INVESTIGATION OF GREEN RURAL ROAD NETWORK ELEMENTS FOR SOCIOECONOMIC DEVELOPMENT IN RURAL AREAS

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ABSTRACT

Sustainable development has been defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Nowadays, the implementation of green practices has become one of the most favoured methods in road construction, given that these vital infrastructure assets have a significant impact on the environment and human well-being. These impacts include alterations to the physical landscape and a negative effect on the quality of life for the surrounding communities. In Malaysia, particularly in rural areas, the networks comprise the largest proportion of roads in the country, making efficient and sustainable rural road networks even more crucial. Therefore, this study aims to identify the elements of green rural road networks that should be considered in the development of rural roads. Additionally, the study investigates the green road elements that potentially contribute to socioeconomic development in rural areas. Moreover, the absence of a specific guideline for green road development in rural areas highlights the need to address this gap through a systematic approach. This study employs five phases of methodology process in order to achieve its objectives, which include identifying the elements of green rural road networks, analysing their effectiveness and determining the significant green rural road elements that potentially contribute to socioeconomic development in rural areas. Through an intensive literature review, 32 elements for green rural road networks were identified. These elements were then presented in the form of a questionnaire. A pilot test was conducted involving 53 road experts and practitioners in Malaysia. For the main survey, a census method was applied for data collection, and a total of 63 questionnaires were successfully collected and returned out of the 119 questionnaires that were distributed. The respondents were individuals working in the field of Civil Engineering, specializing in road construction and maintenance work in Malaysia. In this study, descriptive analysis was conducted to interpret the demographic data of the respondents. Cronbach's alpha was used to determine the internal consistency of the pilot test data, and Goodman-Kruskal Gamma was employed to analyse the association between two variables in the main survey data. Subsequently, the significant elements of the green rural road network that potentially contribute to socioeconomic development were presented in the form of a framework. The validation process of the framework, based on expert views, was conducted to determine its appropriateness, comprehensiveness, simplicity, and applicability. The validation process involved 8 highly experienced individuals. From analysis, it is evident that remaining seventeen (17) green rural road elements were significant and had a strong positive association with at least one of the socioeconomic development indicators studied. In conclusion, this study has successfully achieved all its objectives and has developed a Framework of Significant Elements for My Green Rural Road Index-(Socioeconomic).

ABSTRAK

Pada masa kini, pelaksanaan amalan hijau telah menjadi salah satu kaedah yang paling digemari dalam pembinaan jalan raya kerana aset infrastruktur penting ini memberi impak yang ketara kepada alam sekitar dan juga manusia. Malaysia khususnya, jalan luar bandar merupakan rangjkaian raya yang terbesar di Malaysia. Oleh itu, jalan luar bandar yang cekap dan kukuh adalah penting untuk faedah masyarakat setempat. Walau bagaimanapun, pembangunan dan operasi jalan ini melibatkan skala besar dan memberikan kesan jangka panjang kepada manusia dan alam sekitar seperti menyumbang kepada kesan ekologi serta menjejaskan kualiti hidup masyarakat setempat sepanjang kitaran hayatnya. Oleh itu, kajian ini mengenal pasti elemen bagi rangkaian jalan luar bandar hijau yang perlu dipertimbangkan dalam pembangunan jalan luar bandar hijau serta menyiasat elemen yang menyumbang kepada pembangunan sosioekonomi di kawasan luar bandar. Tambahan pula, ketiadaan garis panduan khusus pembangunan jalan hijau bagi jalan raya di kawasan luar bandar didapati sebagai satu jurang yang perlu diisi melalui pendekatan yang sistematik. Dalam kajian ini, metodologi kajian dibahagikan kepada lima fasa untuk mengenal pasti elemen rangkaian jalan raya luar bandar yang hijau, keberkesanan elemen tersebut, elemen signifikan yang menyumbang kepada pembangunan sosioekonomi. Melalui tinjauan literatur yang intensif, 32 elemen untuk jalan luar bandar hijau telah dikenalpasti. Elemen-elemen ini kemudiannya dibentangkan dalam bentuk soal selidik. Ujian perintis telah dijalankan dengan penglibatan 53 jurutera awam bahagian jalan di Malaysia. Kemudian untuk tinjauan utama, kaedah bancian digunakan untuk pengumpulan data, 63 borang soal selidik berjaya dikumpul dan dikembalikan daripada 119 borang soal selidik yang diedarkan. Responden bertugas dalam bidang Kejuruteraan Awam khusus dalam kerja-kerja pembinaan dan penyelenggaraan jalan raya di Malaysia. Dalam kajian ini, analisis deskriptif dijalankan untuk mentafsir data bagi demografi responden, Cronbach alpha untuk menentukan ketekalan dalaman data ujian rintis, dan Goodman Kruskal Gamma untuk menganalisis perkaitan antara dua pembolehubah bagi data tinjauan utama. Seterusnya, elemen penting rangkaian jalan luar bandar hijau yang menyumbang kepada pembangunan sosio-ekonomi yg keudiannya dibentangkan dalam bentuk rangka kerja. Proses Pengesahan rangka kerja berdasarkan pandangan pakar telah dijalankan untuk menentukan kesesuaian, komprehensif, kesederhanaan dan kebolehgunaannya. Proses pengesahan melibatkan 8 individu yang sangat berpengalaman. Daripada analisis, terbukti 17 rangkaian jalan luar bandar hijau adalah signifikan dan mempunyai perkaitan positif yang kuat dengan sekurang-kurangnya satu daripada petunjuk pembangunan sosioekonomi yang dikaji. Kesimpulannya, kajian ini telah mencapai semua objektif selain berjaya membangunkan Rangka Elemen bagi My Green Rural Road Index- (Sosioeconomic).

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APPROVAL

The Examination Committee has met on **21 September 2023** to conduct the final examination of **Nur Ainina Binti Mustafa** on his degree thesis entitled **Investigation of Green Rural Road Network Elements for Socioeconomic Development in Rural Areas.**

The committee recommends that the student be awarded the of Doctor of Philosophy (Civil Engineering).

Members of the Examination Committee were as follows.

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DECLARATION OF THESIS

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Date of birth : 26 January 1986

Title : Investigation of Green Rural Road Network Elements for Socioeconomic Development in Rural Areas

Academic session : 2016/2017

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TABLE OF CONTENTS

TITLE

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CAREC	-	Central Asia Regional Economic Operation
COTO	-	Committee of Transport Official
FELCRA	-	Federal Land Consolidation and Rehabilitation Authority
FELDA	-	The Federal Land Development Authority
FHWA	-	Federal Highway Administration
GDP	-	Gross Domestic Product
GreenLITES	-	Leadership In Transportation and Environmental Sustainability
HDI	-	Human Development Index
ICSM	-	Inter-Governmental Committee of Surveying Mapping
I-LAST	-	Illinois Liveable and Sustainable Transportation
INVEST	-	Infrastructure Voluntary Evaluation Sustainability Tool
JKR	-	Public Work Department
MHA	-	Malaysian Highway Authority
MRRD	-	Ministry of Rural and Regional Development
MyRRI	-	Malaysia Green Rural Road Index
myGHI	-	Malaysia Green Highway Index
NAPA	-	National American Asphalt Pavement Association
NKRA	-	Malaysia National Key Results Area
OECD	-	Organisation for Economic Cooperation and Development
UPNM	-	Universiti Pertahanan Nasional Malaysia
UiTM	-	Unversiti Teknologi MARA
UTM	-	Universiti Teknologi Malaysia
P. Eng	-	Professional Engineer
Ph.D.		Doctor of Philosophy
STAR	-	Sustainable Transportation Analysis Rating System
SDG	-	Sustainable Development Goals
ROSPA	-	The Royal Society for the Prevention of Accidents
RTA	-	Roads and Transport Authority Dubai

LIST OF SYMBOLS

α	-	Cronbach Alpha
γ	-	Gamma Association Coefficient
p	-	Probability of coefficient

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Sustainable development has been defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Commission on Environment, 1987). Nowadays, the implementation of green practice has become one of the most favoured methods in road construction as these vital infrastructure assets give significant impact on the environment and humans. 'United Nations Sustainable Development Summit 2015' which was held in New York on September 2015 acknowledged 17 Sustainable Development Goals (SDG) (United Nation, 2015). Out of the 17 goals, SDG 9 highlights the importance building of resilient infrastructure that promotes inclusive and sustainable industrialization and foster innovation. This goal will definitely promote safe and sustainable road networks throughout the world, including urban and rural areas. In Malaysia particularly, the rural road networks comprise the largest network of roads in Malaysia (Abd Rashid *et al.,* 2020). Rural road are essential lifelines of rural communities, as it is the only networks that providing connectivity and access to good and services.

Therefore, efficient and sound infrastructure development, such as rural road construction and upgrading the rural road networks that link rural areas to urban areas

are necessary. Resilient infrastructure should be focusing on both rural and urban area without prone to urban areas. To add, rural roads play an important role in socioeconomic development by providing access to economic and social activities (Al Mamun & Paul, 2018). According to Robinson (1999), rural roads generally contribute to development by facilitating local and international trade, improving access to jobs, education, healthcare, and other services worldwide. Robinson further emphasises that an effective and efficient road transport system can lead to higher incomes, greater economic well-being, increased personal mobility and facilitated economic growth. In return, it assists in reducing poverty and contributes to social development. Therefore, in many developing countries, investment in rural road infrastructure has continued to be a priority, as structured rural road plays a catalyst role in socioeconomic development and provides access to amenities such as education, healthcare, marketing and many other important assets.

Furthermore, well-planned rural connectivity improves the economy and reduces poverty level, and leads to increased agricultural productivity by bringing in new land into cultivation (Mamun & Paul, 2018). The role of rural roads is profoundly evident in providing accessibility to social services, agriculture advisory services, markets, credit facilities, modern technologies and agriculture mechanization. The economical, educational and social development of villages heavily relies on their accessibility (Mulmi, 2009). Moreover, rural roads are a vital part of the road network as they play an important role in connecting highways, arterial roads, towns, villages, and tourist spots. They serve as a medium for the flow of people, logistics, and information in rural areas. Moreover, rural roads encourage labour transfer to the non-agricultural sector, thereby enhancing agricultural labour

productivity (Zhong *et al.*, 2020). Identically, Zhou *et al.*, 2021 elaborate on the function of rural roads in agricultures areas, highlighting their significant contribution to rural revitalization and agricultural production.

However, road development and operation involve large-scale activities that can have long-term effects on humans and the environment. Road development has caused significant impacts on the environment, including the contribution of enormous ecological effects and the disruption of community quality of life throughout its lifecycle. To add, rural road construction can lead to issues such as land fragmentation and deterioration of cultivable land areas, which in turn affect agricultural production (Bacior & Prus, 2018). Sipes & Sipes (2013) and Malik *et al.*, (2018) have also elaborated on the impacts of road development, including increased traffic congestion, elevated levels of air pollution and noise, damage to natural resources such as soil erosion, loss of biodiversity and displacement of wildlife, increased land use, fragmentation of habitats and acidification of soil.

Therefore, the adoption of sustainable approach by implementing green elements in the development and operation of rural road infrastructure is the ideal way forward in order in order to concurrently meet economic, social and environmental needs, as shown in Figure 1.1.

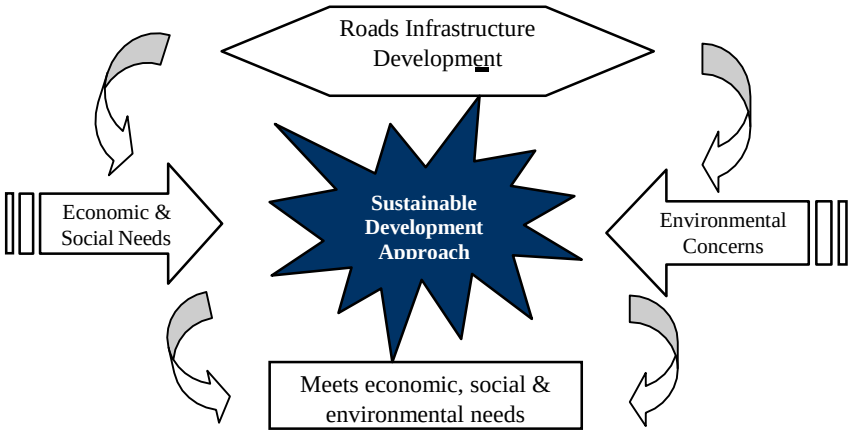

Figure 1.1 Sustainability Outcomes in Road Infrastructure Development

Rural roads pose unique challenges that require a tailored approach and should be designed with the community in mind. To ensure that the system is effective and feasible, it should be tailored to the specific needs of rural areas. Furthermore, the absence of guideline for green rural roads needs is found as a gap that needs to be filled through a systematic approach. Moreover, rural areas have unique attributes as compared to ordinary roads in many aspects; physical, ecological, social and economy (Malik *et al.*, 2018).

Therefore, sustainable elements should be implemented through rural road operation and maintenance as green elements will reduce the significant impact on the environmental, social and economic aspect. As mentioned by Cotton (2011), a sustainable rural road not only addresses environmental concerns, such as water quality, land conservation, and wildlife protection, but also enhances the quality of life in rural neighbourhoods by calming traffic and limiting noise, speed, and safety hazards. This is the reason why green initiatives can be seen through various green rating system all over the world (Alam & Kumar, 2013; Abd Rashid *et al.*, 2020). The elements of road exert an influence on socioeconomic development activities by maximising access to basic facilities such as educational institutions and health centres, enhancing the local natural and identity through the iteration on the local landscape, and improving the quality of life through these elements. It also provides employment opportunities through operation and maintenance activities. Undeniably, the green initiative should be implemented by the Malaysian government for rural road infrastructure development, which can benefit socioeconomically and environmentally. Thus, this study investigates the potential contribution of green road elements to socioeconomic development of rural communities while also benefiting the environment.

1.2 Problem Statements

Sustainable and sound rural roads are imperative as they serve as the only networks connecting rural people to city centres and community facilities such as schools, universities, health centres, and commercial places (Quintera, 2016). Moreover, rural roads comprise the largest road network in Malaysia (Abd Rashid *et al.,* 2020). According to Faiz *et al.,* (2012), rural access is closely related to rural livelihood outcomes, including increased incomes, enhanced social well-being, reduced vulnerability and improved food security. This is supported by Ale *et al.,* (2011), where the scholar claimed that the development of basic infrastructure in rural areas can be seen as an accelerator that speeds up economic growth in those areas. As a result, it simultaneously improves the social quality and well-being of the rural community as a whole. Straka and Tuzova (2016) also emphasized that road infrastructure acts as a medium for improving the socioeconomic and well-being of rural communities. However, rural road development is also associated with negative impacts on the environment, economy, and society. For instance, road construction consumes a large number of natural resources, generates significant amounts of waste, and requires extensive human capital (Morrissey *et al.,* 2012). Moreover, road development has a negative impact on surrounding ecosystems and the overall environmental quality (Mancini & Sala, 2018; Nazir *et al.,* 2020).

Therefore, the development of rural road infrastructure must be chosen wisely and follow sustainable practices, as these measures can significantly reduce the impact on society and the environment. By implementing green practices in road operation and maintenance, it is possible to mitigate the effects on the natural environment, increase capacity, and provide benefits to society beyond what ordinary roads can offer (Bryce, 2008). According to the Sustainable Development Goal 2030 (SDG 2030),

which comprise seventeen (17) integrated goals, it is recognized that actions in one area will have an impact on others. Therefore, development must strive to social, economic and environmental sustainability. In alignment with the aim of the Sustainable Development Goal, rural road infrastructure should provide benefits to society both environmentally and socioeconomically.

Even though the concept of green roads has gained momentum in Malaysia through the implementation of the Malaysia Green Highway Index (MyGHI) for highways and pHJKR (Jalan) for federal roads, there is currently no established guideline for green rural roads in Malaysia. This situation raises concerns about the level of sustainability for the largest road network in Malaysia, which is composed of rural roads.

Therefore, given the negative impacts of road development, significant attention should be given to sustainable rural road development. The development of rural areas should be conducted with a strong emphasis on sustainable principles, ensuring the preservation of the originality of the rural landscape. Furthermore, rural landscapes are noteworthy for their ecological components, such as forests and green lands, as well as their cultural and heritage value and socioeconomic conditions (Nikumbh & Aher, 2019). Thus, it is crucial to preserve the physical conditions in rural areas, which have not been exploited to the same extent as urban areas, by all means. Moreover, Lucas *et al.,* (2016) also claimed that poor rural road connectivity and unsafe travel conditions continue to affect the quality of life in rural communities and hinder their daily economic activities, particularly in developing and undeveloped countries. Hence, there is a need to conduct a specific study that focuses on the elements to be considered in the development of green rural roads, aiming to preserve rural treasures while providing social and economic benefits and concurrently