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Possibility of overcoming obstacles to adopt sustainable practices of road paving layers in Iraq

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ABSTRACT

It is evident that there is an increasing need, day by day, to adopt sustainable practices due to the increasing volume of harmful impacts on the environment, especially in the transportation sector. The situation in Iraq is very clear because of the complete dependence on vehicles in the process of transporting and shipping goods due to the absence of alternatives. The previous literature on the importance of sustainable practices in improving the properties and specifications of roads has been studied, and then the current reality of roads in Iraq has been explained. In the last part, a questionnaire was conducted to clarify the obstacles that impede the use of these sustainable practices, and the reasons were reached. The study concluded that addressing this growing problem begins through education and cultural development of society by all concerned parties while supporting research. The planning process should include finding all special instructions and regulations that affect the safety of the environment, such as granting building or import permits, or in the field of agriculture and industry to serve these practices. The adoption of sustainable practices must meet the local circumstance represented in the behavior, culture and economy of the population community as well as the geographical location and climate of such environment.

Keywords: Road paving, Road management, Sustainability, Sustainable road practices, Sustainability obstacles

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1. Introduction

It is well known that the roads in general and in Iraq in particular are the lifeblood through which different cities are supplied with goods and necessities of life, in addition to the movement of passengers, and for this reason the roads take great importance from the attention of countries in which a lot is consumed in the construction, maintenance and rehabilitation of roads. In the new global economy, sustainable infrastructure has become a central issue for sustainable development. In general, road infrastructure is a key aspect of sustainable infrastructure [1]. Therefore, it became necessary to pay attention to the impact of roads on the environment and find all possible practices to preserve it and the health and safety of society and future generations. To determine the sustainability characteristics of road projects, it must include its entire life cycle, especially in highways, with the realization that highways are the pivotal part of the transportation infrastructure, and that transportation is inevitable to meet human needs. Dealing with the preservation of environmental and natural resources focuses on developing sustainable roads that must be accessed (through finding alternatives) and transporting people and goods (not only by vehicles), and this is achieved by providing people with various means of transportation such as safe and comfortable roads for walking, cycling and crossing [2]. The practice of constructing sustainable roads is based on four basic points:

(a) Satisfactory performance of the pavement during its design period.

(b) Environmentally friendly technology.

(c) Taking into account the economic situation and what is available locally.

(d) Construction should be favorable to human safety, health and comfort around the world [3].

The obsolescence of road networks and the lack of regular maintenance are among the challenges facing the national development of the road sector in Iraq, which is reflected in the increase in the amounts required to conduct regular maintenance of the road network [4]. This paper aims to shed light on the problems of road and vehicle use and to identify obstacles to adopting sustainable practices in the road construction sector in Iraq despite the social, economic and environmental benefits that can be achieved.

2. Litrature review

Many studies about using sustainable practices in roads construction have been conducted all over the world. Sinah et al. (2019) studied the suitability of utilization of jarofix mixes in high embankment and pavement construction. They discussed the test results and its interpretation before concluding about its suitability in road construction [5]. Truong et al. (2019) reveals critical success factors to achieve sustainable toll road projects in the planning stage to control and enhance the financial sustainability in the executing stage in china [6]. Appiah et al. (2017) showed that the waste plastic modified bitumen carries great promise as an alternative recycling method for plastic waste management in Ghana, as well as a non-traditional, modified binder for road construction [7]. Thom and Dawson (2019), reviewed the opportunities to increase sustainability by utilizing less environmentally damaging material sources, and also the associated challenges [8]. Adegoke el al. (2019) examined some limitations regarding the adoption of different recycled waste materials as alternative construction materials for highway/pavement construction. However, it is generally recognized that reuse of waste materials in construction industry has minimal impact on the environmental and their exploration would have huge economic impact [9]. Mondschein (2018) summarized past experience in the use of reclaimed material in road construction layers according to various technologies applied in road construction [10]. Willar et al. (2019) evaluated the means of the implementation of sustainable principles in executing infrastructure projects in Indonesia by the main construction service providers and their partners [11]. Karji et al. (2020) identified sustainable construction barriers in the United States and highlighted challenges to sustainable construction practices in the US construction industry and promote the integration of sustainable practices which expected to pave the way for the application of sustainable practice in the construction industry [12]. Ametepey et al. (2019) identified and prioritized possible barriers to implementing sustainable construction successfully in the Ghanaian construction industry and illustrated measures to overcome potential barriers [13]. G. J. Qasim et al. showed the effect of adding metakaolin (Pozzolan as a partial replacement of cement) on the improving of stability flow, tensile strength and air voids content and resistance to moisture damage [14]. Although, the use of sustainable materials in roads construction still very limited [15, 16] but the increasing in the absorption of sustainable materials across the road sector is one of the infrastructure sector's biggest challenges.

3. Research methodology

The possibility of adopting sustainable practices in transportation projects in Iraq has been studied through several stages. The first stage was the study of previous researches (literature review) on this topic. The second stage clarified the size of the problem related to the impact of roads on the environment and the reasons for the increase in this problem. These impacts have been separated into direct impacts through vehicle emissions and indirect effects through the use of mixtures in construction and maintenance work on paved road layers. At the next stage, barriers to the application of sustainability in road construction sector were identified and a closed questionnaire survey was conducted to identify the extent of each barrier to the use of sustainable practices in road construction sector.

4. The reality of roads in Iraq

In the past, roads in Iraq were few and were not paved. Vehicles began to enter Iraq during the thirties of the last century after Iraq came under British rule, where the number of vehicles was very few. After World War II, the volume of vehicles, especially those used by the British army, began to increase in Iraq, which required the establishment of a simple road system compatible with this size (see Figure 1). The old roads linking Iraqi cities have been developed, and a number of highways were constructed in the eighties due to the increased need, especially during the period of the Iran-Iraq war.

Figure 1. The City of Baghdad at the beginning of fifties of the last century

Many of these roads suffered from neglect due to the lack of financial allocations and weak maintenance programs during the period of wars, as well as because many of them were exposed to missiles, explosives, and damage arising from the movement of tanks and other military vehicles in the nineties and after the events of the war in 2003. Therefore, due to the large number of road users and the lack of maintenance programs (that define priorities depending on the size of the benefits in relation to the costs and the lack of financial allocations, the problems of maintenance and rehabilitation have become a great concern because of the size of the expenditures and the required materials.

4.1 World Bank projects

Because of the increasing use of vehicles and roads, and because of the long period of neglect of these roads in the eighties and nineties, and the subsequent exposure of these roads to damage by war, the size of the required expenditures became so large that the budget could not cover the costs of maintenance and rehabilitation, therefore, the issue of maintenance and rehabilitation, as well as the construction of new road projects outside cities, has been developed within the World Bank projects. The information below shows the length of roads and the volume of expenditures adopted by the World Bank projects on road projects in Iraq in the last years since 2009 as in table 1, where maintenance and rehabilitation works occupy the largest part of the volume of work. The total lengths implemented by the World Bank projects are shown below:

- The length of major roads: 7729.25km.
- The lengths of secondary roads: 8619.47km.
- The lengths of rural roads: 16181km.
- The lengths of border roads: 11000km.

Table 1. The annual spending for these projects

	Year	Financial Allocations I.D.	Actual expenses I.D.
1	2009	74772000000	74567940419
2	2010	52154822000	53234994171
3	2011	132379437440	106712493606
4	2012	130033937440	128652289975
5	2013	142500000000	142498000000
6	2014	140000000000	139835000000
7	2015	32000000000	31998000000
8	2016	9002000000	31217000000
9	2017	1906000000	6940000000
10	2018	15676000000	15676000000
11	2019	33050000000	35950000000

Information in Table 1 was obtained from World Bank Projects in Baghdad

4.2 The impact of using roads on the environment

Roads are of great importance in transportation in Iraq for both passengers and goods, where transportation by vehicles makes up more than 98% of transport between internal regions for the reasons explained below:

- The absence of transportation through rivers due to negligence in preparing rivers for transportation and the low levels of rivers and their fluctuation between summer and winter.
- The limited movement of trains between cities due to the neglect of many decades.
- Limited air transport due to the unavailability of airports in many Iraqi cities and the high transportation prices compared to neighbouring countries.

Due to the large use of roads, the impacts on the environment are naturally significant due to the process of constructing the roads or the process of maintenance and rehabilitation of old road layers, which represent the largest size of such projects.

4.3 Challenges facing the paved mix industry in Iraq

The road layers usually consist of a mixture that includes the bonding material, which is usually a bituminous material with fillers, which are usually fine and coarse aggregates. The mixture is usually heated to facilitate its formation later. There are several specifications and standards that determine the quality characteristics of the mixture such as strength, soundness, stability and flow, durability and some others and in order to reach such limits of the standard, some tests must be made for the materials of the mixture to indicate its validity. The limits of the requirements of the standard specifications take the temperature of the region into consideration and to reach such requirements, some additives must be added to improve the properties, such as polymeric materials to improve the properties of the binder, as well as cement or pozzolana can be added and used.

Iraq is one of the countries well known for its possession of many fields for oil production, and the bituminous material used as a binder in the mixture is one of the products of the oil refining industry, but the properties of the produced bituminous materials depend on the location of extraction and the method of refining. As for polymeric materials, there is no local industry available and they are generally imported from the countries that manufacture them. They are important materials and their presence improves the properties of the mixture and

increases the cost of manufacturing. There are several sites for the manufacture of road mixes distributed from north to south Iraq, but they are generally not sufficient for the increasing need for maintenance of roads, therefore, this industry faces a growing challenge and this requires attention to sustainable practices to preserve the environment.

There are some simple sustainable practices where the damaged layers of the highways are reused after taking off and reheating of those layers and they are used in paving agricultural roads where the number of vehicles that using such roads is few and traveling at relatively low speeds.

5. Environmental impacts and sustainable practices in the pavement layers

The paving layers of the road should have the qualified specifications that are required to withstand different loads and face different climatic conditions during their life cycle. The following points should be concerned in the study of environmental impacts at different stages as shown below:

a- The stages of planning, preparing design and specifications for mixtures for each layer (An interest in material selection and implementation).
b- The environmental impacts accompanied by the stage of extracting and preparing raw materials related to the paving mixture.
c- The impacts of manufacturing, transferring and paving stages of the mixture on the project site.
d- The impacts of road layers on the environment over the entire life stage of such layers and how can it be preserved and maintained to prolong its life.
e- The possibility of benefiting from recycling and reuse.

There is a lot of international and local research, as indicated in a section of the literature review in this research, which encourages adoption of sustainable practices in this field that aim to the followings (see Figure 2):

1- Reducing the harmful effects on the environment and natural resources.
2- Preserving human and community health by minimizing harmful effects and risks in dealing with materials.
3- Supporting the local economy by relying on locally available labor, materials and technologies as much as possible without compromising quality, efficiency and durability.
4- Take advantage of recycling or reuse of some damaged pavement layers.
5- Reducing the cost of importing some expensive materials, especially polymeric materials, through some local products that have been verified of their suitability through local research and experiences that are still ongoing.
6- Take advantage of some wastes, especially industrial ones such as vehicle tires and some waste from local oil industries, in the mixture to compensate for some materials or to improve their performance without impairing their specifications.

6. Identifying obstacles to the use of sustainable road practices

In order to identify the reasons that impede the use of sustainable practices in road construction sector ,a questionnaire survey was conducted .The questionnaire survey involved two sections, the first section included personal information about respondents and the second section included the identified obstacles to the use of sustainable practice in roads construction sector.

The second section of the questionnaire adopted a five- likert scale from 1 to 5, where 1 stands for (strongly disagree) and 5 stands for (strongly agree). Sixty forms of the closed questionnaire were distributed to engineers who are working in roads construction sector while only 50 forms were returned complete and analyzed.

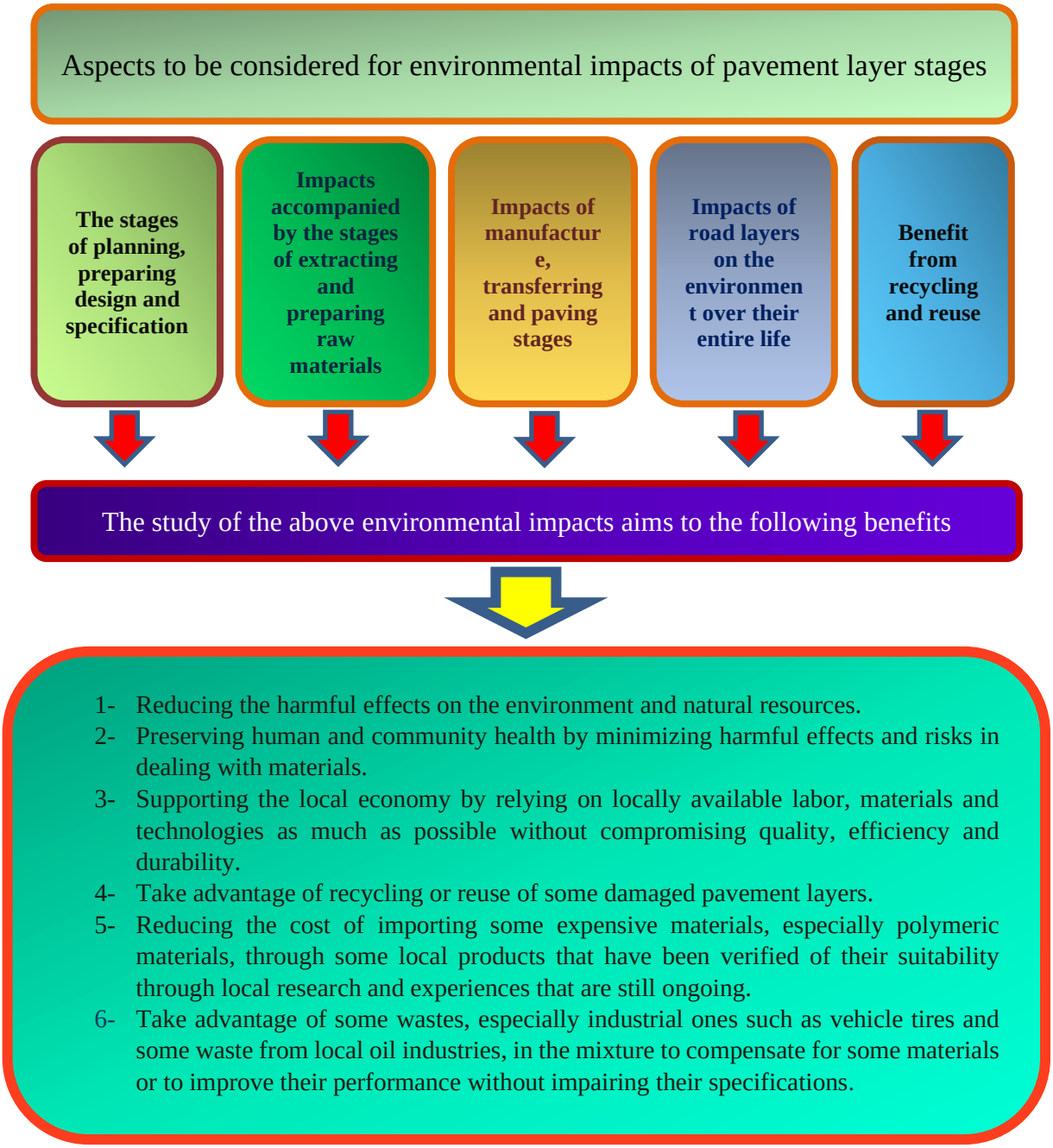

Figure 2. Benefits from adopting sustainable practices

Questionnaire results were subjected to descriptive statistics and were performed using SPSS 14.0. Summary Statistics table including: Mean, Standard Deviation, Relative importance index, were used in data analyzing. Where Relative Importance Index (RII) is calculated by Equation (1) [17]:

$$RII = \frac{\sum W}{A * N} \quad (1)$$

where,

RII: relative importance index

W: the weight of each obstacle that represents responses answers from (strongly agree to strongly disagree).

A: the highest possible rating in the adopted scale in the study which is 5

N: the total number of respondents (50 in this study)

In order to measure the consistency of the questionnaire, Alpha Cronbach reliability factor was determined. The aim of this test is that the questionnaire scale gives the same results if it is applied to the research community again. The result of alpha Cronbach was 0.8 while the standard lower bound is 0.7 and therefore the answers of the study sample can be relied upon as well as their analysis.

7. Results and discussion

The percentage of educational degree of respondents is shown in Figure 3, from 50 respondents, 34 of them had B.Sc. which is equal to 68 percent, 12 of them had M.Sc. which is equal to 24 percent and 4 of them had PhD which is equal to 8 percent. The percentage of years of experience of respondents is shown in Figure 4, from 50 respondents, 22 of them had 5 to 10years of experience in roads design and construction which is equal to 44 percent, and 28 of them had more than 10 years of experience in roads design and construction which is equal to 56 percent.

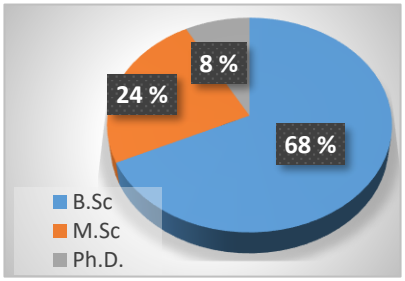

Figure 3. Educational degree of respondent

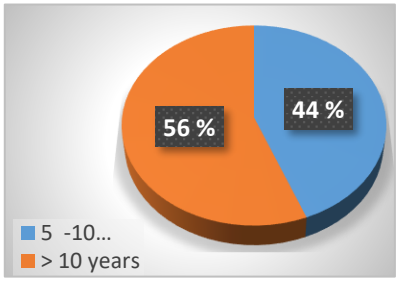

Figure 4. Years of experience of respondents

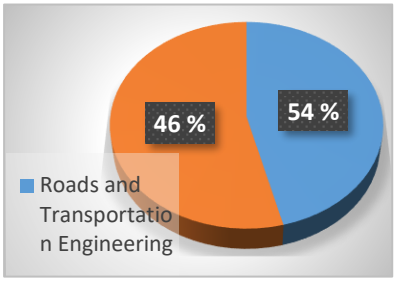

Figure 5. specialist of respondents

The percentage of specialist of questionnaire sample which all were working in roads design and construction is shown in Figure 5, from 50 respondents, 23 of them are Roads and Transportation Engineers which is equal to 46 percent and 27 of them are civil engineers which is equal to 54 percent.

Table 2 shows the ranking of the challenges that face the adoption of sustainable practices of road pavement layers in Iraq in accordance with their calculated RII. The table illustrates that Lack of experienced and skilled people in sustainable road practices with RII=0.792 has the highest impact on the adoption of sustainable practices followed by uncertain economic environment with RII=0.778. Lack of reliable sustainable material suppliers and maintenance process procedures comes in the 3rd rank with RII equal to **0.752** followed by lack of integrated research planning between the theoretical and practical fields with RII= 0.744 . In the same context the lack of alternatives to the existing materials or means of transportation to support sustainable practices was rated as having the lower impact with RII= 0.592. In order to overcome obstacles that stand in the way of adopting sustainability practices in roads, they can be categorized into four main reasons as shown in Figure 6:

- Economic reasons
- Reasons related to management
- Reasons related to lack of awareness and culture
- Technical reasons and poor experience and skill

8. Conclusions and Recommendations

It is evident from the above that there are several obstacles that stand in the way of adopting sustainable practices of road pavement layers in Iraq, as explained below:

1- There is a great need for experts who have sufficient experience and knowledge that qualify them to enter this field.

2- The current economic conditions are not conducive to making major changes.
3- The insufficient availability of the required alternative sustainable materials and the lack of suppliers for them.
4- There is a clear big gap in the application of studies and research on the reality of road layers.
5- There is a clear adherence to traditional methods and opposition to making change.

Table 2. Obstacles that impede adopting sustainable practices in roads

Obstacles	mean	Standard deviation	RII	Rank
Lack of experienced and skilled people in sustainable road practices	3.96	0.84	0.792	1
Uncertain economic environment	3.89	0.83	0.778	2
Lack of reliable sustainable material suppliers and maintenance process procedures	3.76	0.68	0.752	3
lack of integrated research planning between the theoretical and practical fields	3.72	1.02	0.744	4
The rigid adherence to traditional road maintenance and construction processes	3.68	0.95	0.736	5
Lack of government incentives	3.65	0.98	0.73	6
The lack of real commitment from the concerned authorities to develop sustainable practices	3.60	1.14	0.72	7
Political impacts that obstruct adopting the controls, regulations and laws for sustainable practices	3.5	1.08	0.7	8
The lack of accurate data of the impacts of paving materials as well as emissions from vehicles during their life cycle	3.44	0.92	0.688	9
Lack of interest in the issue of sustainability	3.36	0.81	0.672	10
Lack of awareness of sustainable road practices	3.28	1.02	0.656	11
The adoption of sustainable practices may increase the duration of the project	3.20	1.14	0.64	12
The adoption of sustainable practices in roads may be more expensive than traditional methods	3.16	1.03	0.632	13
The lack of alternatives to the existing materials or means of transportation to support sustainable practices	2.96	1.24	0.592	14

Figure 6. Obstacles that stand in the way of adopting sustainability practices

Therefore, there is a need to introduce the changes that must start through planning and adopting a culture of sustainability in the curricula to reach the culture sufficient to make such changes. The study of the environmental impacts of road paving layers should include all the different stages from the beginning of planning and design until the end of the life of these layers as shown below:

- The planning and design stage must include taking into consideration the use of research and studies to select local materials and alternatives and benefit from reuse or recycling while preserving all the required properties and specifications that are appropriate for different weather conditions.
- In the stage of extracting and preparing raw materials, the best techniques and methods must be chosen to reduce environmental damage.
- In the stages of manufacturing, transportation, and placing or laying of paving mixtures, care and caution must be taken in choosing manufacturing sites, machinery and appropriate equipment that provide the quality control and specifications required to reach the best results.
- After paving stage, layers must be monitored and the necessary maintenance carried out to maintain the permanence of these layers for the longest possible period.
- In the final stage, consideration should be given to the possibility of benefiting from recycling and reuse.

Achieving sustainable practices should start by adopting these ideas in society through the media, schools, universities and other institutions to consolidate their bold conviction to preserve the environment and health now and in the future.

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