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Revitalizing Road Management in Iraq: An Economic Assessment of Financing Strategies for Sustainable Infrastructure Development

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Abstract

A road network serves as a fundamental public infrastructure that is essential for a nation's economic progress. Activating the road management system can improve public infrastructure performance over time. Many nations, including Iraq, are trying to build sustainable roads. The feasibility study estimated the financial viability of renewing annual vehicle licenses and compared it with road maintenance to evaluate financing strategies for sustainable infrastructure, focusing on one of Iraq's provinces, Diyala, 's road network.(Hamrin Lake) Road was chosen as the case study. Using the Benefit Cost Ratio (BCR), Net Present Value (NPV), and Internal Rate of Return, average daily traffic and future average daily traffic were calculated to determine the financial feasibility of those vehicles' benefits and compare it with road maintenance costs. At a 12% discount rate, the project's Net Present Value of 9,046,076,859 dinars and benefit-cost ratio of 10.52 exceeded the benchmark score of 1.0. Additionally, the project's 186.87% internal rate of return shows financial viability. Sensitivity analysis was also performed to discover the variables that most affect the project's financial viability. Altering the discount rate from 10% to 50% while examining traffic pattern modifications (r=1% and r=2%), the analysis found that the project was able to withstand these changes and remain economically viable. The positive results indicate that implementing such measures can contribute to the development of sustainable infrastructure in Iraq, benefiting the economy and society as a whole.

Keywords: Road Management, Sustainable, Benefit-Cost Ratio, Net Present Value, Internal Rate of Return, Sensitivity Analysis

Introduction

The road network serves as a fundamental public infrastructure that is essential for a nation's economic progress. It assumes a significant role in enabling commerce activities, fostering connectivity among individuals and goods, and fostering social unity(Ejiogu et al., 2020). The road network in Iraq has experienced a deterioration in quality and accessibility as a consequence of prolonged periods of war, strife, and economic sanctions. The outlined difficulty has had a massive impact on the general development and growth of the entire country. In this context, the expenses related to transportation and logistics have emerged as a notable barrier to commerce(Hasan et al., 2020). Improving the performance of public infrastructure over its lifetime is essential, and one means to do so in Iraq is to activate the existing road management system. This system is especially important because it relates to the management of a particular of the nation's most important public infrastructures - the road network(Robinson, 2008).Due to the numerous factors that influence decision-making at various organizational levels, managing a country's road transport system is a challenging task. These variables can include technical, economic, social, and political factors(Knudsen, F Kirk, 1998). Thus, many nations, including Iraq, are attempting to attain a sustainable road system(Jamshed et al., 2018)(Musawi & Jabbar, 2020) . The Brundtland Report (WCED 1987) by the World Commission on Environment and Development (WCED) provides a definition of sustainability, which is the ability to develop in a way that fulfills the needs of the present without endangering the ability of future generations to meet their own needs. Ensuring economic sustainability is a crucial aspect of overall sustainability (Burrow et al., 2013), And in the case of roads, this entails securing long-term funding for road maintenance and operations. This is required to ensure that road users can continue to receive services over time(Emoto, 2013) . In many nations, the construction, maintenance, and operation of roads are supported by multiple sources, including taxes(Dumortier et al., 2017) , road user fees such as vehicle licenses and tolls(Sihombing et al., 2018) , and private sector involvement through Public-Private Partnerships (PPP)(Queiroz et al., 2016) .

Aims of Study

The study intends to assess financing strategies for sustainable infrastructure development in Iraq, with a focus on the road network managed by the Diyala government, through the feasibility study evaluated the financial efficacy of renewing annual vehicle licenses and road maintenance in the Governorate. The primary goal is to improve road management practices in Iraq, thereby making an important contribution to the country's general sustainable improvement method.

Research Methodology

To achieve the main study's objectives, a methodology incorporating the collection of data from the selected case study and relevant Diyala Governorate departments will be employed. As demonstrated below, economic analysis techniques (Net Present Value, Internal Rate of Return, and Benefits Cost Ratio) will be utilized in the data analysis process with the assistance of computer programs such as Microsoft Excel.

Field Study

The Hamrin Lake Road was chosen as the case study due to its importance as a major road in Diyala Governorate, connecting it to the northern governorates and reducing distance and travel time. In addition, it connects to the Al-Amunthiria border crossing, making it a

commercial route to Iran. As shown in Fig. 1. The road extends 30 km in length and 7.5 m in width as it crosses Lake Hamrin. During the preliminary survey of the road, it was discovered that a variety of vehicles relevant to the study were using it as explained in Fig. 2. Based on interviews conducted with the relevant agency overseeing the road infrastructure, it has been determined that the road necessitates ongoing maintenance efforts due to many reasons that contribute to its deterioration. Of particular significance is the regular transit of large trucks, which exacerbates the road's wear and tear.

Fig 1: Location Hamrin Lake Road by Google Maps

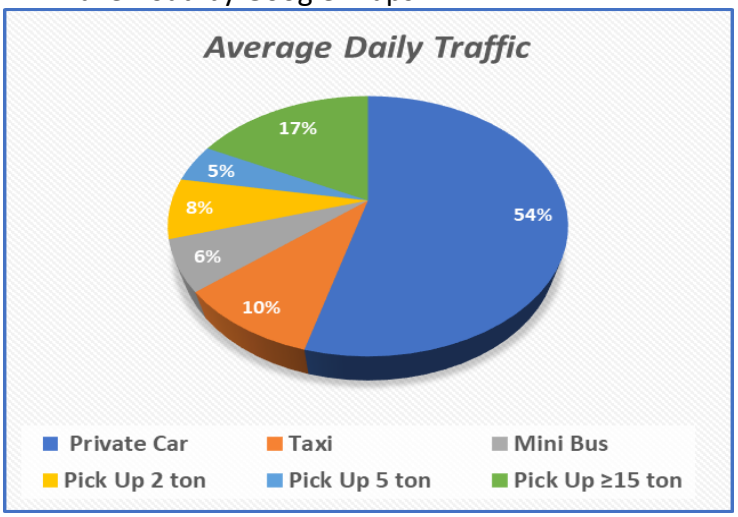

Fig 2: Composition of the Traffic Volume along the Hamrin Lake Road

Data Collection

Collect the necessary data from the chosen case study to fulfill the requirement the law No. (40) In 2015, it mandated the imposition of fees on vehicles to fund the maintenance of roads and bridges in Iraq through the renewal of vehicle licenses. To this end, the manual method was used to indirectly calculate the number of vehicles(FHWA, 2016), and daily traffic volume data was collected using closed-circuit television (CCTV) at the halfway point (Hamrin intersection) for ten days in December, from 6 a.m. to 5 p.m. The vehicles were categorized by the aforementioned law, as detailed in the (Qanunji) application accessible via Google Play.

Data Analysis and Results

This part presents the mechanism used to analyze the results from the case study, where data on traffic volume was collected and future traffic was predicted for various vehicle categories. It also examines how benefits are calculated for these vehicles when licenses are renewed and Compares it with the annual costs spent on maintenance. In addition, an economic evaluation of the benefits is performed using techniques such as the benefit-cost ratio (BCR), the Internal Rate of Return (IRR), and the net present value (NPV). To determine the most appropriate discount rate for future planning and decision-making, the results of NPV and BCR are contrasted across various discount rates, explained below:

1- Calculate current and Future Traffic Volume

The results of the study are dependent on data regarding daily traffic volume and prospective traffic projections. The average daily traffic (ADT) is a significant parameter that can be employed to assess the necessity of road enhancements, the effectiveness of traffic management strategies, and the degradation experienced by a roadway. This information is crucial for maintenance and repair planning. The second metric is the Future average daily traffic, which helps transportation planners and engineers make informed decisions regarding roadway design, capacity, and funding(Administration), 2018). The equations shown below can be used to apply these two metrics. In addition, the future vehicle traffic volume was estimated using a growth rate of 3% (Zehawi et al., 2022) over the next 20 years, as shown in Table 1.

$$AADT = \frac{1}{n} \sum_{k=1}^{n} vol_i \quad (1)$$

Where VOL_k : daily traffic on the k^{th} day of the year, n: number of days in a year (365 or 366).

$$AADT_{Future} = AADT_{Curten} * (1 + AACR)^n \quad (2)$$

Where AADT: Future Annual Average Daily Traffic for the forecasted year (Veh/day),
AADT: Current Annual Average Daily Traffic for the Current year (Veh/day),
AACR: Annual Average Change Rate, n: number of forecasted years.

Table 1
Traffic Volume Calculations of Hamrin Lake Road

Vehicle		Total for ten days Toward Khanaqin districts.	ADT	Total Yearly	Total for ten days Toward Al-Muqdadiya districts.	ADT	Total Yearly	FADT
Private Car		15773	1577	575715	15,539	1,554	567,174	5,655
Taxi		2974	297	108551	2,641	264	96,397	1,014
Mini Bus		1765	177	64423	1,897	190	69,241	661
Pick Up	2 ton	2157	216	78731	2,175	218	79,388	782
	5 ton	1147	115	41866	1,579	158	57,634	492
	≥15 ton	4588	459	167462	5,516	552	201,334	1,825
*FADT= Future Average Daily Traffic								

2-Economic Feasibility Analysis

A feasibility study was carried out to evaluate the economic feasibility of annual vehicle license renewals. This was accomplished by comparing the revenue generated from license renewals to the annual maintenance costs of the roads, with inflation adjustments made from the base year. The study also considered net present value, a financial analysis technique used to determine the value of future cash flows at present(Farida et al., 2019) . The idea of the analysis is to know the adequacy of the revenue generated from vehicle license renewals in relation to the expenses incurred for road maintenance and to evaluate the financial feasibility of the project.

Benefits Calculation. From the application of Law No. 40 of 2015, the annual revenue can be calculated for each type of vehicle passing on the road. And as follows:

1. Determine the traffic volume for each type of vehicle passing on the road.
2. Determine the amount of renewing licenses for each type of vehicle.
3. The percentage of maintenance of roads and bridges is determined by law and is equal to 55%.
4. Determine the percentage of the road from the main roads and equal to 5%, this is done by dividing the length of Lake Hamrin Road (30 km) by the length of the main roads of the governorate, which are (665 km).

Cost Calculation. Depending on maintenance work for the year 2022 by the Directorate of Roads and Bridges of Diyala, cost calculations were determined as below:

1. Initial cost = last Work maintenance for the Road amounting to (1,650,000,000) minus benefits of vehicles for the year 2022.
2. Annual maintenance cost was estimated as (50,000,000) with an increase of 1% every five years for twenty years.

3-Benefit-Cost Analysis (BCA)

This tool is used to evaluate the advantages and disadvantages of a proposed project (in this instance, vehicle licenses and maintenance costs) so that resource allocation decisions can be made with knowledge. The benefits and costs are examined financially, and the analysis is conducted over a specific time frame(Litman, 2001) Several methods, such as the Benefit Cost Ratio (BCR), Net Present Value (NPV), and Internal Rate of Return (IRR), necessitate the application of a discount rate to evaluate the economic efficiency of a project. Their corresponding equations are provided below. The discount rate is significant because the current value of money or assets is considered to be more valuable than its expected future value. In evaluating transportation initiatives, the World Bank uses an average discount rate of 10% to 12 % (Zhuang et al., 2007).

$$p = F\left[\frac{1}{(1+i)^n}\right] \quad (3)$$

Where P Present value of benefits or costs, F benefits or costs value in the future, n number of future years for the project and i discount rate.

$$\frac{B}{C} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \quad (4)$$

Where B_t, C_t Benefit and Cost in year t for any project, n the total number of years for the project duration/lifespan, and i discount rate.

$$npv = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t}$$

(5)

Where B_t, C_t, t, n, and i as was mentioned previously.

Using the above-mentioned equations and a discount rate of 12%, the annual maintenance costs were subtracted from the annual benefits to determine the net value. Results are displayed in (Table 2), revealing that the advantages crossed the costs, resulting in a net present value of 9,046,076,859 dinars. The benefit-cost ratio (BCR) was also extremely favorable, with a score of 10.52 compared to the benchmark of 1.0. The internal rate of return, which measures the point at which benefits equal costs, was calculated using Excel and found to be 186.87%, exceeding the evaluation benchmark rate.

Table 2
Net Benefits Calculations for 20 Years

Year	Annual Maintenance Cost	Benefits Private Cars	Benefits Taxi	Benefits Mini-Bus	Benefits Pick –Up 2 ton	Benefits Pick Up ≥ 5 ton	Benefits Pick-Up≥ 15 ton	Net Benefits
0	-575,274,838	0	0	0	0	0	0	-575,274,838
1	-50,000,000	161,851,174	69,723,687	56,759,051	107,438,991	84,673,339	626,520,675	1,056,966,917
2	-50,000,000	166,706,710	71,815,398	58,461,823	110,662,161	87,213,539	645,316,295	1,090,175,925
3	-50,000,000	171,707,911	73,969,860	60,215,677	113,982,026	89,829,945	664,675,784	1,124,381,203
4	-50,000,000	176,859,148	76,188,955	62,022,148	117,401,486	92,524,843	684,616,058	1,159,612,639
5	-50,000,000	182,164,923	78,474,624	63,882,812	120,923,531	95,300,589	705,154,539	1,195,901,018
6	-50,300,000	187,629,870	80,828,863	65,799,297	124,551,237	98,159,606	726,309,176	1,232,978,048
7	-50,300,000	193,258,766	83,253,729	67,773,275	128,287,774	101,104,395	748,098,451	1,271,476,390
8	-50,300,000	199,056,529	85,751,340	69,806,474	132,136,407	104,137,526	770,541,404	1,311,129,682
9	-50,300,000	205,028,225	88,323,881	71,900,668	136,100,499	107,261,652	793,657,646	1,351,972,572
10	-50,300,000	211,179,072	90,973,597	74,057,688	140,183,514	110,479,502	817,467,376	1,394,040,749
11	-50,600,000	217,514,444	93,702,805	76,279,419	144,389,020	113,793,887	841,991,397	1,437,070,972
12	-50,600,000	224,039,878	96,513,889	78,567,801	148,720,690	117,207,703	867,251,139	1,481,701,101
13	-50,600,000	230,761,074	99,409,306	80,924,835	153,182,311	120,723,935	893,268,673	1,527,670,134
14	-50,600,000	237,683,906	102,391,585	83,352,580	157,777,780	124,345,653	920,066,733	1,575,018,238
15	-50,600,000	244,814,423	105,463,333	85,853,158	162,511,114	128,076,022	947,668,735	1,623,786,785
16	-50,900,000	252,158,856	108,627,233	88,428,752	167,386,447	131,918,303	976,098,797	1,673,718,389
17	-50,900,000	259,723,622	111,886,049	91,081,615	172,408,041	135,875,852	1,005,381,761	1,725,456,940
18	-50,900,000	267,515,330	115,242,631	93,814,063	177,580,282	139,952,127	1,035,543,214	1,778,747,648

19	-50,900,000	275,540,790	118,699,910	96,628,485	182,907,690	144,150,691	1,066,609,511	1,833,637,078
20	-50,900,000	283,807,014	122,260,907	99,527,340	188,394,921	148,475,212	1,098,607,796	1,890,173,190

Sensitivity Analysis

In benefits-costs analysis, sensitivity analysis is advantageous because it enables analysts to evaluate the impacts of various assumptions on the overall outcome. By modifying key hypotheses, analysts can determine which factors have the greatest impact on the analysis's outcomes and which areas require further examination or refinement. In addition, sensitivity analysis can help identify situations where the net benefits of a project are negative, which can influence decision-making (Ha, 2019). The earlier-mentioned study used a discount rate of 12% to calculate the net present value of benefits, yielding a positive result. In addition, to assess the feasibility of the project, the discount rate was increased from 10% to 50%, and the results were compared to the minimum acceptable standards (NPV > 0 or IRR > discount rate) indicated in Table 3.

The computations obtained positive results, indicating the project's economic viability. To ensure a project's financial viability, it is crucial to anticipate potential changes in traffic patterns and assess their impact on its costs and benefits. For instance, if the anticipated traffic growth rate drops to 1% or 2%, as represented in Fig.3 and Fig.4, and the resulting benefit-cost (B/C) ratios are greater than one and the net present value (NPV) is positive, as shown in Table 4, then the project can still be considered financially feasible. This indicates that the project's economic viability can withstand changes in these factors.

Table 3
Net Present Value with Different Discount

Year	Net Benefits	Dis. Rate 10%	Dis. Rate 12%	Dis. Rate 40%	Dis. Rate 50%
0	-575274838	-575,274,838	-575,274,838	-575,274,838	-575,274,838
1	1056966917	960,879,016	943,720,462	754,976,370	704,644,612
2	1090175925	900,971,839	869,081,573	556,212,207	484,522,633
3	1124381203	844,764,239	800,312,331	409,759,913	333,149,986
4	1159612639	792,031,035	736,954,796	301,856,684	229,059,287
5	1195901018	742,560,442	678,586,354	222,359,177	157,484,908
6	1232978048	695,983,965	624,665,051	163,752,195	108,244,986
7	1271476390	652,468,432	575,151,347	120,617,980	74,416,542
8	1311129682	611,651,673	529,543,288	88,842,621	51,158,238
9	1351972572	573,368,348	487,534,863	65,435,822	35,167,909
10	1394040749	537,463,056	448,843,812	48,194,237	24,174,799
11	1437070972	503,684,609	413,123,564	35,487,044	16,614,006
12	1481701101	472,115,633	380,315,768	26,135,101	11,419,984
13	1527670134	442,511,622	350,102,566	19,247,092	7,849,522
14	1575018238	414,751,528	322,279,937	14,174,022	5,395,205
15	1623786785	388,721,646	296,659,775	10,437,788	3,708,174
16	1673718389	364,249,886	273,019,725	7,684,822	2,548,134
17	1725456940	341,372,457	251,303,039	5,658,841	1,751,268
18	1778747648	319,923,400	231,307,615	4,166,868	1,203,571
19	1833637078	299,814,315	212,897,691	3,068,179	827,141
20	1890173190	280,962,201	195,948,140	2,259,128	568,429
	Total	10,564,974,503	9,046,076,859	2,285,051,252	1,678,634,497

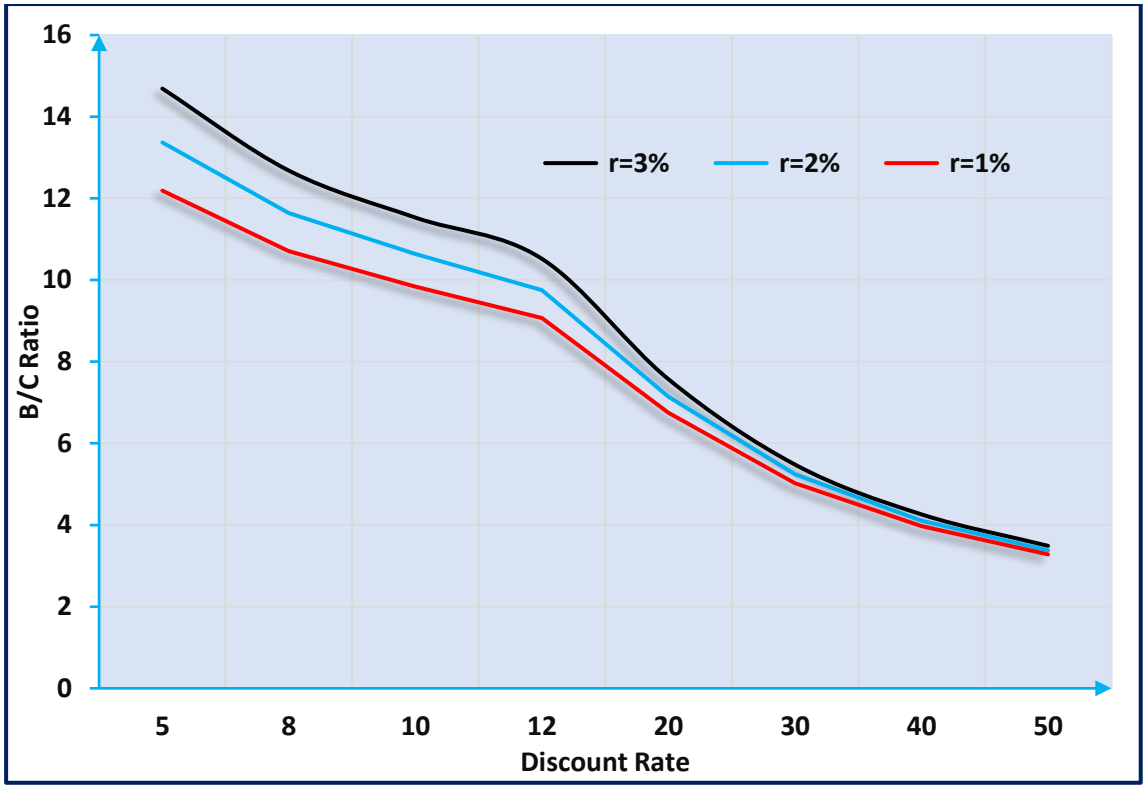

Fig 3: Effective of Traffic Growth Factor on BCR

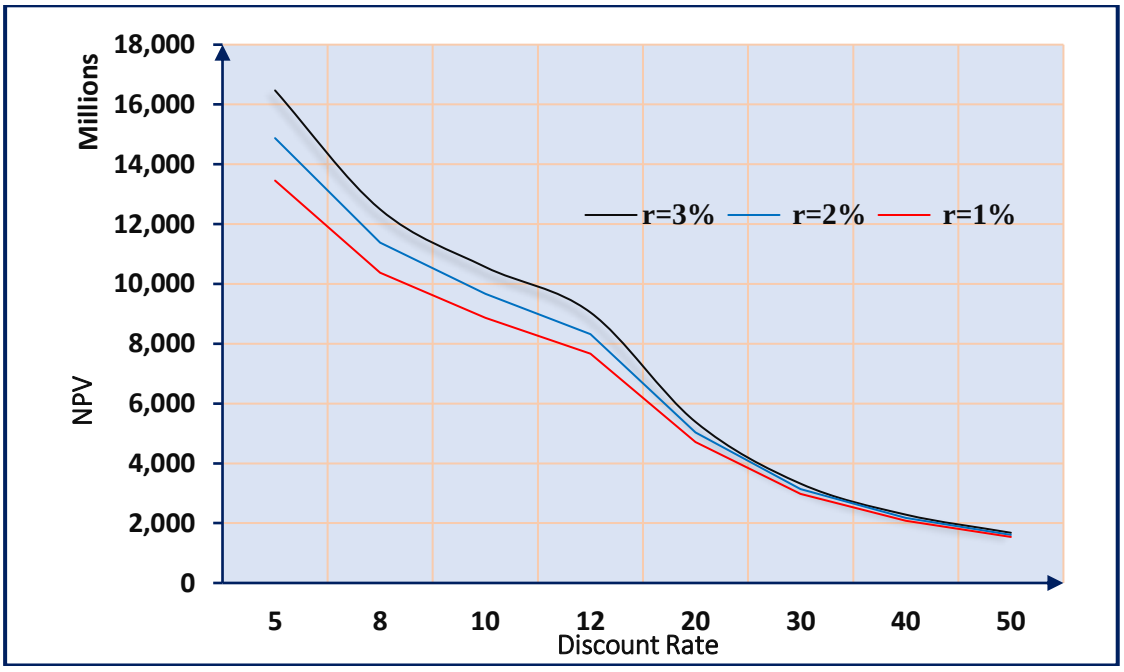

Fig 4: Effective of Traffic Growth Factor on NPV

Table 4
Value of NPV and CBR with Different (Discount Rates and Traffic Growth Factors)

Discount Rate (%)	NPV			BCR		
	r=3%	r=2%	r=1%	r=3%	r=2%	r=1%
5	16,469,615,136	14,873,629,789	13,454,348,948	14.69	13.37	12.19
8	12,491,150,756	11,376,373,123	10,378,003,575	12.68	11.64	10.71
10	10,564,974,503	9,672,776,948	8,869,941,765	11.53	10.64	9.84
12	9,046,076,859	8,322,893,296	7,669,055,556	10.52	9.75	9.07
20	5,385,226,586	5,034,480,596	4,711,602,903	7.57	7.14	6.75
30	3,319,504,677	3,143,049,186	2,977,566,646	5.48	5.24	5.02
40	2,285,051,252	2,179,372,263	2,078,910,633	4.26	4.11	3.97
50	1,678,634,497	1,607,435,408	1,539,101,936	3.49	3.38	3.28

Conclusion and Recommendation

Hamrin Lake Road in Iraq play a significant role in the public infrastructure, serving as a vital component for fostering economic development and promoting prosperity. Nevertheless, financing road maintenance is difficult. A feasibility study was conducted to assess the financial viability of renewing annual vehicle licenses and road maintenance in Diyala Governorate. The benefit-to-cost ratio (BCR), net present value (NPV), and internal rate of return (IRR) are methods used to assess whether the revenue generated from a vehicle license renewal will be sufficient to cover the costs of road maintenance. Where taking into account whether the project is financially feasible for future investment and the sustainability of its financing.

The research revealed that the benefits of the project surpassed its expenses, as evidenced by the favorable Net Present Value of 9,046,076,859 dinars and the benefit-cost ratio of 10.52, which exceeds the benchmark score of 1.0. Furthermore, the research findings indicated a significant internal rate of return of 186.87%. Hence, the proposed effort demonstrates financial feasibility and is expected to enhance the long-term economic sustainability of the road.

To validate the findings, a sensitivity analysis was conducted, considering the key variables that impact the assessment of the feasibility study. By altering the discount rate (from 10% to 50%) as well as examining prospective changes in traffic patterns (r=1% and r=2%), the study determined that the project's economic viability could withstand changes in these factors.

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