



PROMOTING LOW-CARBON TRANSPORT IN INDIA

POLICY SUMMARY



Infrastructure for Low-Carbon Transport in India:

A Case Study of the Delhi-Mumbai Dedicated Freight Corridor

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The Policy Summary is based on a case study of Delhi Mumbai Dedicated Freight Corridor (Pangotra, P., and P. R. Shukla. 2012. Infrastructure for Low-Carbon Transport in India: A Case study of the Delhi-Mumbai Dedicated Freight Corridor. UNEP Risø Centre, Roskilde), which is available online at <http://www.unep.org/transport/lowcarbon/publications.asp>. The findings, suggestions and conclusions presented in the case study and this policy summary are entirely those of the authors and should not be attributed in any manner to UNEP Risø Centre or United Nations Environment Programme, nor to the institutions of individual authors.

1. Executive Summary

The Delhi-Mumbai Dedicated Freight Corridor (DFC), known as the Western DFC, is one of the largest transport infrastructure projects being implemented in India. It is expected to revolutionize freight movement in the country and would thereby play a crucial role in sustaining national economic growth while inducing regional economic development. The DFC project also signifies a major transition in the freight transport sector as it would result in increasing the relative share of rail, which is a more energy efficient, environment friendly and less carbon-intensive mode of transport compared to the other available modes.

This case study of the Delhi-Mumbai DFC project provides long-term assessment of CO₂ emissions during the operations phase of the project. The assessment covers a 30-year time period from 2016–17 to 2046–47, under three future scenarios. There are two business-as-usual (BAU) scenarios based on continuation of current trends of freight movement, technologies and energy mix at the national level. The scenario BAU (With DFC), assumes that the Western DFC would become operational by 2016–17 as planned, while the scenario BAU (Without DFC), assumes continuation of freight movement on the existing mixed traffic network. The third scenario, LC (With DFC), is based on a low-carbon (LC) pathway at the national level, supported by a carbon tax, aimed at achieving the internationally agreed-upon global CO₂ stabilization target. As shown in Table 1, the Western DFC has the potential to bring about a large reduction in CO₂ emissions and thereby generate substantial potential revenues through carbon financing mechanisms.

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Table-1: Potential for CO₂ Emission Reduction from the Western DFC

Scenarios	Annual CO ₂ emissions in 2016–17 (Million tons)	Annual CO ₂ emissions in 2046–47 (Million tons)	Reduction in cumulative CO ₂ emissions, 2016–2046 (Million tons)	Notional value of reduction in cumulative CO ₂ emissions* (Billion Rs.)
BAU (Without DFC)	2.45	12.32	–	–
BAU (With DFC)	0.88	2.33	170.5	46.37
LC (With DFC)	0.76	0.28	204	55.48

* Price of carbon is assumed to be €4 per ton (approximate prevailing price in 2012) and the currency conversion rate is taken as Rs. 68/€ (as of March 30, 2012).

Box-1: Key Findings of the Study

1. Compared to the BAU (Without DFC) scenario, total cumulative CO₂ emissions over the 30-year time period (2016–17 to 2046–47) are expected to reduce from 222 million tons to 52 million tons under BAU (With DFC) and 18 million tons under the LC (With DFC) scenario. This further reinforces the enormous gains from the reduction in CO₂ emissions that are possible through the implementation of the DFC project.
2. Although in absolute terms the reduction among the two business-as-usual scenarios is larger, it is, in fact, the transition to the low-carbon scenario, LC (With DFC), that is more significant because it addresses the target of 2°C global average temperature rise until the year 2100, and has the possibility of generating substantial development co-benefits. Further, the difference between the two BAU scenarios may reduce if some of the efficiency improvements associated with the DFC can be realized in the BAU (Without DFC) scenario.
3. The step-wise decomposition analysis of CO₂ emissions shows that in 2046–47, nearly 87% of the difference in annual emissions between the two BAU scenarios can be explained by modal shift from rail (With DFC) to road (Without DFC). An additional 4% of the difference is due to the use of diesel traction for freight movement by rail in the scenario without DFC, instead of the 100% electric traction in the scenario with DFC. The remaining 9% of the difference is attributable to the higher energy efficiency of the DFC compared to the shared network due to various supply-side interventions.

The overall conclusion of the study is that large rail transport projects have high potential to reduce CO₂ emissions from the transport sector in India. Further, the perspective plans suggest that large transport investments have the potential to induce regional economic development provided complementary investments in economic and social infrastructure are made. Putting a monetary value on such co-benefits is not possible as the project is still in the planning stage.

Box-2: Major Policy Recommendations from this Study

1. Policymakers must recognise the potential for DFCs to generate large CO₂ reductions with significant co-benefits.
2. The creation of matching support infrastructures, such as freight terminals, special wagons, stack containers etc., would play a crucial role in the overall success of the project. Therefore, such infrastructures should be adequately provided and be part of a comprehensive plan.
3. The transport system of the DMIC region should be integrated with the DFC by providing appropriate infrastructures, such as Multi-Modal Logistics Parks and freight terminals at suitable locations.
4. Accelerated implementation of the remaining five DFCs would yield maximum economic returns in the long-run. The six corridors together would make the national freight transport system low-carbon, energy efficient and thereby more sustainable. Therefore, the remaining corridors should be taken up for implementation at the earliest time.
5. Policy decisions regarding location of power plants, cement plants and manufacturing centres would have important implications for development of freight transport infrastructure. To meet the rising demand for freight transport and make the system more efficient, use of pipelines for transport of oil product and natural gas should be expanded.



2. Background

India's economy has seen unprecedented growth during the last decade, averaging 7-8% per annum. While this growth has created a great deal of opportunity, it has also resulted in many challenges, especially for infrastructure required to sustain the rate of growth. Transport is viewed as one of the most important infrastructures for the national economy. In national transport systems, freight transport acts as the critical link between ports, markets and manufacturing centres.

There is increasing recognition among policymakers in India that transport infrastructure could become a serious bottleneck for future economic growth. This is particularly the case for freight transport, as high growth in freight traffic is expected to continue in the medium and long-term. The capacity of the existing rail network for freight transport is saturated on most of the trunk routes and the road network is also highly congested. It is apparent that economic growth at the current pace cannot be sustained without substantial addition to transport and logistics infrastructure.

Although rail is clearly the more energy efficient and environment friendly mode of transport compared to road, recent trends in freight movement show that the share of rail in total freight traffic has been steadily declining. Current policies of uneconomic pricing and cross-subsidy of passenger services by freight traffic are primarily responsible for inadequate investment in augmentation of the rail network capacity. Funding bottlenecks are the main reason for delays in completion of railway projects. Another major issue is the neglect of multi-modal integration, which has resulted in

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In 2006, the Ministry of Railways adopted a long-term strategic plan to develop six high capacity, high speed dedicated freight corridors

(DFC) along the "golden quadrilateral" that connects India's four largest cities, and its diagonals. The Dedicated Freight Corridor Corporation of India Limited (DFCCIL), a special purpose vehicle (SPV) company, was established to implement the DFC projects. The Delhi-Mumbai DFC, also known as the Western DFC, is one of the two corridors being constructed at present. The remaining four corridors would be taken up subsequently. The Government of Japan and the World Bank are providing financial and technical support for these projects.

The DFC project is one of the largest infrastructure projects ever implemented by the Indian Railways. Its main rationale is that the DFCs would enable the Indian Railways



to meet the growing demand for freight transport and induce modal shift of freight traffic from road to rail. The most important benefit of the DFC for the Indian Railways would be the higher operational efficiency in both freight and passenger services since the congestion on existing rail network would reduce significantly. In addition to efficiency improvements, the DFCs would contribute to substantial energy savings and significant reduction of greenhouse gas (GHG) emissions. These, in turn, could provide

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freight corridors, specifically built for transportation of bulk freight goods by railways. However, few countries have dedicated freight corridors. Among the ones that do, the most prominent are Australia, South Africa, China, The Netherlands and USA.

Many countries around the world use rail infrastructure for “long haul operations”, which is another term for

Overall, the global experience of DFCs shows that integration of DFCs with mixed traffic networks is problematic at the convergence points (nodes). These problems must be addressed with meticulous planning of networks and systems.

3. Introduction

The Western DFC, between the national capital region of Delhi and the major port city of Mumbai, is part of the strategic plan of the Ministry of Railways to strengthen India's rail transport infrastructure for freight movement. The DFC project was conceived against the backdrop of the expected growth of high future demand for freight transport in the region and the need to connect the major ports in Gujarat and Maharashtra to the manufacturing centres that lie along the corridor between Delhi and Mumbai.

This case study of the Delhi-Mumbai DFC is based on the premise that large infrastructure projects, such as the six proposed DFCs, are important drivers of the national economy, while also having major implications for policy issues related to sustainability of energy resources and environmental impacts.

The study is part of a larger research project on "Promoting Low-Carbon Transport in India", which is a major initiative of the United Nations Environment Programme (UNEP) aimed at helping policymakers at the national level achieve a sustainable transport system. The broad purpose of this study is to examine the implications of the proposed DFC project for achieving the twin goals of low-carbon growth and sustainable development.



The main rationale for choosing the Western DFC project as the subject of this case study is based on the belief that the proposed DFCs represent a sustainable transport solution for India's freight transport system, which is facing serious capacity constraints. Inadequate capacity of the existing rail network is not only undermining the economic and operational efficiency of the transport system but is also resulting in unsustainably high levels of local pollution and GHG emissions due to over dependence on road transport for freight movement.

Another important reason for choosing the Western DFC project for this case study is the fact that the Government of India has simultaneously initiated the development of an industrial corridor – the Delhi Mumbai Industrial Corridor (DMIC) – along both sides of the DFC to induce economic development in the surrounding region. This shows that the policymakers also recognize the development opportunities offered by investments in transport infrastructure.

The purpose of this case study is to provide a framework for long-term assessment of CO₂ emissions from infrastructure projects like the proposed Western DFC. The study provides estimates of CO₂ emissions under three future scenarios, which are outlined in the following section.

The scope of the case study is limited to assessment of CO₂ emissions, while local air pollution is not considered. Since the DFC would be fully electrified, the local pollutants are emitted at the sites where power generation plants are located. However, another study under the UNEP research project, which deals with the national level integrated assessment of transport sector emissions in India, would cover both local pollutants and CO₂ emissions. Further, this study examines only the operations phase of the DFC project. Emissions during the construction phase, which are short-term in nature, are not considered in this study.

4. Key Results

4.1 Approach and methodology

The analytical framework of this case study is based on the premise that the Western DFC would be commissioned by the year 2016-17, as planned. It would be built to carry the targeted level of freight volume, which would be several times larger than that carried by the existing rail network. For assessing the future CO₂ emissions from the proposed DFC, a scenario-based approach is used. There are two business-as-usual (BAU) scenarios and one low-carbon (LC) scenario that corresponds to a low-carbon development path at the national level. The three alternative scenarios are:

Scenario 1: BAU (Without DFC)

In the absence of the DFC, freight traffic would be transported on the existing rail network shared with passenger traffic. At the macro level, current trends will continue as described below in scenario 2.

Scenario 2: BAU (With DFC)

It is assumed that the Western DFC would be commissioned by 2016-2017, as planned. Current trends in the demand for freight movement, modal split, electrification, and changes in the energy mix would continue. However, supply-side interventions such



as higher average speeds, aerodynamic designs, regenerative braking and automatic control systems would be implemented.

Scenario 3: LC (With DFC)

This scenario is based on a conventional low-carbon path at the national level to achieve the global CO₂ stabilization target corresponding to 2°C global average temperature rise until the year 2100. It assumes policy instruments such as a carbon tax to achieve the CO₂ reduction target. It also assumes some additional supply-side interventions at the project level to improve energy efficiency and energy intensity.

Table-2: A Snapshot of the Study Methodology

Steps	Approach
Alternative scenarios	<ul style="list-style-type: none"> With and Without DFC Business-as-Usual and Low-Carbon pathways
Future traffic projections	<ul style="list-style-type: none"> Estimate targeted traffic Assign to rail and road
Projections of future energy demand	<ul style="list-style-type: none"> Estimate specific fuel consumption for each mode/fuel Multiply with traffic volumes
Estimation of CO ₂ emission factors	<ul style="list-style-type: none"> Integrated Energy-Economy models for India provide future projections of CO₂ emissions intensity for electricity Emission factor for diesel obtained from secondary sources
Future CO ₂ emissions	<ul style="list-style-type: none"> For each scenario multiply estimated energy consumption and corresponding CO₂ emission factors

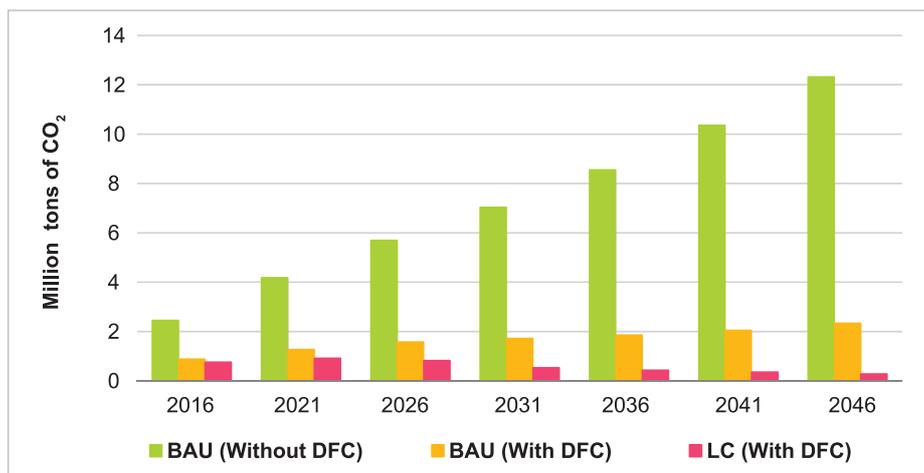
4.2 Key findings

a) Annual CO₂ emissions

- i. Our analysis shows that under the BAU (Without DFC) scenario, the annual CO₂ emissions would increase from 2.45 million tons CO₂ in 2016-17 to 12.32 million tons in 2046-47. In contrast to this, annual CO₂ emissions under the BAU (With DFC) scenario would be 0.88 million tons in 2016-17 and 2.33 million tons in 2046-47. The reduction is even larger under the LC (With DFC) scenario, where the annual emissions can be expected to drop from 0.76 million tons in 2016-17 to 0.28 million tons CO₂ in 2046-47 (Figure 1).

- ii. Therefore, by 2046-47, the Western DFC project would reduce annual CO₂ emissions by nearly 81% under the business-as-usual scenario and by 97% under the low-carbon scenario compared to the level of emissions in the absence of the DFC.

Figure-1: Annual CO₂ Emissions (in million ton CO₂)



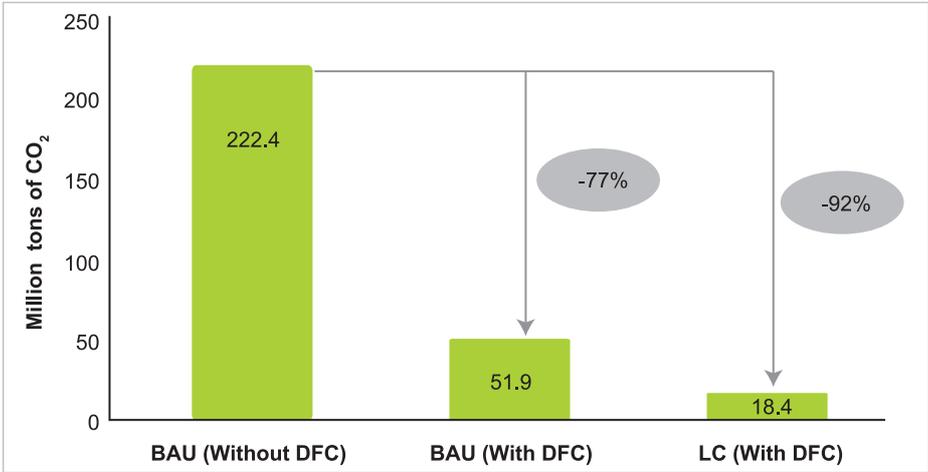
b) Cumulative CO₂ emissions

- i. The cumulative emissions over the 30-year study period (from 2016-17 to 2046-47) would reduce from 222 million tons CO₂ under BAU (Without DFC) to 52 million tons CO₂ under BAU (With DFC) and 18 million tons CO₂ under LC (With DFC). Therefore, the DFC project has the potential to reduce total emissions by nearly 170 million tons CO₂ over 30 years.
- ii. The cumulative emissions under the three scenarios for the 30-year period are shown in Figure 2. Compared to the BAU (Without DFC) scenario, total emissions are expected to reduce by 77% under BAU (With DFC) and by 92% under the LC (With DFC) scenario. This further reinforces the enormous

By 2046-47, the Western DFC project would reduce annual CO₂ emissions by nearly 81% under the business-as-usual scenario and by 97% under the low-carbon scenario compared to the level of emissions in the absence of the DFC.

gains, in terms of reduction in CO₂ emissions, which can be realised by implementing the DFC project.

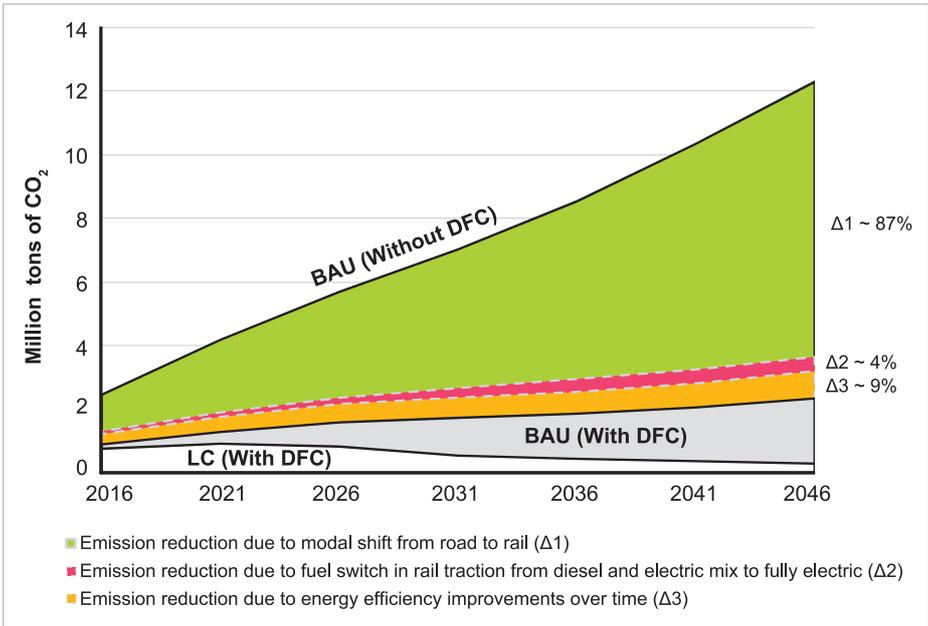
Figure-2: Reduction in Cumulative CO₂ emissions (2016-2046)



c) Decomposition analysis

- i. A step-wise decomposition analysis was carried out to assess the contributing factors that explain the differences in CO₂ emissions between the two BAU scenarios (Figure 3).
- ii. The analysis shows that in 2046-47, nearly 87% of the difference in annual emissions between the two BAU scenarios can be explained by modal shift from road (Without DFC) to rail (With DFC). An additional 4% of the difference is due to the use of diesel traction for freight movement by rail in the scenario without DFC, as opposed to the 100% electric traction in the scenario with DFC. The remaining 9% of the difference is attributable to the higher energy efficiency of the DFC compared to the shared network due to various supply-side interventions.
- iii. Finally, the difference in CO₂ emissions between the BAU (With DFC) and LC (With DFC) scenarios is largely due to differences in the grid mix of the electricity that would change over time. This change may be attributed to the decarbonisation of the electricity, by replacing the current major sources such as coal, gas, oil, hydro power, with lower CO₂ emission intensive renewable energy sources and sequestration of CO₂ under the latter scenario.

Figure-3: Decomposition of difference in annual CO₂ Emissions



d) Potential reduction of CO₂ emissions from the six proposed DFCs

- i. There are six proposed DFCs, including the Western DFC, that are planned along the Golden Quadrilateral (Delhi-Mumbai-Chennai-Kolkata) and its diagonals.
- ii. The combined CO₂ emissions from the six DFCs, in 2046-47, have an annual CO₂ emissions almost 70 million tons lower under the BAU (With DFC) scenario than the BAU (Without DFC). These would be further reduced by 15 million tons of CO₂ under the LC (With DFC) scenario. The maximum cumulative reduction expected from the six DFCs over the 30-year period is 1,168 million tons of CO₂. This could be used to leverage substantial climate financing.

e) Impacts on regional development

- i. The relationship between transportation investments and regional economic development is well established. Soon after the Western DFC project was sanctioned, the Government of India announced plans to develop the Delhi-Mumbai Industrial Corridor (DMIC) alongside the Western DFC.

- ii. The DMIC strategy includes development of market-oriented industrial areas, investment regions, industrial parks, ports and airports, and seven new cities at different locations along the corridor. Several logistics hubs are planned and the DFCCIL also has plans to develop Multi-Modal Logistics Parks in the corridor (Box 2).
- iii. It is evident that a subsequent intra-regional transport system would develop in the region in order to take advantage of the connectivity made available by the Western DFC. Conversely, the DFC can benefit from industrial development in the DMIC by attracting greater share of freight traffic. The challenge would be to ensure that the regional transport infrastructure is also environmentally friendly, low-carbon and sustainable.

Box-3: Delhi-Mumbai Industrial Corridor

When the plans for the Delhi-Mumbai DFC were being formulated, the Ministry of Commerce and Industries, Government of India, saw an opportunity for developing an industrial corridor along the Western DFC alignment that would attract investments in the surrounding region and induce regional economic development.

In 2008, the Delhi Mumbai Industrial Corridor Development Corporation (DMICDC) was formed as the project development agency for implementing the DMIC project. The DMICDC is a SPV, based on public-private partnership model, with 49% equity held by the Government of India and the remaining 51% by financial institutions.

This mega infrastructure project, costing US \$90 billion, was to be implemented with financial and technical aid from the Government of Japan.

The DMIC strategy is to develop high impact development nodes for which 24 market-oriented centres have been identified. Substantial investments are planned for providing industrial and physical infrastructure at each node together with connectivity to the DFC, regional ports and hinterland markets.

There is also a proposal to develop seven eco-friendly cities in the DMIC region to serve as models for sustainable urban development. The plans for eco-cities would emphasize energy efficiency, resource conservation, waste efficiency, waste management and sustainable transport.

The planned transport infrastructure for the DMIC would provide crucial rail and road links to ports, airports and the DFC. The transport networks would also facilitate movement of goods from development nodes to hinterlands.

5. Policy Recommendations and Overall Conclusions

This case study of the Delhi-Mumbai DFC demonstrates that large rail transport projects have huge potential to reduce CO₂ emissions from the transport sector in India. Under the two business-as-usual scenarios, most of the reduction is due to the fact that, in the absence of the DFC, freight traffic moves largely by road, which is a more carbon-intensive mode of transport.

Under the low-carbon development scenario, the additional reduction in annual CO₂ emissions is primarily due to decarbonisation of electricity generation at the national level and, to a lesser extent, the improvements in energy efficiency at the project level.

Large transport investments have the potential to induce regional economic development, provided complementary investments in economic and social infrastructure are made.

The study also leads us to the conclusion that large transport investments have

the potential to induce regional economic development, provided complementary investments in economic and social infrastructure are made. It was this opportunity that led policymakers in the Government of India to initiate the development of the Delhi-Mumbai Industrial Corridor (DMIC) along the alignment of the Western DFC.

Climate financing of infrastructure projects in developing countries is at present mostly centred on the Clean Development Mechanism (CDM) of earning carbon credits (CERs) which can be traded. More avenues are likely to open in the future as initiatives to create innovative climate funds get underway. The true benefit of participating in the CDM process is in the recognition of being a climate conscious organization rather than the monetary value of carbon credits earned.

The following are the major policy recommendations from this case study:

1. Potential to generate large CO₂ reductions with significant co-benefits
 - The DFC project would not only contribute to CO₂ mitigation but would also result in substantial development benefits, including infrastructure development, regional economic growth and employment generation.
 - Therefore, ensuring time bound completion of the project, to have it fully operational by 2017-18, would keep costs under control as well as demonstrate the project development capacities of DFCCIL.

2. Critical role of support infrastructure
 - The creation of matching support infrastructures, like freight terminals, special wagons, stack containers etc., would play a crucial role in the success of the project. Therefore, such infrastructures should be adequately provided and become part of a comprehensive plan.
3. Successful implementation of the DMIC project would maximize secondary development benefits
 - Development benefits of the DFC can be realized only by concurrent implementation of the DMIC project since the DMIC region would act both as origin and destination of freight traffic. Any delays in their implementation can affect the financial viability of the freight corridor.
 - The transport system of the DMIC region should be integrated with the DFC by providing appropriate infrastructures, such as Multi-Modal Logistics Parks and freight terminals at suitable locations.
4. Accelerated implementation of the remaining five DFCs would yield maximum economic returns in the long-run
 - The six corridors together would make the national freight transport system low-carbon, energy efficient and thereby more sustainable. Therefore, the remaining corridors should be taken up for implementation at the earliest time.
 - The strategy requires innovative policies for mobilization of financial resources, ability to implement large projects, planning for balanced regional development, and good governance at all levels.
5. Importance of long-range planning to make the national freight transport system low-carbon and conducive to sustainable development
 - National energy policies, in terms of energy security, safety issues and environmental concerns, have obvious implications for future development of the freight transport system.
 - Policy decisions regarding location of power plants, cement plants and manufacturing centres would have important implications for development of freight transport infrastructure.
 - To meet the rising demand for freight transport and make the system more efficient, use of pipelines for transport of oil product and natural gas should be expanded.

Information about the project:

UNEP Transport Unit (www.unep.org/transport) in Kenya, UNEP Risø Centre (www.uneprisoe.org) in Denmark and partners in India have embarked on a new initiative to support a low carbon transport pathway in India. The three-year 2.49 million Euro project is funded under the International Climate Initiative of the German Government, and is designed in line with India's National Action Plan on Climate Change (NAPCC). This project aims to address transportation growth, development agenda and climate change issues in an integrated manner by catalyzing the development of a Transport Action Plan at national level and Low Carbon Mobility plans at cities level.

Key local partners include the Indian Institute of Management, Ahmedabad, the Indian Institute of Technology, Delhi and CEPT University, Ahmedabad. The cooperation between the Government of India, Indian institutions, UNEP, and the Government of Germany will assist in the development of a low carbon transport system and showcase best practices within India, and for other developing countries.

Homepage : www.unep.org/transport/lowcarbon



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