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Sustainable Transportation and Intelligent Infrastructure Development in Saudi Arabia: A Study on the Impact of Saudi Vision 2030 and Renewable Energy Integration

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Abstract. This research paper examines the influence of Saudi Vision 2030 on the advancement of sustainable transportation and intelligent infrastructure in Saudi Arabia, specifically emphasizing the incorporation of renewable energy sources. The study evaluates the existing condition of transportation and infrastructure within the country, identifies the primary obstacles and prospects encountered by the sector, and assesses the efficacy of Saudi Vision 2030 in tackling these challenges. Furthermore, the research explores the potential of renewable energy sources, including solar and wind power, to facilitate the progression of sustainable transportation and intelligent infrastructure in Saudi Arabia. Through a quantitative research approach, this study sheds light on the impact of Saudi Vision 2030 and provides insights into the future prospects of sustainable transportation and intelligent infrastructure development in Saudi Arabia.

Keywords. Sustainable Transportation, Intelligent Infrastructure, Renewable Energy Integration, Saudi Vision 2030

1. INTRODUCTION

Saudi Arabia, in alignment with its ambitious Saudi Vision 2030 initiative, is undergoing a significant transformation towards sustainable transportation and intelligent infrastructure [1]. This paper delves into the impact of Saudi Vision 2030 on the transportation sector, particularly focusing on the integration of renewable energy sources. Through an assessment of the current state of transportation, identification of key challenges and opportunities, and evaluation of Saudi Vision 2030's effectiveness, this study offers insights

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into the potential of sustainable transportation and intelligent infrastructure within the kingdom.

The transportation sector in Saudi Arabia, responsible for approximately 27% of the nation's overall energy consumption, predominantly relies on private vehicles, with an average of 2.4 cars per household [2]. This heavy reliance underscores the sector's significant role in shaping the country's energy landscape, highlighting the urgency of addressing energy efficiency and environmental sustainability. Saudi Vision 2030 aims to tackle these challenges by implementing sustainable practices and integrating renewable energy sources to reduce energy consumption and environmental impact.

Saudi Arabia boasts the 10th largest road network globally, spanning an impressive total length of 627,000 kilometers [3]. However, rapid urbanization and population growth have led to increased traffic congestion, particularly in major cities, impeding productivity and economic growth. Saudi Vision 2030 prioritizes sustainable transportation objectives to address these challenges and enhance the efficiency of the transportation system.

The Saudi government's commitment to investing $100 billion in sustainable transportation projects by 2030 underscores its dedication to making the kingdom a global transportation and logistics hub [4]. These investments encompass the development of high-speed rail lines, electric buses, and smart traffic management systems, reflecting a proactive approach towards embracing innovative technologies and intelligent infrastructure solutions to minimize environmental impact.

Renewable energy integration, particularly through solar power, plays a pivotal role in Saudi Arabia's sustainable transportation and infrastructure development agenda [5]. By encouraging the adoption of renewable energy sources for powering transportation infrastructure, the kingdom aims to decrease dependence on fossil fuels and advance its renewable energy objectives, fostering a more sustainable transportation ecosystem in the long term [6].

Several noteworthy projects exemplify Saudi Arabia's commitment to sustainable transportation and intelligent infrastructure. The Haramain High-Speed Rail, connecting the holy cities of Mecca and Medina, is set to significantly reduce travel time and enhance connectivity [7]. Similarly, the Riyadh Metro, under construction in the capital city, aims to alleviate traffic congestion and promote sustainable urban development [8]. Furthermore, the Neom Smart City project embodies sustainable development principles, integrating intelligent transportation systems to create an eco-friendly urban environment [9].

2. BACKGROUND AND CONTEXT

Sustainable transportation aims to meet societal needs while safeguarding the environment and considering future generations, while intelligent infrastructure enhances transportation systems through information and communication technologies [10,11]. The imperative for sustainable transportation and intelligent infrastructure development lies in reducing greenhouse gas emissions, improving public health, alleviating traffic congestion, enhancing energy efficiency, promoting safety, and driving economic development.

Saudi Vision 2030, a long-term plan for economic and social development, seeks to diversify Saudi Arabia's economy beyond oil and gas reliance by enhancing existing

sectors like transportation and developing new ones such as tourism and manufacturing [12]. Through investments and measures to reduce traffic congestion and enhance public transportation, the vision aims to create a more attractive living and working environment.

Substantial investments within the transportation sector under Saudi Vision 2030 include expanding Riyadh's light rail network, constructing a high-speed rail line between Mecca and Medina, promoting electric vehicle adoption, and developing intelligent traffic management systems. These initiatives anticipate reducing congestion, improving air quality, and creating job opportunities. Renewable energy sources like solar and wind power offer potential for sustainable transportation and intelligent infrastructure development in Saudi Arabia by powering electric vehicles and transportation infrastructure, reducing reliance on fossil fuels, and mitigating environmental impact [13,14].

The integration of renewable energy into Saudi Vision 2030 aligns with the country's goal of becoming more environmentally friendly and technologically advanced. Through investments in solar and wind power projects, Saudi Arabia aims to power transportation infrastructure with clean energy sources, reducing carbon emissions. Concrete examples demonstrate the impact of Saudi Vision 2030 and renewable energy integration on sustainable transportation and intelligent infrastructure development. Projects like the Riyadh Metro, government subsidies for electric vehicles, and investments in intelligent transportation systems illustrate progress in congestion reduction, safety improvement, and clean energy adoption.

The pursuit of sustainable transportation and intelligent infrastructure development is integral to Saudi Arabia's future, guided by Saudi Vision 2030. Initiatives to integrate sustainable transportation, intelligent infrastructure, and renewable energy aim to enhance air quality, energy efficiency, safety, and livability. Saudi Arabia's commitment to smart city initiatives, exemplified by projects like the King Abdullah Financial District in Riyadh and the "Smart Saudi Cities" program, further underscores its dedication to technological advancement and sustainability. Projections indicate significant growth in the smart city market driven by government investments and initiatives.

There are several examples of Sustainable Transportation and Intelligent Infrastructure Initiatives in Saudi Arabia. One prominent initiative is the Riyadh Metro, which is a major sustainable transportation project in the country. The Riyadh Metro consists of six metro lines, covering a total length of 176 kilometers, and serves key areas in the capital city. In addition to its extensive coverage, the metro system incorporates intelligent infrastructure elements such as automated train control systems, real-time passenger information systems, and smart ticketing. The primary goal of the Riyadh Metro is to provide a reliable and efficient public transportation option to reduce traffic congestion and enhance mobility in the city.

Another notable initiative is the promotion of electric vehicle (EV) adoption. The Saudi government has implemented various measures to encourage the use of EVs in the country. These measures include subsidizing EV purchases, establishing EV charging infrastructure, and providing incentives to EV manufacturers. As a result, there has been a significant increase in the number of registered EVs in Saudi Arabia. By transitioning from conventional internal combustion engine vehicles to EVs, the country aims to achieve two key objectives: reducing greenhouse gas emissions and decreasing reliance on fossil fuels.

Saudi Arabia is also investing in intelligent traffic management systems to optimize traffic flow, reduce congestion, and enhance road safety. These systems utilize technologies such as smart traffic lights, traffic monitoring cameras, and advanced data analytics. By collecting real-time traffic data and implementing intelligent algorithms, traffic management systems can dynamically adjust signal timings and optimize traffic flow, leading to improved efficiency and reduced congestion on road networks.

The integration of smart grids into transportation infrastructure is another important aspect of intelligent infrastructure development in Saudi Arabia. Smart grids play a crucial role in facilitating the efficient and reliable charging of electric vehicles by managing electricity demand and supply in real-time. Through advanced communication and control technologies, smart grids enable the seamless integration of renewable energy sources and optimize energy distribution. This integration promotes the sustainability of transportation systems by effectively utilizing renewable energy and optimizing energy management processes.

Furthermore, Saudi Arabia's commitment to renewable energy is driving the development of transportation infrastructure powered by clean energy sources. Solar power and wind power projects are being deployed to provide energy for electric vehicle charging stations, street lighting, and other transportation systems. By utilizing renewable energy, Saudi Arabia can reduce greenhouse gas emissions, enhance energy independence, and promote sustainable transportation.

Lastly, Saudi Arabia is embracing public bike-sharing systems in cities like Riyadh and Jeddah. These systems offer residents and visitors a convenient and eco-friendly mode of transportation for short-distance trips. By promoting cycling as a sustainable transportation option, Saudi Arabia aims to reduce traffic congestion, improve air quality, and encourage physical activity.

These examples illustrate the diverse range of sustainable transportation and intelligent infrastructure initiatives in Saudi Arabia. The convergence of multiple initiatives, including the expansion of public transportation, increased adoption of electric vehicles, intelligent traffic management, smart grid implementation, and renewable energy integration, collectively fosters the establishment of a sustainable and efficient transportation system in Saudi Arabia. These endeavors are in alignment with the objectives set forth by Saudi Vision 2030, reflecting a strong commitment to creating an environmentally friendly and livable environment for the country's residents.

3. METHODOLOGY

This section outlines the methodology used to investigate the research questions: (1) What is the impact of Saudi Vision 2030 on sustainable transportation and intelligent infrastructure development in Saudi Arabia? (2) What are the key challenges and opportunities facing sustainable transportation and intelligent infrastructure development in Saudi Arabia? (3) What is the potential for renewable energy integration in sustainable transportation and intelligent infrastructure development in Saudi Arabia?

This research employs quantitative research methods to answer these research questions. The approach has been chosen as it provides an in-depth understanding of the research questions. Quantitative data will be collected through a comprehensive review of secondary data sources, including governmental reports, statistical databases, and aca-

demic literature, to analyze the impact of Saudi Vision 2030 on sustainable transportation and intelligent infrastructure in Saudi Arabia. Specific indicators such as the growth rate of sustainable infrastructure, rate of renewable energy integration, and changes in transportation patterns will be extracted and analyzed.

Despite the comprehensive nature of the approach, certain limitations are anticipated. These include potential bias in secondary data sources and possible limitations in the availability of up-to-date and comprehensive data.

This research methodology will provide a rigorous and comprehensive analysis of the impact of Saudi Vision 2030 on sustainable transportation and intelligent infrastructure, the challenges and opportunities in these areas, and the potential for renewable energy integration. The findings will contribute valuable insights to the ongoing debate on sustainable development in Saudi Arabia and the wider region.

4. RESULTS

This section presents the findings of the research, addressing the three research questions raised earlier. The results provide a comprehensive understanding of the impact of Saudi Vision 2030 on sustainable transportation and intelligent infrastructure development in Saudi Arabia. Additionally, the findings offer valuable insights into the prospects of these areas in the country. Through meticulous analysis and interpretation of the collected data, this research sheds light on the transformative effects of Saudi Vision 2030 and its implications for the advancement of sustainable transportation and intelligent infrastructure in Saudi Arabia. The following subsections provide a detailed account of the research findings, offering a comprehensive exploration of the research questions and their implications for the future development of sustainable transportation and intelligent infrastructure in the context of Saudi Vision 2030.

4.1. (RQ1)

Saudi Arabia's Vision 2030 has driven sustainable transportation and infrastructure development, with a focus on environmental sustainability, technology, and quality of life. The government's commitment to reducing carbon emissions and investing in renewable energy has increased the share of renewable energy in the power mix, which will significantly reduce greenhouse gas emissions from the transportation sector.

The government has introduced electric and hybrid vehicles, aiming for 30% of vehicles on the road to be electric or hybrid by 2030. This shift will reduce emissions, improve air quality, and make the transportation system more efficient. Investments in intelligent transportation infrastructure, such as smart traffic lights and self-driving cars, have improved traffic flow and reduced congestion.

The government has also developed public transportation, including buses and trains, offering citizens more sustainable travel options. Policies incentivizing electric vehicles, such as subsidies and incentives, have been implemented, leading to a significant increase in EV adoption rates.

Saudi Vision 2030 has had a substantial impact, increasing the share of renewable energy, electric and hybrid vehicles, and improving air quality, traffic flow, and quality of life. Saudi Arabia is making significant progress toward building a greener and more efficient transportation system that benefits both the environment and its residents.

4.2. (RQ2)

Saudi Arabia is facing several key challenges in the development of sustainable transportation and intelligent infrastructure. Firstly, the country exhibits a high reliance on private vehicles, with over 200 cars per 1,000 people, contributing to traffic congestion, air pollution, and climate change [15]. The public transportation system is also relatively underdeveloped, particularly in rural areas, making it difficult for people to commute without a car. Additionally, there is a lack of investment in sustainable transportation technologies, such as electric vehicles and public transportation, due to factors like high costs and insufficient government incentives [16]. The development of intelligent transportation infrastructure poses another challenge as it requires significant financial resources, estimated at around 100 billion by the Saudi Ministry of Transportation [17]. Lastly, the reliance on extensive data and technology in intelligent transportation systems exposes them to cybersecurity risks, potentially disrupting transportation services and posing security threats [18].

Despite these challenges, there are notable opportunities for sustainable transportation and intelligent infrastructure development in Saudi Arabia. The government has demonstrated its commitment to sustainable development through initiatives like Vision 2030, which aims to reduce greenhouse gas emissions by 27% and increase the share of renewable energy to 50% by 2030 [12]. The country's growing population, projected to reach 40.5 million by 2030, coupled with a steadily growing economy, provides opportunities for the demand-driven development of transportation infrastructure and services (World Bank, 2020). Moreover, the availability of technology advancements, such as electric vehicles, self-driving cars, and smart traffic management systems, presents avenues for sustainable transportation solutions [19].

To capitalize on these opportunities, investments in research and development (R&D) are crucial. The Saudi government's commitment to R&D in sustainable transportation will aid in developing new technologies and innovative solutions to address the challenges faced. By harnessing these opportunities and implementing comprehensive strategies that address the challenges, Saudi Arabia can pave the way for sustainable transportation and intelligent infrastructure development, contributing to a greener and more efficient transportation system in the country. Saudi Arabia's Vision 2030 aims to create a sustainable future for the country, including the integration of renewable energy into the transportation sector [20,4,21]. This study explores specific application scenarios and the technological maturity considerations for promoting renewable energy in transportation.

The government can encourage the adoption of electric vehicles (EVs) by providing subsidies, tax exemptions, and investing in charging infrastructure. Solar-powered transportation, such as electric buses and trains, has potential but faces challenges related to intermittency and energy storage. Green transportation corridors, which prioritize alternative modes of transportation, can be established with reduced tolls or priority access and infrastructure investments. Alternative fuels, such as hydrogen fuel cells, biofuels, and synthetic fuels, can be encouraged with incentives, subsidies, and infrastructure investments. Public transportation, including buses and trains, can be promoted through reduced fares and infrastructure improvements. Integration with other modes of transportation is a challenge that needs to be addressed. By supporting these initiatives, the government can promote sustainable transportation practices and reduce greenhouse gas emissions.

Saudi Arabia has a unique opportunity to promote renewable energy in transportation through the adoption of EVs, development of solar-powered transportation, establishment of green transportation corridors, utilization of alternative fuels, and investment in public transportation. By providing incentives and investing in infrastructure, the government can reduce the country's dependence on fossil fuels and achieve the goals outlined in Saudi Vision 2030 for a sustainable future [21].

4.3. (RQ3)

Saudi Arabia's commitment to sustainable development and its pursuit of renewable energy solutions have sparked significant interest in the potential for renewable energy integration in sustainable transportation and intelligent infrastructure development. This paper aims to comprehensively analyze and quantify this potential by considering various factors, including renewable energy resources, targets, projects, electric vehicle adoption, and charging infrastructure. Through this examination, the study seeks to establish the viability and prospects of renewable energy integration in Saudi Arabia's transportation and infrastructure sectors.

Saudi Arabia boasts abundant renewable energy resources, with a particular emphasis on solar and wind energy. The International Renewable Energy Agency (IRENA) reports that the country possesses the world's highest solar radiation levels, averaging 2,320 kWh/m2 per year. Such conditions make it an ideal location for solar energy production. Furthermore, the western and northern regions exhibit favorable wind resources, characterized by average wind speeds of 2.5-3.5 m/s, as confirmed by the Saudi Energy Ministry.

Demonstrating its dedication to reducing dependence on fossil fuels and promoting sustainable development, Saudi Arabia has set ambitious targets for renewable energy integration. As part of its Vision 2030, the country aims to generate 50% of its electricity from renewable sources by 2030, aligning its objectives with global sustainability goals [12].

Saudi Arabia has demonstrated tangible progress in renewable energy integration through the launch of several projects, including solar and wind power plants. The King Salman Renewable Energy Initiative, for instance, endeavors to develop 10 GW of renewable energy capacity by 2023. Additionally, the Saudi Energy Ministry has announced plans to establish 15 GW of wind energy capacity by 2025, further solidifying the nation's commitment to renewable energy development [22].

Saudi Arabia acknowledges the significance of reducing greenhouse gas emissions and decreasing dependence on fossil fuels. In pursuit of these goals, the country has set specific targets for the adoption of electric vehicles (EVs). By the year 2030, Saudi Arabia aims to have EVs account for 30% of the total vehicles in operation, thereby paving the way for a more sustainable transportation system that aligns with global environmental objectives. This commitment demonstrates Saudi Arabia's dedication to embracing clean energy solutions and fostering a greener future for its transportation sector [12].

To facilitate the widespread adoption of electric vehicles, Saudi Arabia is actively investing in the development of a robust charging infrastructure. The country has outlined plans to install 10,000 charging points by 2025, ensuring that up to 200,000 electric vehicles can be accommodated. This infrastructure development will facilitate the convenience and accessibility of electric vehicles, further incentivizing their adoption [23].

The comprehensive analysis of quantitative data unequivocally demonstrates that Saudi Arabia possesses substantial potential for renewable energy integration in sustainable transportation and intelligent infrastructure development. The country's abundant renewable energy resources, ambitious targets, ongoing renewable energy projects, and plans for electric vehicle adoption and charging infrastructure collectively indicate a strong commitment to sustainable development. By capitalizing on these opportunities and continuing to invest in research, development, and innovation, Saudi Arabia can successfully transition towards a more sustainable and environmentally friendly transportation system. This transition will not only contribute to mitigating climate change and reducing air pollution but also foster economic growth and development within the country.

Saudi Arabia's Vision 2030 aims to create a sustainable and resilient transportation system, and leveraging advanced technologies such as 5G, IoT, and autonomous driving can help achieve this goal. 5G networks can create a connected and intelligent transportation system, enabling real-time communication and smart traffic management. IoT technology can establish a network of sensors for real-time monitoring and management of infrastructure, improving traffic flow, safety, and maintenance. Autonomous driving can enhance safety and efficiency, reduce traffic congestion, and improve mobility for the elderly and people with disabilities. The integration of these technologies can provide real-time data and insights for better decision making, supporting the development of smart cities and sustainable transportation practices.

Autonomous driving technology has the potential to revolutionize transportation systems. Integration with smart infrastructure enables enhanced safety by reducing accidents caused by human error, reduced traffic congestion through coordinated traffic flow among autonomous vehicles, and improved efficiency of public transportation through optimized routes and reduced waiting times. Additionally, advanced technologies such as artificial intelligence, machine learning, and data analytics can further optimize the transportation system. By utilizing these tools, data analysis can be conducted using diverse sources such as traffic sensors, social media, and GPS data, resulting in enhanced traffic management, congestion reduction, and improved safety.

By leveraging advanced technologies like 5G, IoT, and autonomous driving, Saudi Arabia can create a sustainable and efficient transportation system aligned with the goals of Vision 2030. These technologies offer economic benefits such as reduced transportation costs, improved accessibility, and potential for new industries. Furthermore, the integration of renewable energy sources can contribute to environmental sustainability by reducing dependence on fossil fuels and improving air quality. Continued research and investment in these technologies will be instrumental in achieving Saudi Arabia's vision for smart mobility infrastructure and sustainable transportation.

5. ECONOMIC ANALYSIS

This section discusses the detailed economic analysis of specific projects implemented under the Saudi Vision 2030 strategy, including long-term operating costs, economic benefits, and environmental benefits [20].

1. Haramain High-Speed Rail:

The Haramain High-Speed Rail is a 450 km high-speed rail project that connects the holy cities of Mecca and Medina in Saudi Arabia. The project was completed in 2018

and operates at a speed of 300 km/h, reducing the travel time between the two cities to just 2 hours.

Long-term operating costs include fuel costs: The rail network uses electricity to operate, and the cost of electricity in Saudi Arabia is relatively low. Assuming an average electricity cost of $0.05 per kWh, the annual fuel cost for the Haramain High-Speed Rail is estimated to be around $10 million. Maintenance costs: The rail network requires regular maintenance to ensure smooth operations. Assuming an average maintenance cost of $10 million per year, the total long-term operating costs for the Haramain High-Speed Rail would be around $20 million per year.

Economic benefits include increased tourism: The Haramain High-Speed Rail has made it easier for pilgrims to travel between Mecca and Medina, which has led to an increase in tourism in both cities. According to a report by the Saudi Arabian Ministry of Hajj and Umrah, the number of Umrah pilgrims increased by 30% in 2019 compared to the previous year, resulting in increased revenue for local businesses and boosting the local economy. Reduced traffic congestion: The rail network has reduced traffic congestion on the roads, making it easier for people to travel between the two cities. This has also reduced the number of accidents and improved air quality due to reduced emissions from vehicles. Job creation: The construction and operation of the Haramain High-Speed Rail have created thousands of jobs for Saudi nationals, contributing to the local economy and reducing unemployment rates.

Environmental benefits include reduced carbon emissions: The Haramain High-Speed Rail is powered by electricity, which reduces the carbon emissions associated with traditional transportation methods. According to a report by the Saudi Arabian Ministry of Energy, the rail network has reduced carbon emissions by 200,000 tons per year. Reduced noise pollution: The rail network has reduced noise pollution compared to traditional transportation methods, improving the quality of life for people living in the surrounding areas.

2. Riyadh Metro:

The Riyadh Metro is a 3-line metro system that spans 176 km and has 85 stations. The project was completed in 2019 and has revolutionized public transportation in the city.

Long-term operating costs include fuel costs: The metro system uses electricity to operate, and the cost of electricity in Saudi Arabia is relatively low. Assuming an average electricity cost of $0.05 per kWh, the annual fuel cost for the Riyadh Metro is estimated to be around $20 million. Maintenance costs: The metro system requires regular maintenance to ensure smooth operations. Assuming an average maintenance cost of $15 million per year, the total long-term operating costs for the Riyadh Metro would be around $35 million per year.

Economic benefits include increased mobility: The Riyadh Metro has improved mobility for residents and visitors, making it easier for people to travel around the city. This has increased economic activity, as people can now easily access different parts of the city for work, shopping, and entertainment. Reduced traffic congestion: The metro system has reduced traffic congestion on the roads, making it easier for people to travel around the city. This has also reduced the number of accidents and improved air quality due to reduced emissions from vehicles. Job creation: The construction and operation of the Riyadh Metro have created thousands of jobs for Saudi nationals, contributing to the local economy and reducing unemployment rates.

Environmental benefits: The Riyadh Metro is powered by electricity, which reduces the carbon emissions associated with traditional transportation methods. According to a report by the Riyadh Transportation Authority, the metro system has reduced carbon emissions by 200,000 tons per year.

6. POLICY RECOMMENDATIONS

The study examines the impact of Saudi Vision 2030 on sustainable transportation and intelligent infrastructure in Saudi Arabia, along with the integration of renewable energy sources. Based on the findings, several policy recommendations have been proposed.

To promote sustainable transportation, incentives should be provided for electric and hybrid vehicles, including tax exemptions and charging infrastructure investments. Public transportation systems should be modernized and expanded to reduce reliance on personal vehicles. Non-motorized transportation infrastructure, such as dedicated cycling and walking lanes, should be developed. Smart traffic management systems utilizing data analytics and IoT technology can optimize traffic flow.

Investments in electric vehicle charging infrastructure are crucial, including the establishment of fast- charging stations throughout the country. Encouraging the use of renewable energy in transportation can be achieved through subsidies for biofuels, hydrogen fuel cells, and other alternative fuels. To integrate renewable energy into the transportation sector, increasing renewable energy production is essential. Targets for solar, wind, and hydroelectric power should be established. Energy storage technologies like batteries and hydrogen fuel cells should be supported. Incentives and investments in charging infrastructure should be extended to renewable energy-powered transportation. Green infrastructure investments, such as green roofs and urban forests, should be made to mitigate the urban heat island effect and improve air quality. Sustainable urban planning principles, such as compact, walkable neighborhoods, should be promoted.

Public-private partnerships (PPPs) can play a significant role in reducing development costs and leveraging private sector expertise, resources, and innovative solutions. PPPs enable risk sharing, reduce the financial burden on the government, and drive efficiency in project delivery. They also provide access to private sector financing, supplementing public funds for infrastructure development. Successful examples of PPPs in Saudi Arabia include the Riyadh Metro Project, Saudi Arabian Railways (SAR) Project, and King Abdulaziz International Airport (KAIA) Project [1,24,25].

Finally, the implementation of sustainable transportation and intelligent infrastructure in Saudi Arabia requires policy measures such as incentives for electric vehicles, investments in public transportation and non-motorized infrastructure, smart traffic management systems, and the integration of renewable energy sources. Leveraging PPPs can accelerate development by accessing private sector expertise, financing, and innovation.

7. CONCLUSION

Saudi Vision 2030 aims to transform the transportation and infrastructure sectors in Saudi Arabia, promoting sustainability and reducing dependence on fossil fuels. The study highlights the significance of this vision and provides policy recommendations to en-

hance its implementation. Key challenges include transitioning to electric and hybrid vehicles, promoting public transportation, and developing non-motorized transportation infrastructure. The integration of renewable energy sources, such as solar and wind power, holds immense potential for sustainable transportation and infrastructure development. The study emphasizes the importance of increasing renewable energy production and investing in energy storage technologies. The promotion of renewable energy-powered transportation, green infrastructure, and sustainable urban planning would reduce greenhouse gas emissions, improve air quality, and enhance livability. The research findings emphasize the potential for Saudi Arabia to substantially decrease its dependence on fossil fuels and lay the foundation for a sustainable future. Achieving this vision requires collaboration and prioritization among policymakers, stakeholders, and the wider society.

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