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Sustainable transport infrastructure: Road asset management in the CAREC region

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ADB Working Paper Series

**SUSTAINABLE TRANSPORT
INFRASTRUCTURE: ROAD
ASSET MANAGEMENT IN
THE CAREC REGION**

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and Ayoob Ayoobi

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Abstract

The Central Asia Regional Economic Cooperation (CAREC) region has historically been an important route for global trade – connecting Asia to Europe (and vice versa) and beyond through the ancient Silk Road before the evolution of maritime trade and commerce in the 1500s. The Asian Development Bank initiated the subregion development program, CAREC, in 2006 with the aim of reviving the region's commerce and trade significance by investing in six CAREC corridors. In 2013, the People's Republic of China (PRC) launched the Belt and Road Initiative to further accelerate efforts on this front. In general, over the past two decades a lot of investment has been made in reviving the ancient Silk Road.

Since 2010, the Asian Development Bank (ADB) has been putting significant effort into upgrading and building CAREC corridors, which run through the whole region. These corridors enhance inter- and intraregional connectivity and consequently promote regional economic cooperation and cross-border trade. While further efforts and resources need to be optimized for upgrading and building the corridors, special attention must be paid to looking after these corridors in terms of sustainable asset management.

This paper investigates road asset management (RAM) practices within the CAREC nations through which the CAREC corridors pass, with the objectives of understanding (i) what the current status of RAM is, (ii) the importance of RAM to the CAREC corridors, and (iii) the role of RAM in addressing climate change, and also (iv) identifying policies for RAM implementation.

The paper draws on data collected through RAM maturity assessments for 17 primary aspects of RAM practice that were completed via a self-assessment methodology, but with subsequent validation completed in four CAREC countries. The findings indicate that while the best practice within the region for any individual aspect of RAM is of an acceptable level, there is significant variation in results both between countries and between aspects of RAM within a given country.

Finally, the paper has used the findings to develop a range of policies that could be used to create a more sustainable and resilient road network for the region – thereby enabling the benefits envisioned from the investments in the corridors to be realized.

Keywords: road asset management, maturity assessment, sustainable transport, CAREC Institute

JEL Classification: R42, O18

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1. INTRODUCTION

Sustainable transport infrastructure (STI) is a concept aimed at balancing the economic, social, and environmental aspects of transport development. Road asset management (RAM) is one of the key components of STI, as it helps to optimize the performance, safety, and durability of road networks. RAM involves planning, designing, constructing, operating, maintaining, and renewing road assets in a systematic and cost-effective way.

The CAREC region, which comprises 11 countries, faces many challenges in developing and managing its corridors, such as harsh weather conditions, terrain diversity, security issues (in the case of Afghanistan), and limited financial resources. To address these challenges, the CAREC Program, supported by the Asian Development Bank (ADB) and other development partners, has been implementing various initiatives to improve RAM and STI in the region. These initiatives include, among others:

- Developing and disseminating best practices and guidelines on RAM and performance-based road maintenance contracts (PBCs) in the CAREC region.
- Conducting railway sector assessments and providing recommendations for railway commercialization, reform, and investment.
- Promoting low-cost carrier opportunities, air transport liberalization, and post-pandemic recovery in the aviation sector.
- Enhancing regional cooperation and coordination on transport policies, strategies, and projects through the CAREC Transport Sector Coordinating Committee.
- Organizing workshops and capacity-building activities on various topics related to RAM and STI, such as road safety, climate resilience, green transport, and intelligent transport systems.

By improving RAM and STI in the CAREC region, the CAREC Program aims to achieve its vision of “Good Neighbors, Good Partners, and Good Prospects” and contribute to the sustainable development goals of the region. Overall, as people and goods move faster and more efficiently through the corridors, significant improvements are seen in trade between the CAREC countries, with other regions, and in transit trade. Increased trade, in turn, supports business development, creates jobs, and brings a better quality of life to the people of the region.

While the construction of the six CAREC corridors has brought immediate positive economic spillover in the countries of the CAREC region, they require road asset management to sustainably keep them maintained. To this end, the Asian Development Bank, in collaboration with other international development agencies (i.e., the Asian Infrastructure Investment Bank, the CAREC Institute), have been supporting the CAREC countries in addressing the pressing needs of the region for a systematic sustainable transport asset management.

1.1 Objectives

Since 2015, the authors have been involved in efforts to lift the quality of RAM practice across the region as part of many discrete projects. In 2020, this became a direct initiative leading to the development and delivery of an online RAM training program (during Covid-19 travel-constrained times), the development and support of a RAM self-assessment framework, and finally by delivering in-country workshops (four countries completed to date). This prior work confirmed to the authors that there was a need to raise the benefits of RAM and promote key policies to a wider audience than the previous approaches.

This paper, therefore, was developed with the following primary objectives in mind:

- (i) Documenting the current status of RAM practice across the region.
- (ii) Developing key RAM improvement initiatives that could be incorporated into the overall CAREC corridor investment program.
- (iii) Examining how RAM can assist in addressing the impacts of climate change.
- (iv) Developing policy initiatives that would assist in the wider application of RAM practices.

1.2 Scope

The focus of this paper is on the benefits of RAM to the CAREC corridors (refer to Section 1.4) but is equally applicable to all road networks both within the CAREC region and beyond. The reason for focusing on the CAREC corridors is that these roads are currently receiving significant investments for the purpose of upgrading them to international standards, and the benefits assumed to be delivered by these investments can only be optimally attained if good RAM practice is in place.

Furthermore, the authors, having led the RAM training and self-assessment exercise across the region, were able to readily access data sets to help them understand the current status of RAM. Combined with discussions held with CAREC member country representatives during both online and in-person workshops, the authors had a deep understanding of issues and impediments hindering better RAM implementation.

1.3 Methodology

The assessment of current RAM practice (refer to Chapter 4) is based upon a comprehensive self-assessment methodology. The assessment follows the structure of the International Infrastructure Management Manual (IIMM),¹ which has provided leading guidance to the management of all infrastructure (not just roads) since the year 2000. Covering 17 primary aspects of RAM practice (with several split into subaspects to address different asset types such as pavements, bridges, etc.), these self-assessments provide a quantitative set of data on which the core understanding of current practice is based.

Building on from this data set, the authors have captured the learning and feedback gained from both the online and in-person workshops to ascertain the impediments to better RAM practice. From this learning, policy initiatives have been developed to address identified shortcomings.

¹ International Infrastructure Management Manual (IIMM). <https://apopo.co.nz/product/international-infrastructure-management-manual/> (accessed 28 December 2023).

1.4 The CAREC Corridors

As explained by Meeuws (2020), the concept of a transport corridor is typified by a focus on a multimodal approach aimed at identifying the overall transport requirements to provide the movement of goods and people in a seamless and efficient manner. Meeuws continues by observing that *“in most countries and regions, the multimodal transport network is (still) a patchwork of single modal networks of roads, railways, waterways, airports and seaports. Realizing efficient supply chains in practice is hampered especially by the: cross border or cross region infrastructures; cross border or cross region operations; different cross border regulatory and legal regimes; technical interoperability; integration of different transport modes.”*

Roberts et al. (2019) state that *“transport corridors can generate both wider economic benefits (WEBs) and costs through their effects on diverse development outcomes. The analysis finds that characteristics of individual studies and the design of the transport infrastructure influence estimated benefits. It also shows that, on average, while corridor interventions tend to benefit economic welfare and equity, they often detrimentally impact the environment. To mitigate trade-offs, policymakers can consider using complementary interventions.”*

The Central Asia Regional Economic Cooperation (CAREC) corridors refer to a network of transportation and trade routes that connect various countries in Central Asia and beyond. These corridors play a significant role in promoting regional connectivity, enhancing trade, and facilitating economic cooperation among the CAREC member countries. A more detailed background on the corridors is found on the CAREC Program website.²

There are currently six CAREC corridors. These corridors consist of highways, railways, and other transportation infrastructure that enable the efficient movement of goods, services, and people across different regions. The corridors are strategically designed to link landlocked countries in Central Asia with neighboring countries, ports, and major international trade routes.

The six CAREC corridors are as follows:

Corridor 1: The Europe-Caucasus-Asia (TRACECA) corridor, which connects Europe with the PRC through the Caspian Sea region.

Corridor 2: The Almaty-Bishkek Economic Corridor, connecting Almaty in Kazakhstan with Bishkek in the Kyrgyz Republic, thereby improving trade between the two countries.

Corridor 3: The North-South Transport Corridor, connecting the Russian Federation with Iran via Azerbaijan and Central Asia, enabling efficient transportation and trade between the regions.

Corridor 4: The Central Asia Regional Economic Cooperation Railway Corridor, connecting major economic centers in Central Asia with the PRC and other countries in the region.

Corridor 5: The Karakoram Highway, connecting the PRC and Pakistan through the rugged mountainous terrain of the Karakoram range.

Corridor 6: The South Caucasus Corridor, connecting Black Sea ports to the Caspian Sea ports through Georgia, thus promoting trade and connectivity in the region.

² Central Asia Regional Economic Cooperation. https://www.carecprogram.org/?page_id=20 (accessed 28 December 2023).

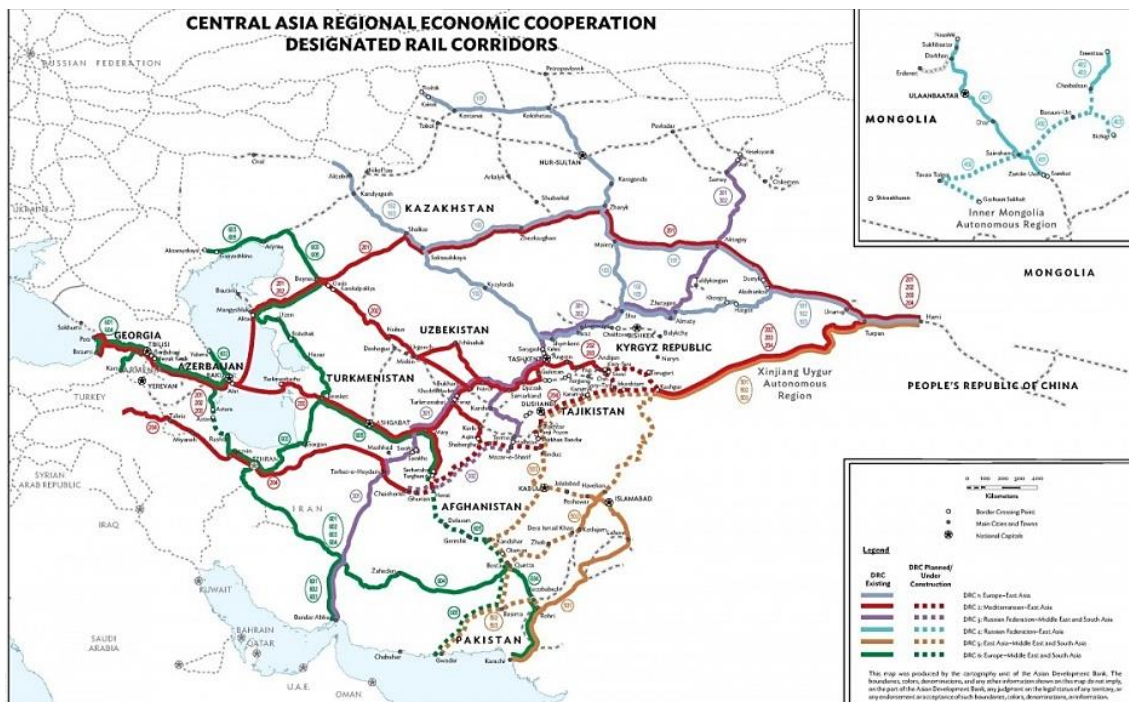
These corridors are part of CAREC’s overall vision to promote economic growth, reduce poverty, and enhance regional cooperation through improved infrastructure connectivity. They not only facilitate the movement of goods and people but also serve as platforms for collaboration and knowledge sharing among the member countries.

Figure 1 shows the six CAREC corridors that link the region’s key markets together both internally and to the countries beyond the CAREC region. The CAREC Transport and Trade Facilitation Strategy (TTFS 2020) presented an investment plan in upgrading all six transport corridors to international standards. Under the 2020 strategy, the goals of 7,800 kilometers (km) of CAREC corridor roads and 1,800 km of rail track built were achieved in 2017.³

The CAREC Program² notes that “[a]s of December 2021, 218 CAREC-related projects worth more than \$41 billion have been implemented in the areas of transport, trade, energy and economic corridors development, allowing better connectivity and easier movement of people and freight throughout the region, enhancing energy efficiency and security, increasing trade, and improving the quality of life for all.”

The CAREC Program notes that “[a]s people and goods move faster and more efficiently through the corridors, significant improvements are seen in trade between the CAREC countries, with other regions, and in transit trade. Increased trade, in turn, supports business development, creates jobs, and brings a better quality of life to the people of the region.” While the construction of these corridors has brought immediate positive economic spillover in the countries of the CAREC region, they require road asset management to sustainably keep them maintained.

Figure 1: CAREC Corridors



Source: CAREC Secretariat.

³ Central Asia Regional Economic Cooperation Program. <https://www.carecprogram.org/> (accessed 28 December 2023).

1.5 What is Road Asset Management (RAM)?

The IIMM (2020), the American Association of State Highway Transportation Officials (AASHTO), Greenwood (2021), and others define road asset management to include the systematic and strategic approach of managing and maintaining road infrastructure in order to maximize its value and life span. It involves a range of activities aimed at ensuring that roads are safe, functional, and cost-effective over the long term. Road asset management includes various components such as inventory and condition assessment of road assets, prioritization of maintenance and rehabilitation activities, budgeting and resource allocation, and monitoring and evaluation of performance. It also involves making informed decisions based on data and asset management principles to optimize the use of available resources.

The key objectives of road asset management are to improve the overall condition and performance of road networks, minimize life cycle costs, enhance road safety, and provide satisfactory levels of service to road users. It helps transportation agencies and road authorities to prioritize investments, allocate budgets effectively, and make informed decisions regarding maintenance, repair, and rehabilitation activities. Effective road asset management requires the use of appropriate tools and techniques, such as road condition surveys, asset management systems, and performance-monitoring frameworks. It also involves the integration of various disciplines, including engineering, finance, and planning, to ensure the long-term sustainability of road infrastructure.

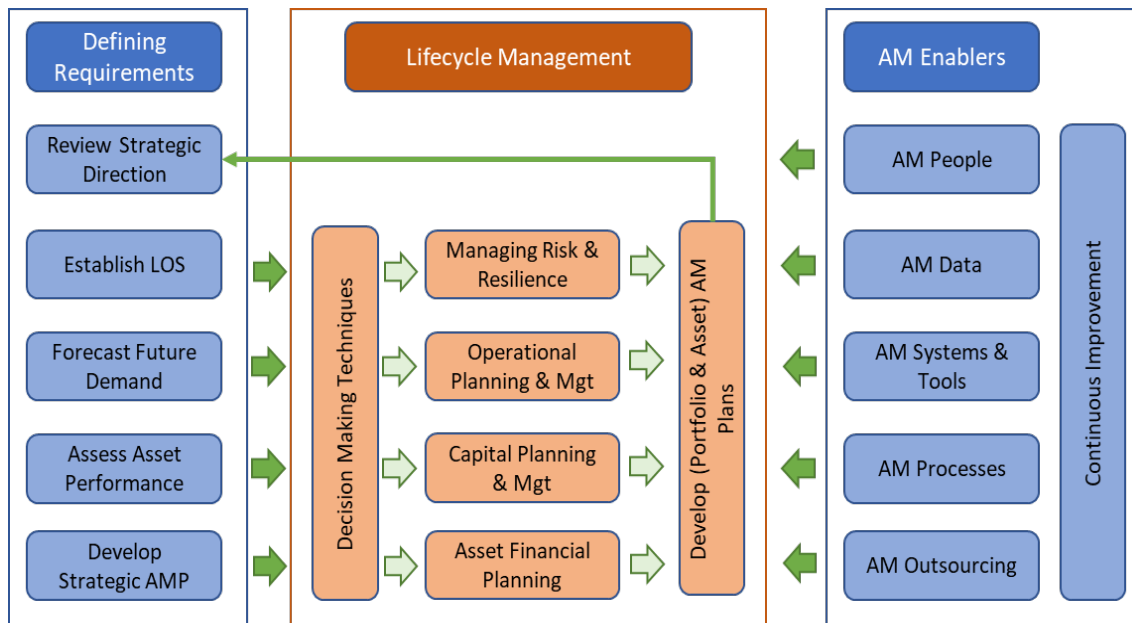
Overall, road asset management is crucial for maintaining and optimizing the performance of road networks, ensuring the efficient use of public resources, and providing safe and reliable transportation infrastructure for the benefit of the community.

More importantly, RAM involves the application of business and engineering practices to the management of the road network. As defined by AASHTO, RAM is a “*strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives.*”⁴

The ISO 55000 standard further defines asset management as “[t]he coordinated activity of an organization to realize value from assets.” What is consistent across the many definitions is that the practice of RAM is both systematic and holistic, with the International Infrastructure Asset Management process (refer to Figure 2) providing a good indication of the scope of activities that are required to be undertaken in order to meet good levels of RAM maturity.

⁴ American Association of State Highway Transportation Officials Transportation Asset Management Guide. <https://www.transit.dot.gov/sites/fta.dot.gov/files/2022-03/AASHTO-Transportation-Asset-Management-Guide.pdf> (accessed 28 December 2023).

Figure 2: Asset Management Process



Notes: LOS = level of service, AMP = asset management plan, AM = asset management.
 Source: International Infrastructure Management Manual (2020)

The above process diagram is equally applicable to a road as it is to a hospital, a shopping center, or any other asset. It is also equally applicable to a national highway network as it is to a local road. What varies is the details within each step of the process – for instance, on a national highway, assessing asset performance may involve the application of equipment with multiple cameras and lasers to measure road condition, while on a low-volume rural road this assessment may be via visual observations and a simple “good/fair/poor” rating assigned.

2. THE IMPORTANCE OF RAM TO CAREC CORRIDORS

Road asset management is important for CAREC corridors for various reasons in general terms. Firstly, it enhances connectivity by ensuring that the anticipated investments in upgrading the corridors are realized over the long term. Effective road asset management helps to maintain road infrastructure in good condition, ensuring seamless connectivity within and between countries. This enables efficient movement of goods, people, and services along the CAREC corridors, thereby facilitating regional trade and economic integration.

Secondly, it improves safety. Well-maintained roads reduce the risks of accidents and fatalities, thus enhancing road safety for all users. Proper asset management practices, such as regular inspections, repairs, and upgrades, can help in identifying and addressing potential safety hazards promptly.

Thirdly, it makes maintenance cost-effective. Timely maintenance and rehabilitation of road assets can prevent small issues from turning into major problems. Effective asset management practices can help in prioritizing maintenance activities and allocating resources efficiently, reducing long-term maintenance costs and increasing the life span of road infrastructure.

Fourthly, it fosters economic development. CAREC corridors play a crucial role in promoting economic development and regional cooperation. Good road infrastructure, supported by robust asset management practices, attracts investments, encourages trade, and facilitates tourism, thereby creating opportunities for economic growth and job creation.

Fifthly, it makes transport infrastructure resilient to climate change, which poses significant challenges for road infrastructure. Asset management techniques can help in assessing and addressing the potential impacts of climate change on CAREC corridors, such as increased flooding, extreme temperatures, and erosion (World Bank 2017). By incorporating climate resilience strategies, road asset management can ensure the durability and sustainability of road infrastructure in the face of climate-related challenges.

Finally, it helps with efficient resource allocation. Road asset management enables effective utilization of limited resources. By using data-driven decision-making processes, asset managers can identify the most critical areas for investment and allocate resources strategically, optimizing the use of available funding.

Overall, road asset management is essential for CAREC corridors to ensure connectivity, safety, cost-effectiveness, economic development, resilience, and efficient resource allocation. By maintaining road infrastructure in good condition, CAREC countries can maximize the benefits of regional integration and promote sustainable development in the region. Not only is this an outcome of implementing RAM, but it is also by definition the core objective of RAM – wherein a focus on delivering the desired outcomes in the most optimal manner is the essence of the overall RAM process.

In more specific terms, the CAREC Transport Strategy 2030⁵ identifies RAM as one of five strategic pillars, with Figure 3 containing an extract from the strategy. While the TTFS covers some of the key benefits of RAM for looking after existing roads, it doesn't fully convey the key role that RAM plays in addressing a range of topics such as decarbonization of transport, climate resilience and adaptation, and the integration of road safety into day-to-day operations. Indeed, the main focus of the TTFS is on ensuring that there is an IT solution (defined in the TTFS as the RAMS) and the implementation of performance-based maintenance contracts. These two items equate to the "AM Systems and Tools" and "AM Outsourcing" aspects of RAM as presented in Figure 2 – or just two out of 17 aspects that need to be addressed to ensure that RAM can be delivered in a comprehensive manner.

⁵ CAREC Transport Strategy 2030. CAREC and ADB. January 2020. <https://www.carecprogram.org/uploads/CAREC-Transport-Strategy-2030-1.pdf> (accessed 28 December 2023).

Figure 3: CAREC TTFS 2030 – Asset Management

CAREC and Roads and Road Asset Management (RAM). Over the last decade, investments in the road sector focused on the construction and rehabilitation of priority road networks in CAREC countries to increase the standard and condition of these roads to meet current and future transport needs. To ensure the long-term sustainability of these road improvements, the TTFS 2020 envisaged the development of Road Asset Management Systems (RAMS) and the implementation of performance-based maintenance (PBM) contracts in several CAREC DMCs [Developing Member Countries]. To support this objective, a regional Road Asset Management Workshop was held in April 2015, followed by the preparation and dissemination of three road asset management publications.

DMCs designed and used CAREC self-assessment tools to assess their status and capacity to implement robust RAMS. Throughout the TTFS 2020 implementation period, the CAREC DMCs and development partners continued working on the modality of PBM contracts and arrangements for development financing of the PBM-related projects.

Key issues. *Despite improvements of the CAREC road network infrastructure and road maintenance practices, budgets prioritize construction and rehabilitation and the existing funding allocation for maintenance only covers a fraction of the estimated need. Furthermore, the limited maintenance funding is not necessarily needs- and demand-driven, but tends to be targeted at older roads in poor condition. As a result, proper maintenance of recently completed road networks is lacking in most CAREC DMCs. This led to accelerated deterioration of these roads which reduced the actualization of travel time savings expected from the investments.*

Moreover, a lack of investment in upfront, routine, and preventive maintenance reduces the life span of the assets, as the roads will get to a point where they are no longer maintainable, requiring costly rehabilitation or reconstruction. As a result, countries have been unconsciously increasing life cycle costs of the road assets.

Actions. *The objective of this strategic pillar of the CAREC program is to strengthen road asset management in the CAREC countries to respond to these issues. Road asset management is a strategic approach that seeks the optimal allocation of resources for the management, operation, preservation, and enhancement of road infrastructure to meet the needs of current and future road users. Road asset management looks at the optimization of available funding and determines the optimal allocation of this funding to different roads and investment types, with the aim of maximizing the benefits of improved road conditions and reduced road user costs over time.*

By collecting and analyzing data regarding the road network and its users, governments can make more informed choices regarding the allocation of funding to either develop, rehabilitate, or maintain an ever-expanding network of roads. This may also consider any expected climate change impacts. This approach introduces a shift in focus from short-term targets regarding the upgrading of road standards, to the long-term benefits of road maintenance for asset sustainability and future road sector funding requirements.

Source: CAREC Transport Strategy 2030.

The three road asset management publications referred to in the TTFS cover the following topics: (i) a compendium of best practices in RAM; (ii) RAM information systems and performance-based contracting; and (iii) the preparation and delivery of training materials. These reports are available on the CAREC Program website.⁶

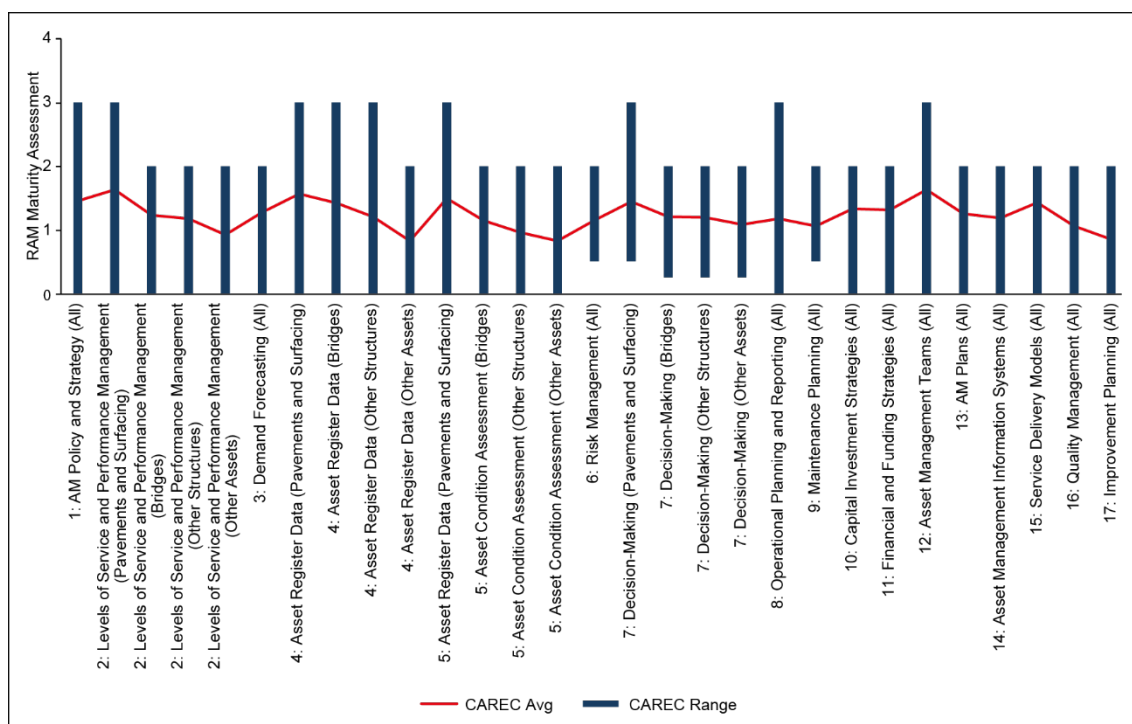
⁶ Central Asia Regional Economic Cooperation Program. <https://www.carecprogram.org/> (accessed 28 December 2023).

3. RAM IN CAREC COUNTRIES

3.1 Current Status

The current status of road asset management in the CAREC corridors varies among countries and projects. Figure 4 illustrates the range of results from the self-assessment between countries across the full spectrum of criteria assessed. In just about all cases the responses range from 0 (nothing has occurred) through to 2 or more (indicative of a good level of RAM practice). When the detailed data underlying the figure below are examined, it is evident that even countries that have an overall very good level of RAM practice still have scores as low as 1 for some aspects of RAM.

Figure 4: Variation of RAM Between Countries



Source: Adapted from Greenwood (2021).

However, there are several initiatives and actions that have been undertaken to improve road asset management in the region (Greenwood 2021), including: a) Asset management systems: Several countries within the CAREC region have implemented, or are in the process of implementing, asset management systems for their road networks. These systems help in inventorying road assets, collecting data on asset condition and performance, and making informed decisions on maintenance and investment. b) Road condition assessment: Many CAREC member countries have conducted road condition assessments to determine the current state of their road infrastructure. This allows them to identify areas in need of maintenance or rehabilitation and allocate resources accordingly. c) Performance monitoring: Performance monitoring frameworks are being developed and implemented to measure and evaluate the performance of road assets in the CAREC corridors. These frameworks help in setting performance targets, tracking progress, and making data-driven decisions. d) Investment planning: CAREC member countries, together

with multilateral development banks and other stakeholders, are engaged in investment planning for road asset management. This includes identifying priority projects, allocating funds, and coordinating efforts to efficiently manage and maintain road infrastructure. e) Collaboration and knowledge sharing: The CAREC Program provides a platform for member countries to collaborate and share knowledge and best practices in road asset management. This includes workshops, seminars, and other capacity-building initiatives aimed at enhancing the expertise and skills of practitioners.

While progress has been made in road asset management within the CAREC corridors (most often through the implementation of asset management software and initial data collection activities for the pavement assets as reflected by the higher scoring averages in Figure 4), challenges still remain. These include limited financial resources, capacity constraints, and the need for improved data collection and analysis. Continuous efforts in capacity building, investment planning, and collaboration among member countries and stakeholders are crucial to further enhance road asset management in the CAREC corridors.

Since 2020, the authors of this chapter have been working together to both benchmark and improve the practice of RAM across the CAREC region. This has been through a combination of:

- (i) Online training (during COVID-19 travel constraints) over a period of one week in 2020.
- (ii) Remote support to complete a RAM maturity self-assessment in 2020/2021.
- (iii) In-country workshops to validate the self-assessment results, further entrench key RAM messages, and refine the RAM improvement plans – held to date in Azerbaijan, Georgia, the Kyrgyz Republic, and Tajikistan during 2022/23.

The RAM maturity self-assessments were completed with the help of a series of online virtual support workshops, and while open to the inherent variations in assessment, they do provide the basis for a consistent look at RAM practice across the region. The self-assessment process worked as follows:

- (i) An Excel toolkit was developed in which for each aspect of the RAM process, a series of statements were prepared that relate to what would be demonstrative of the rating grades (from 0 to 4).
- (ii) An online workshop was held with the CAREC region participants to explain the toolkit and how to complete the assessment (note that predominantly the same participants had already undertaken the online RAM training sessions).
- (iii) Countries then undertook the ratings, and additional workshops were held one-on-one with countries as requested.
- (iv) The results were reviewed and clarification (and rescoring as appropriate) was undertaken in conjunction with the respective countries.

The ratings assigned in step (i) above were defined as 0 = Aware; 1 = Basic; 2 = Proficient; 3 = Advanced; and 4 = Advanced+. In effect, it was felt that achieving a rating of 2 should be the minimum level that all road authorities should be at for all aspects of RAM, and that an assessment with multiple scores of 3 or more would suggest that the authority would be well placed to seek a formal review under the ISO 55000 framework.⁷

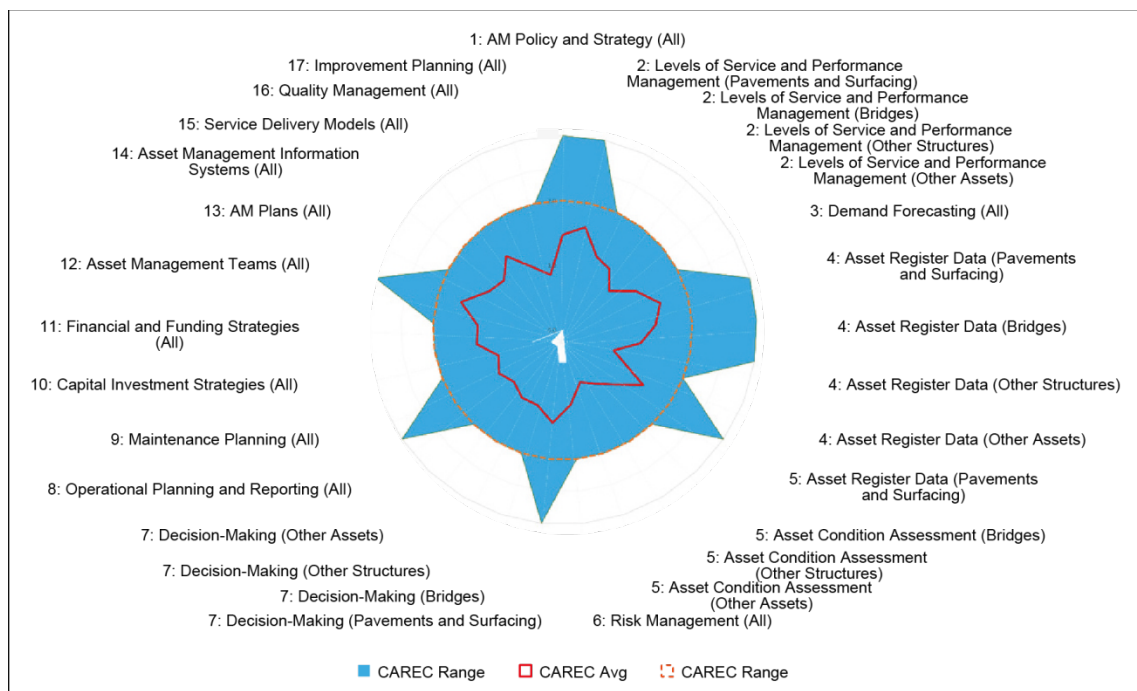
⁷ ISO 55000 is the international standard for asset management. <https://www.iso.org/standard/55088.html> (accessed 28 December 2023).

These self-assessments were then further refined during 2022–2023 following in-country workshops completed so far in Azerbaijan, Georgia, the Kyrgyz Republic, and Tajikistan. These in-country validations of the results provide a crucial benchmarking of these results. Overall, the validations suggest (no statistical analysis has occurred) that the self-assessments were robust – although there were both high ratings that couldn't be justified on the basis of evidence and low ratings that didn't reflect the current situation. A key issue here was how to evaluate items where work was actively underway: Is it a zero score because it is not completed or a high score to reflect what will be once the work is completed?

The results of the self-assessment for the region (and hence for the corridors within the region) are illustrated in Figure 5, which is a variation on the format used in Figure 4. The solid red line is the CAREC average results, while the shaded area reflects the range of results recorded across the full scope of the RAM process. The orange dashed line indicates what could be defined as a competent level of RAM.

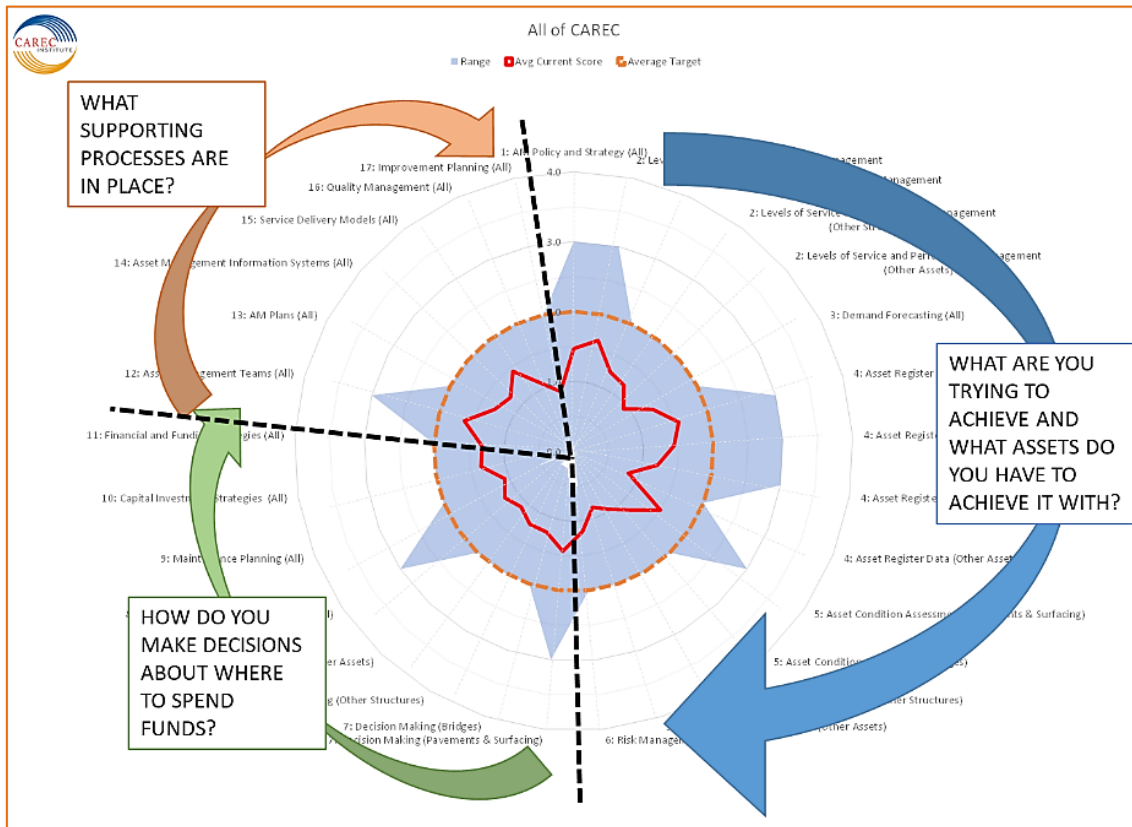
Figure 6 provides a simple way of considering the results within Figure 5 by splitting the scores into those that are related to: (i) knowing what you have and what you are trying to achieve; (ii) decision-making and funding; and (iii) the supporting aspects of systems, reports, and people.

Figure 5: Current RAM Status



Source: Greenwood (2021).

Figure 6: Explanation of RAM Maturity Assessment Results



Source: Greenwood (2021).

A key observation from the above figures is that within the CAREC region, there is very good RAM practice occurring. Therefore, the sharing of knowledge and experience across borders within the region could serve to lift the RAM practice of all nations to a level that would be deemed competent.

3.2 Key RAM Initiatives

The RAM workshops and self-assessments have provided a broad platform to engage with leading CAREC RAM policy influencers and experts as well as to facilitate expert discussions on various aspects of RAM. From the self-assessments, an overall RAM improvement plan was prepared as per the table below, which now needs to be implemented on a country-by-country basis.

Table 1: CAREC Key RAM Improvement Actions

Aspect of RAM	Improvement Action	Priority
Policy	Develop a RAM policy template.	High
Levels of Service	Develop a range of service-level indicators and performance measures for all asset types that countries can adopt if desired.	High
Future Demand	Develop a TOR for the development of a network-level traffic-monitoring program.	Low
Asset Register	Develop guidance on minimum data to be collected for major asset types.	High
Asset Condition	Develop guidance on recommended data collection for major asset types (what to collect and how often). Include discussion on equipment to use and indicative costs (equipment + staff) to complete the data collection on an annual basis.	High
Risks	Develop guidance on defining route criticality, and a risk management framework.	Low
Life cycle Decision-Making	Ensure that investment decisions are aligned with RAM policy and appropriately utilize maintenance cost data to generate life cycle cost forecasts.	Medium
Operations	Assistance in developing emergency response plans.	Low
Maintenance	Business case for increasing maintenance funding.	Medium
Capital Works	Support to produce an evidence-based five-year rolling capital investment plan (including renewals, capacity expansion, asset condition, and asset valuation).	Medium
Funding Strategies	Align with development of five-year rolling capital investment plan to identify funding needs for all aspects of the asset (including RAM, operations, maintenance, and capital). Produce a knowledge product on the various sources of funding covering road user charges (RUCs), tolling, vehicle registration fees, fuel taxes (including EV issues), general budget allocation, and road funds.	Medium
AM Team	Provide some benchmark indicators for the human resources needed to appropriately manage a road network under various delivery models.	High
AM Plans	Produce an AMP template.	High
AMIS and Tools	Produce TOR for consultant to work with road authority to determine needs and support procurement of an AMIS. [Consider further whether this is better provided as support on a country-by-country basis, rather than as a CAREC-wide initiative.]	Medium
Service Delivery	Workshop (online) on various contractual models (from force account to PBC).	Medium
Quality Management	Encourage ongoing documenting of processes.	Low
Improvement Plan	Produce country-specific support to take findings from this maturity assessment and turn them into a country-level improvement plan.	High

Source: Greenwood (2021).

4. RAM AS A SOLUTION TO CLIMATE CHANGE AND CLIMATE-RESILIENT TRANSPORT SYSTEMS

As with roads across the globe, the CAREC corridors will continue to be impacted by climate change – with some roads facing more frequent or intense rain events, others going through a greater number of freeze-thaw cycles as winters warm, and in other cases roads suffering from a lack of permafrost conditions. While managing roads in a static climatic environment is a challenge in its own right, the additional complexities of dealing with changing climatic conditions are of critical importance to the CAREC region.

Table 2: Climate Definitions

Climate change	Is a change in the usual weather found in a place. This could be a change in how much rain a place usually gets in a year. Or it could be a change in a place's usual temperature for a month or season.
Climate resilience (CR)	Is a measure of a system's ability to absorb and recover from changes to climatic events.
Climate adaptation and mitigation	Adapting to life in a changing climate – involves adjusting to the actual or expected future climate.
Climate mitigation	Reducing climate change – involves reducing the flow of heat-trapping greenhouse gases into the atmosphere.

Source: Adapted from NASA.org.

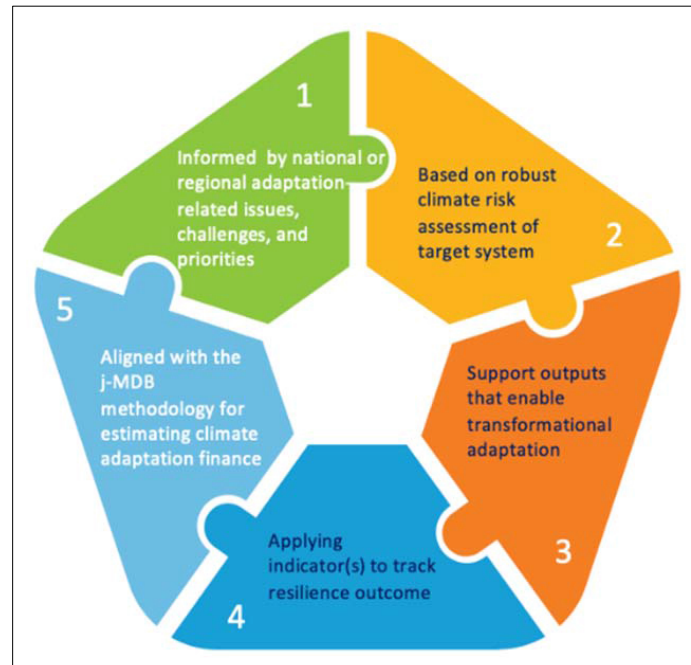
RAM has a key role to play in addressing climate change through addressing issues of climate resilience and adaptation of the CAREC routes. At the simplest level, through the appropriate defining of levels of service that relate to the resilience of the road infrastructure, RAM immediately focuses resources on achieving those resilience goals. For example, if a level of service of “CAREC corridors must not be interrupted by less than a 1 in 100-year flood event” were set (alongside more common measures around ride quality, road safety, travel speed, etc.), then RAM practices would immediately become aligned to optimize for this target.

At a more basic level, however, it is known that the simplest steps towards delivering a climate-resilient (CR) road network are to ensure that basic routine maintenance (cleaning drains, sealing cracks, ensuring that the slope of shoulders is such that water flows away from the road) is fully funded, along with ensuring that the resurfacing of roads is funded to maintain the integrity of the surface. RAM can play an important role in both these areas, firstly in demonstrating the impacts on the asset from underinvestment, and secondly in optimizing the allocation of any budget that is forthcoming.

Moving beyond that basic impact of RAM, the systems can be used to track the occurrence and impact of climatic events, answering such questions as: Where did the network flood? How deep was it? How much damage was done? This information then enables the enhanced calibration of flood prediction models, along with a better understanding of the likely impacts of future events. Assets that have high-risk costs can then be subject to more detailed design considerations – such as increasing drainage capacity, raising road embankments, and constructing roads that are less susceptible to damage from floods or other climatic events.

One of the keys to identifying vulnerabilities to the routes from climate change (and other natural hazards) is to adopt a systems approach. Such systems thinking goes to the heart of RAM, wherein high-level strategic objectives, risk assessments, and decision-making combine to strive towards meeting the desired levels of service (in this case, resilience levels) over the life cycle of the assets for the least cost. This is illustrated in the figure below, wherein the identification consideration of national and regional issues, and “systems” thinking make up the first two principles for determining whether a project meets the definition of climate resilience or adaptation.

Figure 7: Principles for Climate-Resilient Projects



Source: Asian Development Bank.

While service levels are regularly understood in terms of traffic congestion levels (such as via the Highway Capacity Manual), or in terms of road condition (such as the use of the International Roughness Index), or in road safety measures (such as iRAP ratings), it is much less common for road authorities to think of service levels around the level of resilience (or availability) that they require from their assets. Once resilience-based service levels are defined, RAM then provides the overarching framework to develop work programs and institutional policies and procedures that can optimize all factors in a single pass.

RAM can play a significant role in mitigating or adapting to climate change impacts in the CAREC corridors. Here are some ways in which RAM can contribute to climate change mitigation and adaptation:

1. Green infrastructure planning: RAM can incorporate climate change considerations into infrastructure planning by identifying areas prone to climate-related risks such as flooding, landslides, or extreme weather events. This allows for the prioritization of mitigation measures, such as incorporating drainage systems, protecting natural habitats, or implementing slope stabilization techniques.

2. Sustainable design and construction: RAM can promote the use of sustainable design and construction techniques that help reduce the carbon footprint of road infrastructure. This includes using recycled materials, implementing energy-efficient technologies, and considering climate-resilient designs to withstand changing weather patterns.
3. Climate-friendly maintenance practices: RAM can include climate-friendly maintenance practices that help reduce greenhouse gas emissions, energy consumption, and resource depletion – for example, adopting eco-friendly pavement preservation techniques, implementing energy-efficient lighting systems, and exploring alternative fuel sources for vehicles involved in road maintenance activities.
4. Low carbon transport solutions: RAM in CAREC corridors can play a role in encouraging low-carbon transport solutions, such as promoting the use of electric vehicles, improving public transportation infrastructure, and integrating nonmotorized transport options like cycling and walking paths into the road network. This can help reduce emissions from transportation and promote sustainable mobility.
5. Data monitoring and analysis: RAM involves data collection, analysis, and decision-making processes. By incorporating climate-related data, such as temperature and rainfall patterns, into these processes, road agencies can identify trends and potential climate change impacts on the road network. This enables proactive planning and timely adaptation measures.
6. Collaboration and knowledge sharing: RAM provides a platform for collaboration among countries and stakeholders within the CAREC Program. Sharing knowledge and best practices on climate change mitigation measures can help generate innovative solutions and promote the adoption of sustainable practices across the region. By integrating climate change considerations into RAM, the CAREC corridors can build more resilient and sustainable road infrastructure, reduce carbon emissions, and contribute to overall climate change mitigation efforts.

While the above list is essentially focused on the road itself, roads can also be used to provide mitigation benefits for the wider society. For example, in locations where climate change may be expected to lead to droughts, road embankments and drainage systems can be used to direct water to ponds. Or in locations where there is a risk of downstream flooding of towns and villages, roads can be used as dams to reduce the peak flows. It is therefore important to bring all such factors into a comprehensive decision-making framework – which is what RAM provides.

In the World Bank technical report on Integrating Climate Change into Road Asset Management (World Bank 2017), one of the key messages is that there are not two separate initiatives of RAM and addressing climate change. It is important that addressing climate change (and by extension delivering a resilient transport network) is integrated into RAM practices across the full spectrum of the RAM process. This means that refining RAM practices from high-level policies, through the setting of levels of service, the data to be collected, information management systems (particularly GIS), allocation of funds, and on to disaster financing mechanisms all need to be revised to ensure that the necessary climatic attributes are covered – alongside the traditional RAM focus on ride quality, safety, and reliability.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This paper has presented work that sets out to ascertain the current state of RAM practices across the CAREC region. Based upon a self-assessment methodology, the results indicate that there is a wide range of capability among countries. There is additionally a high degree of variability between different aspects of RAM within a given country. More important, though, is the observation that within the region there exist good examples of RAM practice for all aspects of RAM, such that a CAREC-based application of RAM can be delivered.

The paper has also illustrated the importance of improvements to RAM practices for the CAREC corridors, which are undergoing massive levels of investment. Without good RAM practice, many of the benefits projected from those investments will either not be realized or will be achieved at an unnecessarily high cost.

RAM is also the framework through which climate change, resilience, adaptation, and mitigation can be addressed in a comprehensive manner. It is fundamental that these items are seen as integral to RAM and not separate objectives.

5.2 Recommendations

Sustainable transport asset management should be at the forefront of the CAREC corridors going forward. It is often said that the construction of an infrastructure is easier than its sustainable maintenance. While the CAREC corridors have brought various immediate benefits to the CAREC communities, they require sustainable asset management for the long run. As discussed earlier, the CAREC countries' efforts in sustainable road asset management vary. Some countries have made significant progress in RAM, the rest are yet to progress. Hence, for the CAREC region to continue benefiting from the corridors, the CAREC countries need to intensify their efforts in bridging the gap and achieving coordinated results in sustainable asset management of the CAREC corridors.

There are several policy options that can be implemented to promote sustainable transport infrastructure asset management in the CAREC (Central Asia Regional Economic Cooperation) region. These options include:

Recommendation 1: Integrating sustainability into infrastructure planning: Governments in the CAREC region should prioritize sustainable transport infrastructure projects in their planning processes. This includes considering the social, economic, and environmental impacts of infrastructure development and incorporating sustainability criteria into project selection and evaluation.

Recommendation 2: Promoting green infrastructure: Governments should encourage the development of green infrastructure, such as eco-friendly transportation modes like electric vehicles, cycling infrastructure, and efficient public transport systems. This can help reduce greenhouse gas emissions, improve air quality, and enhance overall sustainability. Initiatives that reduce the carbon footprint, protect the roads, and protect the adjacent land users should be prioritized.

Recommendation 3: Achieving a minimum standard of road asset management systems: Governments should establish robust asset management practices to ensure the efficient operation and maintenance of transport infrastructure assets. These should be assessed and reported upon at the CAREC level at two-year intervals to ensure that progress is being made. The sharing of good practice across the region should be key to this improvement in RAM practice.

Recommendation 4: Incorporating resilience measures: Governments should incorporate resilience measures into transport infrastructure asset management. This includes building infrastructure that can withstand natural disasters, climate change impacts, and other external shocks, thereby reducing vulnerability and minimizing damage and service disruptions. For instance, what level of flood event are the corridors expected to be unimpacted by? How long after a flood should roads of different hierarchy be open to traffic? Measures such as these then fit within the overall RAM processes and can be optimized alongside targets for ride quality, road safety, etc.

Recommendation 5: Prioritizing capacity building and knowledge sharing: Governments should invest in capacity-building programs to enhance technical skills and knowledge in sustainable transport infrastructure asset management. This can include training programs, workshops, and knowledge-sharing platforms to ensure that governments and relevant stakeholders have the necessary expertise for sustainable infrastructure management.

Implementing these policy options can help the CAREC region move towards a more sustainable and resilient transport infrastructure asset management system, promoting economic development while minimizing adverse social and environmental impacts.

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