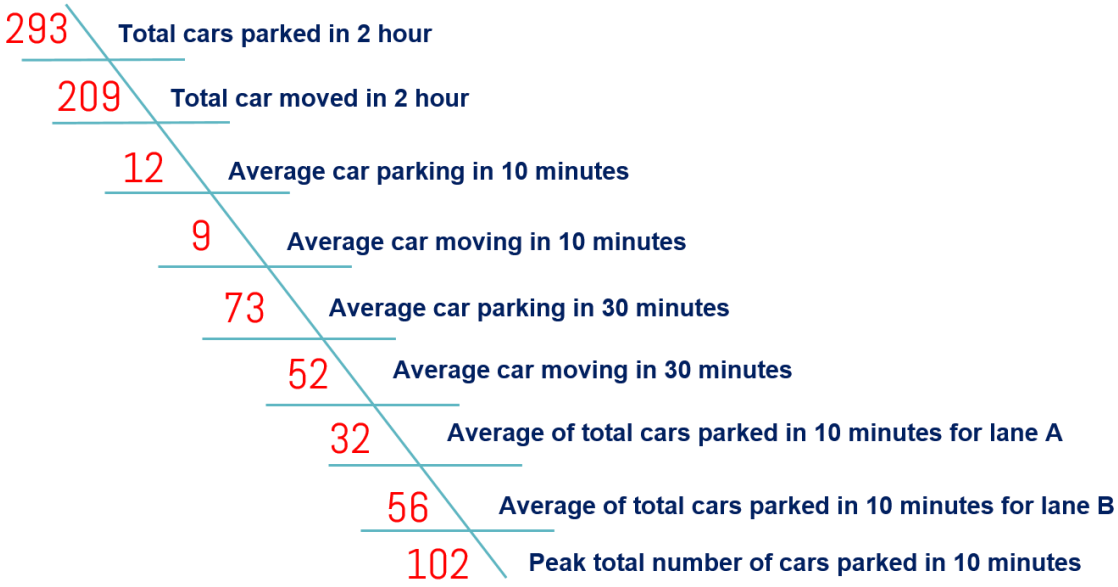

Figure 6: The Result of Salim Street **(ST1).**

In summary, our analysis of the data from Salim Street reveals a significant issue with parking availability and management. The data shows that on average, 293 cars are parked on both lanes of the street every two hours. Out of this number, 209 cars are subsequently moved. These findings indicate a shortage of parking spaces and an inadequate parking system on the street. As a result, drivers on Salim Street are consistently facing challenges in finding suitable parking spots.

Additionally, the data highlights that an average of 12 cars are parked on the street every ten minutes. While the number of the cars moved in 10 minutes are 9 cars. This frequent influx of parked cars further emphasizes the urgent need for a comprehensive parking solution on both sides of Salim Street as shown in **Figure 6.**

In conclusion, it is evident that the lack of sufficient parking facilities and an efficient parking management system are the primary issues affecting the drivers on Salim Street. Given the consistent demand for parking spaces and the regular turnover of parked cars, it is imperative to implement a prompt and effective solution to address these challenges. Implementing effective actions to control long-duration parking can significantly improve the parking-related issues faced by drivers and enhance overall traffic flow and convenience on Salim Street.

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Table 3: Ibrahim Pasha Lane A

Time	Parked	Parking Cars			Moving Cars			Remained Parked Cars
		Lane 1	Lane 2	Total	Lane 1	Lane 2	Total	
5:25 - 5:35	24	0	7	7	2	5	7	24
5:35 - 5:45	24	4	2	6	2	4	6	24
5:45 - 5:55	24	2	8	10	2	3	5	29
5:55 - 6:05	29	0	3	3	1	3	4	28
6:05 - 6:15	28	3	3	6	2	4	6	28
6:15 -6:25	28	3	7	10	2	4	6	32
7:30-7:40	22	3	2	5	2	3	5	22
7:40-7:50	22	3	4	7	5	4	9	20
7:50-8:00	20	6	2	8	3	0	3	25
8:00-8:10	25	6	4	10	8	3	11	24
8:10-8:20	24	9	1	10	8	1	9	25
8:20-8:30	25	12	1	13	11	1	12	26
				95			**83**	

Table 4: Ibrahim Pasha Lane B

Time	Parked	Parking Cars			Moving Cars			Remained Parked Cars
		Lane 1	Lane 2	Total	Lane 1	Lane 2	Total	
5:25 - 5:35	21	4	1	5	3	2	5	21
5:35 - 5:45	21	2	4	6	1	4	5	22
5:45 - 5:55	22	1	5	6	3	0	3	25
5:55 - 6:05	25	5	7	12	4	2	6	31
6:05 - 6:15	31	3	0	3	4	2	6	28
6:15 -6:25	28	6	2	8	2	3	5	31
7:30-7:40	18	4	11	15	5	6	11	22
7:40-7:50	22	5	6	11	6	8	14	19
7:50-8:00	19	5	9	14	1	12	13	20
8:00-8:10	20	7	7	14	6	9	15	19
8:10-8:20	19	4	1	5	2	8	10	14
8:20-8:30	14	3	3	6	3	5	8	12
				105			**101**	

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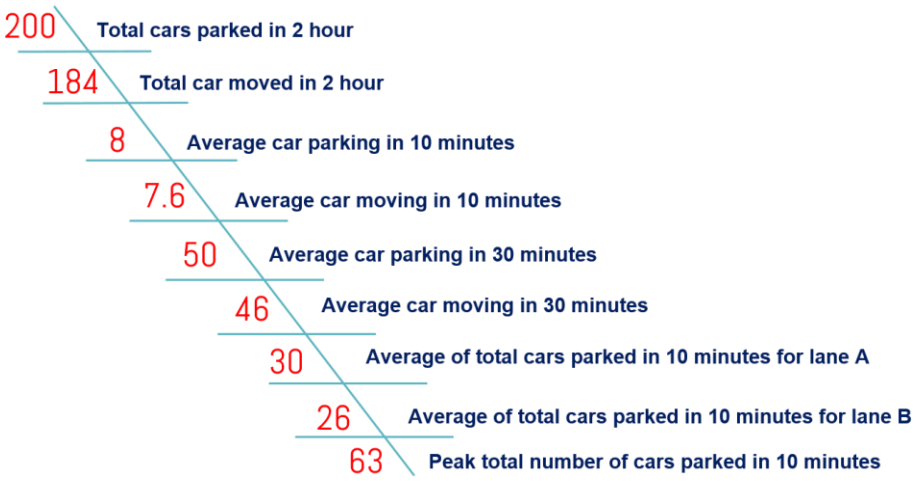

Figure 7: The Result of Ibrahim Pasha Street (ST2).

Indeed, the data from Ibrahim Pasha Street (ST2) provides valuable insights into the parking patterns and demands in the area. The observation that the highest number of cars is associated with cars parked and moving in two hours suggests a clear need for long-duration parking options. This finding indicates that a significant portion of drivers require parking solutions that cater to extended stays, such as those associated with work, shopping, or leisure activities. Furthermore, the fact that cars parked and moving in 30 minutes are the second highest category implies that there is also a demand for shorter-duration parking. This could be related to quick stops, drop-offs, or short visits to nearby establishments. **see Figure 7.** Increase Off-Street Parking: Given the evident need for both long-duration and shorter-duration parking, investing in off-street parking facilities becomes crucial. This can include constructing multi-level parking structures, parking lots, or garages in strategic locations near Ibrahim Pasha Street. By providing ample off-street parking options, you can cater to the diverse parking needs of drivers and alleviate congestion on the street.

Table 5: Orzdy Street (One Way)

Time	**Parked**	**Parking Cars**			**Moving Cars**			**Remained Parked Cars**
		Lane 1	**Lane 2**	**Total**	**Lane 1**	**Lane 2**	**Total**	
6:15 - 6:25	29	10	7	17	11	1	12	34
6:25 - 6:35	34	14	5	19	16	5	21	32
6:35 - 6:45	32	26	2	28	18	0	18	42
6:45 - 6:55	42	25	4	29	22	2	24	47
6:55 - 7:05	47	27	5	32	26	6	32	47
7:05 -7:15	47	29	2	31	36	1	37	41
				156			**144**	

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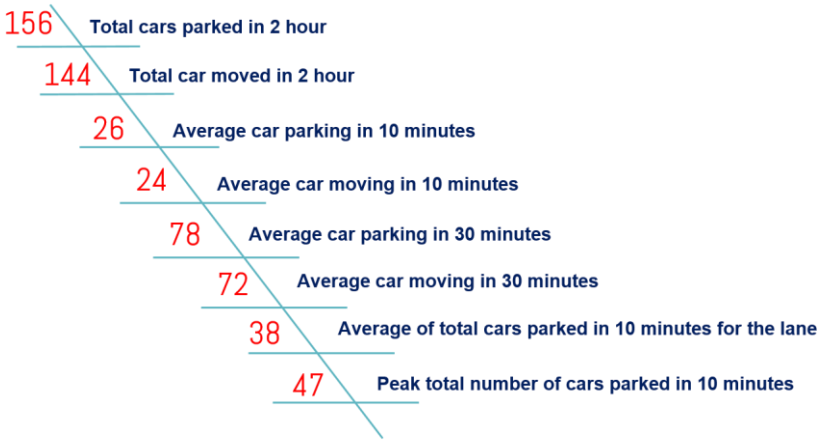

Figure 8: The Result of Orzdy Street (ST3).

The survey conducted on Orzdy Street (ST3) has yielded results that confirm the interpretation of the data. The fact that the highest number of cars are parked and moving in two hours underscores the significance of the demand for long-duration parking options in the area. This observation aligns well with the idea that many drivers require parking solutions that cater to extended stays associated with various daily activities, **see Figure 8.**

Ultimately, the accurate interpretation of the survey results positions you well to make informed decisions about parking management strategies in Orzdy Street. By focusing on the demand for long-duration parking options and aligning them with the specific needs of the area, you can create a more convenient, efficient, and well-balanced parking environment for everyone.

6. "Implementing a Smart Parking System: The Ultimate Solution for Enhanced Parking Management"

The smart parking system discussed in the article focuses on improving parking management through real-time data and advanced technologies. The system utilizes various sensing technologies for parking detection, including inductive loop sensors, ultrasonic sensors, infrared sensors, video cameras, wireless sensor networks, smartphone apps, magnetic field sensors, and Lidar sensors. The article highlights the importance of Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) connectivity for seamless communication between vehicles and the allocation center. This communication occurs through a smartphone application, enabling drivers to pre-book parking spots with minimal distraction while driving. Reservation guarantee is a crucial aspect of the smart parking system, ensuring that a reserved parking space remains unavailable for other vehicles. The article discusses two approaches for on-street parking: a wireless technology system with hardware interfaces and a more resource-efficient light-based setup indicating parking spot availability. The system's optimal allocation feature utilizes real-time data, user preferences, location information, and historical data to identify and allocate the best parking space for each driver. Overall, the smart parking system aims to enhance the parking experience for individual drivers, contribute to traffic management, and reduce congestion in urban areas.

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7. Conclusion and Recommendation:

In summation, the city of Sulaimani has undergone substantial growth and urban development, accompanied by a noticeable increase in its population. Positioned as the bustling core of the city, its road infrastructure requires adaptation to accommodate this progress. However, the convergence of challenges in this region has imposed significant strain on its infrastructure, resulting in intricate planning dilemmas. As a response, a comprehensive examination, ongoing evaluation, and strategic interventions are imperative to ensure the city's sustainable development.

Moreover, the central area of Sulaimani faces a critical quandary reverberating throughout its urban fabric. This challenge arises from its role as an attractive hub for both local residents and external migrants, driven by its strategic positioning. The exacerbation of these issues is compounded by land mismanagement, traffic congestion, inadequate infrastructure, a disregard for architectural and recreational elements, and an absence of distinct urban demarcation.

The data reinforces the importance of planning and developing parking infrastructure that accommodates both short-term and long-term parking needs.To address this, the implementation of a "smart parking" system emerges as a promising remedy. By leveraging advanced technologies and real-time data analytics, such a system can offer optimized parking allocation, alleviate parking shortages, and contribute to enhanced traffic flow and overall urban mobility.

From an academic standpoint, this study underscores the importance of innovative urban solutions that harmonize urban growth with sustainable development. The integration of a "smart parking" system stands as an exemplar of how technology-driven strategies can address multifaceted urban challenges. By embracing progressive ideas and robust methodologies, Sulaimani city has the potential to forge a more efficient, accessible, and livable urban environment. This study serves as a reminder that urban planning should encompass not only physical infrastructure but also intelligent systems that enhance the quality of life for residents while promoting sustainable urban progress.In essence, the "smart parking" system represents a promising step towards a more streamlined and user-centric approach to urban parking. As technology continues to evolve and urbanization persists, solutions like these play a pivotal role in creating more livable and efficient cities for both residents and visitors alike.

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