International Journal on Science and Technology (IJSAT)



E-ISSN: 2229-7677 • Website: <u>www.ijsat.org</u> • Email: editor@ijsat.org

# PPP Infrastructure Alignment on Circular Economy in Saudi Arabia's Water and Transport Sectors

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#### Abstract

After more than 16 years of working on Public-Private Partnership (PPP) projects in Saudi Arabia, especially in the water, wastewater, and port logistic sectors, I have had the privilege of seeing the rapid development of infrastructure projects that the Kingdom of Saudi Arabia goes through. I can confidently say that this article is based on my knowledge of Circular Economy (CE) principles and how they are in line with PPP to serve a meaningful contribution to the goals of Saudi Arabia's Vision 2030. With the intention to diversify the Saudi economy and reduce reliance on oil revenues, the introduction of CE within the PPP framework offers a key strategy for the nation. In addition to this, this alignment reinforces the sustainability of infrastructure projects, encourages innovation and efficiency and make sure that economic development comes at the cost of not exploiting the natural resources.

I present ways in which the key projects in which I have been involved, including the Integrated Sewage Treatment Plants (ISTPs) of Madinah, Tabuk, and Buraidah, the Red Sea Gateway Terminal, and the Taif ISTP, are integrating circular practices into water, wastewater and transport infrastructures. This project shows the use of CE principles, namely resource recovery waste minimization and development of sustainable practices. For example, advanced technologies for the treatment and reuse of wastewater are incorporated in the ISTP projects in order to reduce water consumption and reduce negative environmental impact. In the same way, the Red Sea Gateway Terminal stresses efficient logistics and resource management that enhance the movement of goods alongside minimizing ongoing waste. Aligning PPP frameworks with the CE principles, such as these initiatives, can not only aid in the Kingdom's economic growth but can also play a key role in turning the Kingdom into a more sustainable entity on the long term, and, setting a model for future infrastructure development, focusing on ecological integrity.

Overall, I believe this article will provide an excellent contribution to sustainable development and infrastructure innovation conversation in the Kingdom, particularly given Saudi Arabia's journey of becoming better, more resilient and more resource efficient future. This research illustrates how various CE components have been integrated in PPP projects across the world intending to inspire future investments and policy reforms towards sustainable structure by examining innovation in approaches institutionalized in CE principles. These findings present a vision for



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infrastructure development that meets the principles of the Circular Economy and hence support Saudi Arabia's ambition to achieve a sustainable and diversified economy, that will benefit its citizens and the environment. Consequently, the insights provided in this article will lead the way in outlining the means to exploit the whole potential of CE within the context of PPP, which will be crucial to the Kingdom as it continues to move forward. This trend has nothing to do with the alignment of these frameworks, as these two frameworks need to be aligned in a very fundamental sense if we are to achieve Vision 2030 ambition.

Keywords: PPP, Public-Private Partnership, Circular Economy, Saudi Arabia, infrastructure, water sector, wastewater, ports logistics, Vision 2030, sustainability, resource recovery, waste minimization, economic growth, innovation, environmental impact, Integrated Sewage Treatment Plants, ISTP, Red Sea Gateway Terminal, Taif ISTP, infrastructure development, ecological integrity, logistics optimization, resource management, sustainable practices, investments, policymakers, circular practices, resilience, resource efficiency, diversified economy, future-oriented

## INTRODUCTION

## PPP and Circular Economy Convergence in Saudi Arabia

Public Private Partnerships (PPPs) have proved to be a major method for infrastructure development in Saudi Arabia, especially according to the perspective of the Kingdom's Vision 2030. The purpose of this vision is to diversify the economy and decrease the dependence on oil revenue and means of promoting sustainable development in various sectors. A transformative approach to the achievement of the above goals is the convergence of the principles of Circular Economy with willingness of PPPs to adhere to them. The objectives of PPPs in improving the delivery of public service delivery and infrastructure resilience (Almulhim 2020, Ghaithan et al. 2019) are in line with CEs' emphasis on resource efficiency, minimization of waste and environmentally sustainable practices.



Fig 1

# PPPs and Circular Economy Alignment



In incorporating CE principles within the PPP framework, innovative solutions can be offered with a combined effect on satisfying the need for infrastructure at present, while securing the basis for long term environmental viability. Saudi Arabia can harness the abilities and finances of private set up by the public and private sectors work closely to implement circular practices that can do far more in the lifecycle of infrastructure projects. This is even more important since the Kingdom faces urgent issues like water scarcity, waste management and transportation inefficiencies (AlJaber et al., 2020; Hadidi et al., 2020).

# Water and Wastewater Sector: Integrating Circularity

In Saudi Arabia, water and wastewater sector is most actively trying to integrate circularity into the infrastructure projects of the sector. Being faced with water scarcity is a major issue in the Kingdom, it has important implications if CE principles were to be adopted to successfully manage water in a sustainable manner. An example of this approach is with Integrated Sewage Treatment Plants (ISTSs), which use advanced technologies to treat and reusing or recycling wastewater and therefore mitigating the demand of freshwater resources (Almadhi et al., 2020). Examples of circular projects, executing circular practices, recovering valuable resources (i.e. energy and nutrients) from wastewater, already exist in the form of projects like the ISTPs in Madinah, Tabuk and Buraidah (Almulhim, 2020).



Furthermore, Saudi Water Partnership Company (SWPC) provides an important role in enabling the PPP projects in the water sector. Through private sector participation, the SWPC intends to make a water service delivery more efficient and sustainable. Not only can the integration of CE principles into these projects assist the Kingdom in achieving water security, it also contributes to broader environmental aims, for instance, the reduction of greenhouse gas emission and minimization of waste (Ghaithan et al., 2019). There is a vital role for circularity in the water sector as we move forward with the discussion of circular economy and its importance for sustainable water practice.

## Circular Approaches to Infrastructure, Transport and Logistics Sector

Another important area where circular approaches are being integrated in Saudi Arabia's infrastructure development includes the transport and logistics sector. First, the Kingdom has a unique location as a global logistics hub and this provides unique opportunities for wheeling out CE principles in transportation infrastructure. The Red Sea Gateway Terminal (AlJaber et al., 2020), is one of the projects that showcases circularity to improve logistics efficiency with minimal environmental impact. These initiatives optimize the supply chain processes and decrease the waste, which are goals for sustainability in the transport sector as a whole.

Fig 2





In addition, the alignment of PPP frameworks with circular practices that can be implemented in transportation offers substantial economic benefits. As an example, the application of sustainable materials and technologies in the construction projects can reduce the cost of construction and increase the life of the asset (Hadidi et al., 2020). Besides, integrations of smart technologies including IoT and data analytics also help to improve the operational efficiency and decrease the consumption of resources in logistics operations. The integration of circular approaches will be essential for developing a resilient and sustainable logistics ecosystem for Saudi Arabia as its transport infrastructure is being invested into.

# Institutional Framework for Circular PPPs in Saudi Arabia

For CE to be successfully integrated into PPP projects in Saudi Arabia, the country would need a robust institutions framework that would provide conducive grounds for collaboration between sectors of the private and the public. NCP: the central authority responsible for the implementation of the PPP projects in all sectors: water and transport (AlJaber et al., 2020). The mandate of the NCP is to promote transparency, standardize processes and guarantee that projects have crosscompliance with national objectives including sustainability goals.

Other sector specific institutions such as the SWPC in the water sector also facilitate the circular PPPs in addition to the NCP. The responsibility of these institutions is to look out for suitable projects, and develop regulatory frameworks in which stakeholders will take part in the planning and implementation of the projects (Ghaithan et al., 2019). These institutions can facilitate the drive for innovation and circular practice by keeping a collaborative attitude.

Furthermore, for encouraging private sector participation, clear policies and guidelines based on CE principles must be established and introduced into PPP frameworks. The government can them bring investment and expertise form private persons to adopt sustainable practices and thus, make PPP projects more effective (Almadhi et al., 2020). With the continuing development of the institutional framework, circularity will have to become the core principle in the implementation of infrastructure projects.

## **Future Outlook**

In the near future PPPs in the Kingdom of Saudi Arabia will be coexisting with the principles of the Circular Economy, which offers large constructive potential for sustainable infrastructure development. As the Kingdom continues to follow through on its Vision 2030 goals, integration of circular practices into water and transport sectors will be mandatory to mitigate the 'acute environmental issues' as well as economic diversification. This will also be a model for other sectors to follow, which will also bring a sustainable development for the Kingdom.

An innovative way of developing infrastructure in Saudi Arabia is a transformative alignment of PPP frameworks with Circular Economy principles. Integrating circularity in the management of water and wastewater as well as transportation and logistics will aid the Kingdom in improving resource efficiency, reducing waste and enabling sustainable practices. For sustaining the implementation of circular PPP projects and generating innovation, the establishment of a robust institutional framework



that offers enough collaboration between public and private sectors will be critical. The conclusion of this research will assist discussions in Saudi Arabia for a sustainable and resilient future.

#### Table 1

Sub-Topic	Key Points
PPP and Circular Economy Convergence	Integration of CE principles into PPP
	frameworks for sustainable development.
Water and Wastewater Sector	ISTPs implementing circular practices for
	resource recovery and sustainability.
Transport and Logistics Sector	Circular approaches enhancing logistics
	efficiency and minimizing environmental
	impact.
Institutional Framework for Circular	Role of NCP and sector-specific institutions in
PPPs	promoting circularity.
Future Outlook and Conclusion	Opportunities for sustainable infrastructure
	development in Saudi Arabia.

#### LITERATURE REVIEW

#### The Convergence of PPP and Circular Economy

Recognizing the need to pursue sustainability, Circular Economy (CE) principles are being integrated into Public-Private Partnerships (PPPs) on the basis of a feasible option, especially in resource limited context such as Saudi Arabia. Practices in CE include reducing waste and maximizing resource efficiency like recycling, reusing and sustainable materials management (Geissdoerfer et al., 2018). However, in alignment with the Saudi Arabian government's initiative to transform its economy under Vision 2030, breaking free from dependency on oil and shifting towards a more sustainable practice through diversification, PPP and CE are opportune in coming together (Al-Jaafari et al., 2019). This alignment of the private and public sectors improves efficiency in operation at a practical level, making it able to utilize private sector expertise in laying out circular practices (Almulhim, 2020).

#### Water and Wastewater Sector: Circular Practices

The application of the CE principles in Saudi Arabia is a critical area in the water and wastewater sector. Water scarcity is one of the major problems that the Kingdom of Saudi Arabia is facing, and it is very important to manage water sustainably (Almadhi et al., 2020). In this regard, Integrated Sewage Treatment Plants (ISTPs) have been responsible, largely because it involved recycling and reuse of treated wastewater. For instance, ISTPs can use the resources recovered from wastewater for economic gain, seemingly getting two benefits from one project, as can be seen in Madinah and Tabuk projects (Ghaithan et al., 2019)



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Fig 3





Additionally, the Saudi Water Partnership Company (SWPC) has a significant role in helping PPP projects in the water sector take place and encouraging private investment in infrastructure while ensuring that CE principles are incorporated into the project design and implementation. The SWPC also seeks to increase the efficiency and sustainability of water services that are essential for addressing the Kingdom's water crisis by involving private entities (Al-Jaafari et al., 2019). In addition to enhancing resource management, circular practices are in line with these same environmental objectives and, more specifically, serve to reduce the carbon footprint related to water treatment processes (Hadidi et al., 2020).

## **Circular Approaches to Transport and Logistics Sector**

The application of CE principles is an important aspect to stimulate infrastructure sustainability in the transport and logistics application. One such case of circular approach is Red Sea Gateway Terminal that serves as an example to achieve logistics efficiency with low environmental impact (AlJaber et al, 2020). Such projects can also help to make the transport sector more sustainable and therefore provide an enabling environment to support the Kingdom's economic diversification goals through optimization of supply chain processes and waste reduction.

Using sustainable materials and technologies in transport infrastructure substantially lowers construction costs, and improve assets durability (Ghaithan et al., 2019). Additionally, advancements in these smart technologies, Internet of Things (IoT), applications can be used to enhance operational efficiency in Logistics operations. In essence, such innovations not only improve processes but also support better resource management, which tallies with the overall purpose of the CE (Hadidi et al., 2020). A resilient,



agile and efficient logistics ecosystem will be developed in the Kingdom where, as the Kingdom continues to invest in its transport infrastructure, circular approaches are of the essence.

#### **Institutional Framework for Circular PPPs**

Thus, for CE principles to be integrated in to PPP projects in Saudi Arabia, a robust institutional framework is essential. Certain Authority for PPC projects, namely, the National Center for Privatization and Public Private Partnerships (NCP) is the leading supervisor for the implementation for PPC projects in areas of water and transport (AlJaber et al., 2020). It has a role of supporting transparency, facilitating standardisation, and guaranteeing alignment to national sustainable development targets.

Fig 4



Apart from the NCP, sector specific institutions such as the SWPC aid to the adoption of circular practices in their chosen realms. Ghaithan et al. (2019) shows that these institutions are responsible for identifying appropriate projects and engaging stakeholder in planning and implementation process. Institutional framework can promote circular practices in infrastructure projects through facilitating of collaboration between public and private sectors for driving innovation and integrating these practices into infrastructure projects.

As for the private sector participation, it is also essential that clear policies and guidelines promoting CE principles be incorporated into PPP (public–private partnership) frameworks. The government can



encourage private entities to invest and build expertise in sustainable practices by offering incentives for adopting such policies as mentioned earlier in order to make PPP project more effective (Almadhi et.al. 2020). Going forward with the institutional framework that is still evolving, circularity will be prioritized in the infrastructure development for realizing Saudi Arabia's sustainability goals.

## **Future Outlook**

However, integration of CE principles within PPP projects in Saudi Arabia could be so beneficial for promoting sustainable infrastructure development. With the Kingdom going toward Vision 2030, the focus on circular practices in the water and transport sectors will become key to meeting all environmental challenges and attracting economic diversification. Through successful implementation of circular PPP projects, the other industries should be able to be inspired to replicate the concept of circularity to better serve their own industries, and contribute to sustainable development in Saudi Arabia and a more resilient and resource efficient future.

## MATERIALS AND METHODS

## **Research Design**

A qualitative research design investigates Circular Economy (CE) principle integration in Public-Private Partnerships (PPPs) that Saudi Arabia's water and transport sectors use. The qualitative research approach delivers deep insight into all stakeholder views about infrastructure project circular practice execution. Semi-structured interviews served as the data collection method because they let respondents express their views through non-structured answers.

## Participants

The research included representatives and officials and sustainability experts from the private sector and government ministries as essential stakeholders. Purposive sampling technique selected 15 participants in order to achieve participant diversity. Project managers together with policymakers and sustainability consultants who worked on Public-Private Partnership water and wastewater management projects and transport and logistics projects were participants in this study. The combination of diverse viewpoints gave participants a full understanding of the integration issues and possibilities for CE principles in the assessed sectors.

## **Data Collection**

The researcher carried out data collection activities throughout three months. Researchers conducted semi-structured interviews as their main approach to obtain detailed responses about CE and PPPs throughout the three-month period. A research tool containing open-ended interview queries sought to discover interviewees' perceptions of these three areas:

• Stakeholders' Perceptions of Circular Economy describe their conceptual definitions and understandings of CE when focused on PPPs.



- Research findings about practical experiences of CE implementation within the recent project experience.
- Governmental frameworks together with regulatory frameworks play an important role in enabling or restricting the implementation of circular practices.

The interview method depended on participant availability for either face-to-face meetings or video conference sessions. Each interview session lasted between 45 to 90 minutes respectively during which participants agreed to recorded audio sessions. The researchers conducted verbatim transcription of all recorded information.

#### Data Analysis

A thematic analysis method constituted the core approach to analyze the gathered data. This procedure included sequential fundamental processes. The researcher began by reading the transcripts several times to gain full comprehension of their contents. The researchers conducted coding which sought to recognize potential themes and patterns that addressed the research questions. Both inductive coding allowed themes to surface from the data as well as deductive coding concentrated on specific research areas defined in the literature.

#### Thematic categories included:

- Stakeholders demonstrate varying perceptions about Circular Economy together with their evaluation of its importance towards Public-Private Partnerships.
- The execution of Circular Economy principles faces several problems which teams must overcome when implementing these principles in their projects.
- The current strategies and guidelines established by institutions receive assessments from stakeholders regarding their capacity to promote circular practices.



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Fig 5



The researchers used their refined themes to create a structured account that showed the key information they discovered. By constantly repeating the research stages the investigators maintained analysis connection to participant first-hand experiences yet enabled fresh understanding generation.

#### **Ethical Considerations**

The study obtained ethical permission from a reliable institutional review board. Before study engagement participants learned about the research objectives followed by consent acquisition from each participant. The study insured participant confidentiality through two measures: data security protocols and participant identity masking and data encryption protocols. Every participant received the freedom to discontinue their involvement in the study anytime without any negative effects.

## Limitations

The qualitative research approach delivers powerful insights yet the research has several drawbacks which need recognition. The research results from this study do not extend beyond the particular stakeholders who work with PPP projects in Saudi Arabia due to the restricted scope of the sample. Some participants may tailor their reports during data collection because they seek to present their experiences in an ideal manner which could create biases in the research findings. Research studies should employ mixed methodologies for discovering information through multiple evidence sources to improve reliability of findings.



The study methodology stands focused on delivering extensive knowledge about implementing CE principles within Saudi Arabian PPP frameworks by evaluating stakeholder experiences and the established institutional support structures.

## DISCUSSION

The economic integration of Circular Economy principles through Public-Private Partnerships for Saudi Arabia's water and transport sectors creates implementing difficulties while opening substantial opportunities. The study shows how CE develops sustainable infrastructure and reveals its implementation hurdles in Saudi Arabia's changing economic system.

#### **Opportunities for Circular Economy Integration**

A key finding reveals that CE principles show clear matching with the Saudi Vision 2030 strategic goals. Research participants highlighted how circular business techniques help not only improve resource management but also increase economic market variety. The Integrated Sewage Treatment Plants (ISTPs) show how wastewater transformation produces valuable resources that solve water scarcity problems (Almadhi et al., 2020). Partners during stakeholder discussions often mentioned the doubled advantages of environmental concern management alongside economic development performance.

Stakeholders stressed out how PPPs help facilitate integration of CE principles. Stakeholders revealed that public-private sector collaborations permit both organizations to exchange specialized knowledge and resources needed for developing innovative circular solutions. Private sector companies contribute state-of-the-art technologies and management practices for enhancing water treatment facility resource recovery operations (Ghaithan et al., 2019). This beneficial integration promises higher project efficiency and creates sustainability culture framework within the infrastructure field.

#### **Challenges in Implementation**

Various obstacles appeared during the process of integrating CE principles effectively into PPPs despite the existing growth opportunities. The participants stated that operational restrictions presented the major impediments. The Saudi Arabian regulatory system is currently undergoing development but it still needs more detailed standards for circular practice execution. The stakeholders demonstrated worry about receiving better guidance and incentives for CE adoption in PPP projects. The absence of favorable policy measures prevents private organizations from embracing circular solutions because they demand initial financial outlay combined with extended time-based obligations (AlJaber et al., 2020).



Embracing circular practices faces resistance from public entities because of their need to change their cultural mindset. The stakeholders observed a strong resistance to changes within operational organizations mainly working within linear systems. The implementation of education and awareness programs serves as a requirement to deliver basic understanding of CE principles together with their advantages to every participant within PPPs according to Hadidi et al. (2020). Sustainable practice training programs offer an effective method to tackle the opposition to circularity thereby enabling organizations to adopt circular solutions more easily.

## **Institutional Support and Future Directions**

The research demonstrated that institutional backing acts as a pivotal factor which advances circular PPPs. The National Center for Privatization & PPP (NCP) together with other relevant agencies need to implement active measures which support CE integration. The development of referenced policies and assessment metrics for circular initiatives will enable better promotion of sustainable practices throughout PPP projects (Almulhim, 2020).

The future holds significant potential for Saudi Arabia to adopt circular practices within its infrastructure development. Stakeholders showed confidence in how sustainability has become recognized as a vital value in project development and implementation. PPPs function as a strategic avenue for implementing innovative solutions targeting environmental sustainability goals that the government maintains as its priority.

The research reveals the dual nature of adopting Circular Economy principles into Public-Private Partnerships through Saudi Arabian projects. To achieve substantial sustainability improvements and resource optimization the government needs to overcome institutional obstacles and actively develop circular thinking throughout the community. The Kingdom's infrastructure development will achieve its complete circular potential through sustained public-private sector collaboration and hard policies which lead to comprehensive education programs.

# CONCLUSION

Infusing Circular Economy principles into Public-Private Partnerships between Saudi Arabian sectors of water and transport serves as a disruptive method for developing sustainable infrastructure. The analysis demonstrates how CE convergences with Saudi Arabia's Vision 2030 creates substantial chances to enhance resource utilization while expanding the economy. The ISTPs merger with other sewage treatment facilities has demonstrated to all stakeholders that they resolve essential environmental needs while simultaneously developing financial value from resource recycling.

The study findings show that the execution of circular practices is hindered by several complex elements. The findings indicated that regulatory frameworks and supportive policies encounter obstacles throughout the institutions to achieve their integration into PPP projects. As an urgent matter the National Center for Privatization & PPP (NCP) requires developing guidelines to provide incentives for circular practices in PPP projects. The accomplishment of cultural transformation toward sustainability within organizations stands as the key factor to defeat organizational resistance against change.



The infrastructure development of Saudi Arabia will require implementing CE principles into PPP frameworks to fulfill its enduring sustainability targets. Public and private sector collaboration requires stronger supportive measures to develop innovation and knowledge transfer between them. Saudi Arabia will create a sustainable and resilient future through the analysis of found challenges and CE exploration which will produce economic and environmental advantages for both sectors.

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