Freight Transportation Sector in Brazil

Marcia Valle Real
Haroldo Machado Filho

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Executive Summary

There are few research papers at international level that focus on greenhouse gas mitigation actions related to freight transportation. The Australian National Transport Commission (NTC, 2008) has indicated that policies related to freight transportation are a “blind spot” worldwide. In Brazil, despite the emphasis on biofuels and transportation policy, there is still a shortage of studies analyzing mitigation efforts in transport.

As transport accounts for the majority of costs in the logistics chain, it is rational to believe that market laws will lead to the choice of more efficient and economic means of transport, due to competitiveness concerns. However, in order to be able to choose more efficient transport methods it is necessary to have options and infrastructure in place.

Previously, transportation systems in countries and regions have been predominately determined by national circumstances, territory, land occupation, as well as economic and production systems; however, energy is likely to be the most important factor for future choices between transport modes. Nowadays, environmental issues have also been a driving force; given recent pressures for the adoption of low carbon and low pollutant transportation systems.

It is well known that road transport is one of the most widely used modes in the world for transportation of goods and passengers. So it is by far the largest energy user and accounts for 89% of total transport energy use in 2005. (IEA, 2009)

The Brazilian land area is twice the size of the European Union and the country is a major producer and exporter of agricultural and mineral products; these products usually come from the interior of Brazil, which is a substantial distance from the sea. It has been recognized that the integration of various means of transport using less energy-intensive modes such as rail and waterways would facilitate the movement of these goods to the coast. This would increase the competitiveness of products abroad, reduce prices in internal markets, increase highway safety and help to mitigate greenhouse gases.

Currently, the mix of transport in Brazil is highly concentrated on road transportation. However, with the implementation of the National Plan for Logistics and Transport - PNLT, the government intends to modify this profile; increasing modal integration by balancing road infrastructure with a greater use of land and water transport. Implementation of the plan also has longer-term sustainable development and social co-benefits. For example, improving the transportation network can help to facilitate population diffusion; as the current population is concentrated in coastal cities expansion into rural areas can help to improve quality of life compared to densely populated urban areas, while also creating employment opportunities in the countryside.

If the PNLT is effectively implemented and the envisioned transport mix becomes a reality in 2025, the plan could allow the reduction of more than 40% of GHG emissions in freight transportation compared to the business as usual scenario. This figure does not take into account the use of biodiesel, which currently represents 4% of diesel sales in the country, and presents an additional mitigation opportunity. However, as the PNLT authors acknowledge, “this radical shift that is desired in the transportation mix in the country, would require energetic actions by all the stakeholders, including at all levels of government and those directly involved in the production and distribution of goods, so that better modal integration could be promoted, especially the flows of freight containers, which will require logistic facilities, as a network of intermodal terminals and amplification of the storage network”.

In order to achieve this transport mix a series of political and economic barriers must be overcome. These barriers, especially those related to taxation, can undermine the confidence of both domestic and international investors and reduce the potential emissions reductions resulting from full implementation of the plan.
1. Introduction

There are few research papers at international level that focus on greenhouse gas mitigation actions related to the transport sector; freight transportation is especially overlooked. The Australian National Transport Commission (NTC, 2008) has indicated that policies related to freight transportation are a “blind spot” worldwide. In Brazil, despite the emphasis on biofuels and transportation policy, there is still a shortage of studies analyzing mitigation efforts in transport.

It is well known that the transportation system in any country is predominately determined by its national circumstances, its territory and land occupation. With an area of more than 8.5 million square kilometers, Brazil is the fifth largest country in the world, with a dynamic and complex economy and physical and social diversity. Population and industrial production are concentrated in cities along the 7,400km Brazilian coast. Among the 27 states in Brazil (including the Federal District), seventeen of them have Atlantic Ocean coasts, and only three do not have their capital on the coast. More than 70% of the population lives within 200km of the coast. Moreover, due to the high plateau within the interior Brazilian territory, land-based transport is often favored.

This situation is the result of long standing structural factors, when energy and environmental issues were not part of the necessary criteria to establish the transportation infrastructure. As far as international competitiveness is concerned, transportation costs may represent a significant difference for the export of commodities in a globalized market.

At the beginning of the 1950’s, governmental priorities related to the transportation sector were directed towards the roadways. At that time, it was necessary to create new industries and promote the integration of the territory. The creation of roads to broaden the network, and the establishment of vehicle-based transport and the oil industry, were perceived as good opportunities to create jobs. This was perpetuated during the 1970’s by the military dictatorship who continued to overemphasize the roads. Policy changes were established in the 1990’s when a neoliberal government started planning policy to minimize the role of the State, transferring the administration of ports, railways and roadways to the private sector.

The economic difficulties that the country has faced since the end of the 1970’s have been responsible for a progressive deterioration of the road network. In 2007, an annual survey conducted by the National Transport Confederation (CNT) showed that 74% of national roads were in bad or very bad conditions, while 54% of the roads assessed were not of good quality due to the pavement condition. It is worth highlighting that only 200,000 km of the 1.6 million km of roads are paved in Brazil. Moreover, the country has a waterway network that corresponds to 42,800 km, but only 13,600 km have been used. There are 29,800 km of railways in the country, of which 28,671 km have been administrated by the private sector through concessions since 1997.

Given the current road concentration and the expansion of the agricultural frontier, the condition of the national transportation system has been a constant issue of debate. A transport mix excessively based on roadways leads to an increase in production costs, given the distances that agricultural and mineral products need to travel to reach consumers, and lacks the security of a safer, more integrated and efficient transportation infrastructure. Transport is the main cost in the logistics chain; according to the World Bank, transport costs can account for 30% of the logistic costs in Brazil, reaching 60% in certain sectors (Fleury, 2000).

With the aim of improving the planning process within the transportation sector for the mid- and long-term, and prioritizing the necessary investments, the Brazilian government elaborated the first draft of the National Plan for Logistics and Transport - PNLT in 2007. The plan is a governmental plan emerging as a result of a partnership between the Ministries of Transports and Defense. It is intended that the PNLT will become a plan of the Brazilian State, in other words, a proposal to the country, which must be the main
contributor for the elaboration of the next four pluriannual plans. However, as is discussed further during the next section, concerns related to the emission of greenhouse gases were not taken into account in the elaboration of the PNLT. Therefore, this study represents a first attempt to estimate whether it is possible for the plan to make a contribution towards a low carbon development path. This effort is important, given that international support may be mobilized at an international level to support domestic efforts in this regard.

2. Short description of the National Plan for Logistics and Transport

The National Plan for Logistics and Transport (PNLT) has been suggested as a governmental initiative that could promote a lower emission scenario of greenhouse gases in the transportation sector at medium and long term timelines by specialists who took part in a workshop on “Implementation of Low Carbon Freight Transportation Policies in Brazil and Options for International Support”\(^1\). Implementation of the PNLT could lead to the realization of low carbon policies in the transportation section in Brazil.

For more than fifty years, the Brazilian transportation mix has overemphasized the importance of roads. Use of railways and waterways has increased, but the implementation of the PNLT could lead to a more balanced distribution of transportation modes in the freight transport sector, as can be seen in the graph below (PNLT, 2007), showing percentage of tons shipped (PNLT, 2007).

![Graph 1. Freight Transportation Mix in Brazil (PNLT, 2007)](image)

The implementation of the new infrastructure proposed in PNLT will promote the achievement of a better balance between modes of freight transportation. The numbers for 2025 are projected estimations of what could be achieved.

This would have several co-benefits; for instance, reduction of transportation costs, especially in logistics costs associated with the transportation of agricultural and mineral commodities from the Brazilian countryside, a decrease in road transportation traffic and, consequently, better safety conditions on the roads. Moreover, implementation of the plan would lead to an increase in the energy efficiency of the transport used for national outputs, and contribute to considerable mitigation efforts for greenhouse gases in the sector.

The main policies recommended by the PNLT encompass distinct interventions in the infrastructure, as presented in Table 1. In order to expand the transport system, it is necessary to regenerate and rehabilitate many networks in order to permit that existing infrastructure can be used. To further develop these networks, new infrastructure may also be required’.

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\(^1\) A description of the objectives of the workshop can be found in section 3.
Table 1. Expanded network according to the PNLT (km)

- Regarding roadways, policies will mainly correspond to the maintenance or recuperation of the existing roadway network, as well as the extension of certain roads, resulting in a total of 43,200 kilometers of roadways;
- Regarding railways, the plan envisages both new-build and the regeneration of existing railways and rail terminals (including the establishment of intermodal terminals to facilitate the integration of transport modes) resulting in a total of 20,200 kilometers;
- Regarding waterway infrastructure, the plan outlines 169 interventions related to waterways in the interior, coastal navigation and long-course navigation. This also involves the establishment of intermodal terminals, lock construction, as well as the creation and regeneration of 14,500 kilometers of usable waterways;

It is worth highlighting that the PNLT has been structured with the main focus on economic growth over the medium- and long-term. Costs related to the maintenance or regeneration of the existing roadway network have not been included in the table below. The implementation of the PNLT is scheduled to take place in various stages, with investments until 2023, as it is summed up in Table 2.

<table>
<thead>
<tr>
<th>Phases</th>
<th>Highways</th>
<th>Railways</th>
<th>Waterways</th>
<th>Ports</th>
<th>Airports</th>
<th>Total</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2008-2011</td>
<td>42,296</td>
<td>16,969</td>
<td>2,672</td>
<td>7,301</td>
<td>72,700</td>
<td>42,2%</td>
</tr>
<tr>
<td>II</td>
<td>2012-2015</td>
<td>13,109</td>
<td>3,048</td>
<td>3,962</td>
<td>5,45</td>
<td>28,573</td>
<td>16,6%</td>
</tr>
<tr>
<td>III</td>
<td>after 2015</td>
<td>18,789</td>
<td>30,539</td>
<td>6,173</td>
<td>12,411</td>
<td>71,141</td>
<td>41,3%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>74,194</td>
<td>50,556</td>
<td>12,807</td>
<td>25,162</td>
<td>172,414</td>
<td>100%</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td>43,0%</td>
<td>29,3%</td>
<td>7,4%</td>
<td>14,6%</td>
<td>100,0%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Investments in each implementation stage of the PNLT (R$millions)

Investments have been distributed across seven relevant regions, known as Logistic Vectors, in the light of integration perspectives and inter-relationships from the economic point of view (presented in Figure 1).
The logistic vectors that have been considered are: Amazonic, Center-North, East, Northern Northeast, Southern Northeast, Center Southeast and South. Table 3 shows some socio-economic indicators for each vector. It is worth noting that, during 20 years from 2002, an annual average economic growth rate of 3.2% is expected, while the expected annual population growth should be, on average, 1%. It is also interesting to note that the areas in the South and East have an economic growth rate higher than the average, as shown by the projections shown in table 3.

In the Amazonic and Center North areas, which have significant environmental barriers, the population density remains lower than the average, although the population growth represents twice the average. Similar figures are reported for the economic growth rate of these vectors.
## Table 3. Socio-economic indicators of the Logistic Vectors (Source: PNLT, 2007)

<table>
<thead>
<tr>
<th>Area</th>
<th>Amazonic</th>
<th>Center North</th>
<th>East</th>
<th>Northern Northeast</th>
<th>Southern Northeast</th>
<th>Center Southeast</th>
<th>South</th>
<th>BRAZIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 km²</td>
<td>3.372</td>
<td>1.721</td>
<td>654</td>
<td>555</td>
<td>670</td>
<td>1.118</td>
<td>436</td>
<td>8.526</td>
</tr>
<tr>
<td>%BR</td>
<td>40%</td>
<td>20%</td>
<td>8%</td>
<td>7%</td>
<td>8%</td>
<td>13%</td>
<td>5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>%BR</td>
<td>4%</td>
<td>8%</td>
<td>21%</td>
<td>16%</td>
<td>9%</td>
<td>32%</td>
<td>11%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>2023 Absolute</td>
<td>12,318,878</td>
<td>20,152,914</td>
<td>46,041,998</td>
<td>32,194,369</td>
<td>18,060,834</td>
<td>69,035,985</td>
<td>21,277,873</td>
<td>219,082,851</td>
<td></td>
</tr>
<tr>
<td>%BR</td>
<td>6%</td>
<td>9%</td>
<td>21%</td>
<td>15%</td>
<td>8%</td>
<td>32%</td>
<td>10%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

| Variation | %/ year        | 2,5      | 1,8       | 1,1        | 0,8        | 0,8        | 1,1        | 0,7         | 1,1         |

| Demographic Density | 2002 (hab/km²) | 2,19     | 8,02      | 56,51      | 49,55      | 22,92      | 49,24      | 42,06       | 20,46       |
|                    | 2023 (hab/km²) | 3,65     | 11,71     | 70,40      | 58,01      | 26,96      | 61,75      | 48,80       | 25,70       |

| GDP | 2002 Absolute | 61,892 | 58,967 | 448,963 | 132,833 | 92,470 | 763,709 | 236,785 | 1,795,619 |
|     | %BR            | 3%     | 3%      | 25%      | 7%       | 5%      | 43%     | 13%      | 100%       |
|     | 2023 Absolute | 123,474 | 106,593 | 914,037 | 232,829 | 168,694 | 1,525,101 | 495,932 | 3,566,660 |
|     | %BR            | 3%     | 3%      | 26%      | 7%       | 5%      | 43%     | 14%      | 100%       |

| Variation | %/ year        | 3,34    | 2,86     | 3,44      | 2,71      | 2,9      | 3,35      | 3,58      | 3,32        |

| GDP/capita | 2002 | 8373,2 | 4272,0 | 12148,2 | 4829,8 | 6020,9 | 13873,1 | 12912,0 | 10295,9 |
|            | 2023 | 10023,2 | 5289,2 | 19852,2 | 7232,0 | 9340,3 | 22091,4 | 23307,4 | 16280,0 |

| Variation | %/ year        | 0,86    | 1,02     | 2,37      | 1,94      | 2,11    | 2,24    | 2,85     | 2,21        |
Both the public and private sectors of the Brazilian transportation network have made little technical information available for research use, especially on freight and passenger movements. Until 2001, the GEIPOT (Brazilian Enterprise for Transport Planning), the former Executive Group for Transport Policy Integration, was the enterprise in charge of producing an annual book of sectoral statistics. However, currently some statistics related to freight transportation are produced by the Economic Research Foundation Institute - FIPE, an entity linked to the economics department at the Faculty of Economics, Management and Accountability of the University of Sao Paulo (FEA-USP), who make information available on the internet. Other statistics, related to modal infrastructure, are produced by agencies linked to the Transportation Ministry; such as the National Agency of Terrestrial Transports (ANTT), the National Agency of Water Transports (ANTAQ) and the National Agency of Civil Aviation (ANAC). Some data is also made available by business entities such as the National Confederation of Transport (CNT), the National Association of Public Transport (ANTP), and the National Association of Urban Transportation Enterprises (NTU). Therefore, there is a disparity of information from a wide range of institutions, each one of them using a different methodology. Even more concerning is that when information from different sources is compared, they are usually contradictory and uncertain.

The transportation mix of the PNLT has been calculated on the basis of the transportation of goods, based on the Gross Production Value (GPV). This methodology is not usually applied in energy planning, but is more common in the field of strategic transport planning. The PNLT is a strategic plan that projects production flows, in terms of value x ton of product (R$xjt), and the needs required by regional and country economic development in the future.

Thus, the PNLT provides different data from that required to evaluate the performance of the energy sector, both in terms of energy efficiency and greenhouse gas emissions. In order to do that, data on tonnes or passengers per kilometer, as well as the energy used in the transport as a whole or disaggregated by mode of transport, are required. Having said that, the energy consumption analysis presented below were created using a top-down approach, which allows the original information to be deduced from disaggregating the final data.

Table 4 shows the projected PNLT mix, which considers the total flow of freight in 2007 (current) and provides estimates for 2023, given policy implementation with or without interventions under the plan. In other words, by 2023, both scenarios consider transport demand growth, but provide information on the difference between whether or not the estimated infrastructure interventions proposed under the PNLT are achieved.

Additionally, an ideal mix has been included, which reflects the desire to fully implement the PNLT over time. On this point, it is important to clarify that, according to the PNLT, this ideal mix is aspirational, and would require aggressive action by all railway and waterway stakeholders to attract significant freight flows (especially the flows of containers), both in terms of medium and long distances. This would require a net of terminals of intermodal integration, associated to the expansion of storage networks. In Table 4 it can be observed that infrastructure expansion would allow a reduction in the share of the roadways used for freight transport.

<table>
<thead>
<tr>
<th>Year</th>
<th>Road</th>
<th>Rail</th>
<th>Water</th>
<th>Others</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>61</td>
<td>30</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2023</td>
<td>62</td>
<td>28</td>
<td>7</td>
<td>3</td>
<td>Without PNLT</td>
</tr>
<tr>
<td>2023</td>
<td>58</td>
<td>32</td>
<td>7</td>
<td>3</td>
<td>With PNLT</td>
</tr>
<tr>
<td>2025</td>
<td>33</td>
<td>32</td>
<td>29</td>
<td>6</td>
<td>Ideal</td>
</tr>
</tbody>
</table>

Table 4. Freight transportation mix (%)
In order to estimate the reduction of energy consumption and the consequent potential mitigation of greenhouse gases through the implementation of the PNLT, data from the National Energy Balance – BEN (an annual publication of the Energy Research Enterprise – EPE, linked to the Ministry of Mines and Energy) has been used. Using this data (BEN, 2008), it was possible to separate freight transportation from the overall transportation energy consumption, especially because the use of diesel is prohibited for light vehicles in Brazil. However, difficulties in differentiating the fuel that has been used by a certain fleet must be taken into consideration. Therefore, some considerations have been simplified for the purpose of the research.

Nevertheless, taking into account the year 2007, of the 57.6 Mtoe consumed by the transportation sector, 91.8% was consumed through road use; 47.5% of this was consumed by individual passenger transportation (automobiles and motorcycles).

In absolute terms, energy consumption in the transportation sector in Brazil increased 75% from 1990 to 2007, an average annual growth of 3.3% (roadway consumption was even higher, with an average annual growth of 3.5%). Although the energy necessary for the transportation of individual passengers in roadways is almost equal to the energy required by trucks and buses (MME, 2008), in terms of greenhouse gas emissions, the former contributes much less; with only 32% of total transportation sector emissions being due to individual passenger transportation, thanks to the use of ethanol. In 2007, the use of hydrated ethanol by the national flexfuel vehicle fleet (around 3.8 million vehicles) avoided 5.6 MtCO2 of emissions, which represents a reduction in GHG emissions of 10% from light vehicles.

The 2005 figures for Brazil, according to the World Resources Institute (WRI) estimates, suggest that the transportation sector has been responsible for 13.5% (0.137 GtCO₂) of CO₂ emissions (WRI, 2009), given that Brazil is less dependent of oil than other countries. The use of alternative fuels in Brazil helps to explain this; for example, CNG (Compressed Natural Gas) and bioethanol represented 16.5% of the energy consumed in the sector in 2007. As previously suggested, the energy consumption in freight transportation has been calculated by default, disaggregating the quantity of energy consumed in the freight transportation in roadways and the collective number of passengers. Table 5 shows the values used to estimate the energy consumed by the collective passenger transportation.

<table>
<thead>
<tr>
<th>Service</th>
<th>Average annual kilometers (km/year)</th>
<th>Fuel Efficiency (\text{km/l})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus</td>
<td>63,600</td>
<td>2,50</td>
</tr>
<tr>
<td>Microbus</td>
<td>31,940</td>
<td>3,00</td>
</tr>
</tbody>
</table>

**Table 5.** Parameters considered to estimate the energy consumed in the TRCP (Source: Borba, 2008)

The calculations identify that, on an average from 2005 to 2007, 67% of diesel used in road transport was consumed by freight transportation, which corresponded to 18.9 Millions tonnes of oil equivalent (Mtoe) in 2007. Thus, in order to project the future consumption of energy related to the freight transportation, the energy intensity of each mode has been considered as constant, based on the data from the PNLT.

Table 6 shows the calculations made that allow the estimation of future energy consumption in the transportation sector, taking into account implementation with and without the estimated investments under the PNLT.
<table>
<thead>
<tr>
<th>Year</th>
<th>Roadway</th>
<th>Railway</th>
<th>Waterway</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td>38.427</td>
<td>1.086</td>
<td>3.751</td>
<td>With PNLT</td>
</tr>
<tr>
<td>2023</td>
<td>35.948</td>
<td>1.241</td>
<td>3.751</td>
<td>Without PNLT</td>
</tr>
<tr>
<td>2025</td>
<td>18.946</td>
<td>1.397</td>
<td>4.209</td>
<td>Ideal</td>
</tr>
</tbody>
</table>

Table 6. Projected energy consumption (ktoe)

Finally, Table 7 sums up the emissions of CO$_2$ per each mode of transportation, based on energy consumption in freight transportation.

<table>
<thead>
<tr>
<th>Year</th>
<th>Roadway</th>
<th>Railway</th>
<th>Waterway</th>
<th>Implementation</th>
<th>Total</th>
<th>Mitigation GHG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td>117.921</td>
<td>3.333</td>
<td>11.881</td>
<td>Without PNLT</td>
<td>133.135</td>
<td>%</td>
</tr>
<tr>
<td>2023</td>
<td>110.313</td>
<td>3.809</td>
<td>11.881</td>
<td>With PNLT</td>
<td>126.004</td>
<td>5.4%</td>
</tr>
<tr>
<td>2025</td>
<td>58.140</td>
<td>4.287</td>
<td>13.332</td>
<td>Ideal</td>
<td>75.759</td>
<td>43.1%</td>
</tr>
</tbody>
</table>

Table 7. CO$_2$ Mitigation per year (GgCO$_2$/year)

In Table 7, it can be observed that the implementation of the PNLT would result in a minimum annual reduction of 5.4% of greenhouse gas emissions after 2025. However, the ideal mix of the PNLT, would allow the reduction of more than 40% of GHG emissions in freight transportation compared to the business as usual scenario. However, as the PNLT authors state, “this radical shift that is desired in the transportation mix in the country, would require energetic actions by all the stakeholders, including at all levels of government and those directly involved in the production and distribution of goods, so that better modal integration could be promoted, especially the flows of freight containers, which will require logistic facilities, as a network of intermodal terminals and amplification of the storage network”.

Considering the type of data available, it is not possible to predict the financial resources that will be applied in the interventions under the PNLT during its implementation and the reduction of greenhouse gases, which would allow to estimate the unitary cost of mitigation ($/tCO$_2$). However, it is possible to estimate the benefits for the next twenty years, if it is assumed that the volume transported will be constant after 2025, and that this will happen based on the new modal mix.

Preliminary estimates indicate that the PNLT will cost R$172.4 billion (PNLT, 2007). After its implementation, and considering that any further growth would be sustained in the following 20 years, a minimum of 143 MtCO$_2$ would be reduced. Therefore, the mitigation cost would be higher than R$1,205/tCO$_2$ (equivalent to 646 US$/tCO$_2$); much higher than the current prices in the carbon market. However, it must be acknowledged that the mitigation of GHG is only one co-benefit of the plan and that its implementation is fundamental for the establishment of a better transport infrastructure for Brazil. Improved infrastructure will lead to the reduction of transportation costs, especially for agricultural and mineral commodities from the countryside, while also having other co-benefits.

Moreover, it must be taken into account that the estimated cost of mitigation is related to the total cost of the implementation of the PNLT. For a more precise calculation, the marginal cost related to the emission reduction should be considered (compared to a likely scenario), which would reduce the cost of mitigation (in terms of tonnes of CO$_2$).
3. Needs and Barriers

As previously indicated, the ideal implementation of the PNLT would lead to a significant mitigation of greenhouse gases. However, there are a series of needs and barriers that must be taken into consideration for the effective implementation of the plan.

The needs and barriers described below were identified at the workshop “Implementation of Low Carbon Freight Transportation Policies in Brazil and Options of International Support”. The workshop focused on policies, actions and programs that have been implemented in the country and which may lead to the reduction of greenhouse gas emissions in the transportation sector. It could further lead to the identification of barriers and driving forces that could favor the consolidation of low carbon transportation system in the country.

The methodology used in the research encompassed the consultation of several specialists in the sector (among them, representatives from governmental agencies and ministries and academics who deal with logistics and transport). The survey conducted during the workshop was structured in two phases, using exploratory techniques that were applied within strategic planning. The table below sums up the main barriers and needs that have been pointed out for the implementation of the PNLT:

<table>
<thead>
<tr>
<th>Needs</th>
<th>Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation</td>
<td>More important than innovation, different stakeholders must strive to keep themselves updated. The only area really associated with innovation in the sector is the integration of new information technologies to logistics and the projects related to freight flows.</td>
</tr>
<tr>
<td>Adoption / manufacturing</td>
<td>Brazil has a strong and modern industrial sector, but could enhance development of equipment required for the movement of containers at ports and terminals (Portainers, Reach stackers, Straddle Carriers, Mobile Harbour Cranes, etc).</td>
</tr>
<tr>
<td>Operation / maintenance</td>
<td>Elaborate and promote capacity building and training activities for the operation and maintenance of equipment and intermodal information systems.</td>
</tr>
<tr>
<td>Regulation</td>
<td>Strengthen and articulate the regulatory aspects of different agencies.</td>
</tr>
</tbody>
</table>
| Finance                | a) Solve the problem of dual-taxation in the inter-modality /multi-modality;  
b) Intensify Public-Private Partnerships (PPPs)  
c) Adopt economic mechanisms, such as reduction of interest rates, specific credit incentives to logistics projects;  
d) Combine economic mechanisms and “push and pull” policies,  
e) Anticipate public investments to leverage private investments; |
| Stakeholder interest   | Stakeholders interests vary:  
a) In favor of: agricultural producers in the central region of the country; logistics, railways and waterways enterprises; commodities exporters; mayors from cities close to terminals; importers, in general; companies related to container equipment;  
b) Against: Individual truckers. |
Stakeholder concerns

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>Lack of competitiveness of agricultural commodities if transport infrastructures is not improved;</td>
</tr>
<tr>
<td>b)</td>
<td>Expressive and continuous predominance of roadways in the freight transportation;</td>
</tr>
<tr>
<td>c)</td>
<td>Lack of institutional articulation, at all the levels of government;</td>
</tr>
<tr>
<td>d)</td>
<td>The sustainability of the plan, which must go beyond the mandate of governments;</td>
</tr>
<tr>
<td>e)</td>
<td>Need for governmental interaction with private sector;</td>
</tr>
<tr>
<td>f)</td>
<td>Regional economic disparities.</td>
</tr>
</tbody>
</table>

**Box 1. Barriers and needs related to the implementation of the PNLT**

The success of PNLT will require more investment in the country's infrastructure than that which the government is able to supply. Also, the federal government must untangle the problem of dual-taxation for commercial transport of goods between states. Finally, to reach the ideal goals set forth, extensive financing will be required. The only way to achieve the necessary funds will be by cooperating with the private, productive sector of society. Governments will have to make their policies clearer and convince the private sector of their programs' viability in order to inspire the confidence necessary to gain the private sector's support. In short, government programs need to be more transparent to attract the financing necessary from the private sector.

### 4. Discussion of major barriers

#### 4.1 Dual-Taxation on Multimodal Transportation

The incidence of taxes on the transport of cargo varies with several factors, including: the means of transport, the localities of origin and destination, the product, the activities and expertise of the company. Tax burden for the cost of transport is high and a more representative tax is the ICMS (Tax on Circulation of Goods and Services). The value of the tax on load transport is calculated using price, and the freight rate varies from 12 to 19% for both ISS (Tax for Circulation of Goods and Services inside the municipalities) and the ICMS, depending on the state and municipality.

In transferring cargo from one place to another it may be convenient to use one or more means of transport. When using more than one means of transport, operations may be (i) *intermodal*, ie, the transport is completed by more than one carrier and by different modes of transport; in this mode, each company is responsible for their section of the trip and holds its own fiscal document, or (ii ) *multimodal*, requiring a single transport document, issued by the Multimodal Transport Operator (OTM), a company which may be a carrier or not, but is responsible for the load for the duration of the transport period.

In accordance with legislation, payment of the tax (ICMS) must be contained within the State where the fiscal document for transport is issued. However, states do not recognize the Multimodal Freight Transportation (issued by OTM), which creates a single document for transportation. So when a modal shift occurs in another state, states often attempt to charge the ICMS in transport again. This results in dual-taxation. Such dual-taxation is a significant barrier to the consolidation of modal integration in the country, which is hampered by a lack of rationality in the collection of taxes. Unfortunately, in the short term it is unlikely that the taxation sector will undergo significant changes.

Beyond this barrier, another tax exists - the Additional Freight for the Renewal of the Merchant Navy (AFRMM), as well as taxes on fuels, which increases economic disadvantages for water transport when compared to road transportation.
Moreover, the transport sector is a short segment of the chain which generates low claims. Transport is also labor-intensive, increasing the tax burden (COFINS / PIS). According to Fundação Getulio Vargas - FVG, the tax burden of the transport sector reaches 50.8% of sectoral GDP.

4.2 The Dominance of Road in Freight Transport

As reviewed in the introduction of this article, road transportation has been encouraged for over half a century in Brazil. Currently, due to entrepreneurial pressures, especially from the agri-business sector, the discourse has been changing. The PNLT is a government response to the needs of modal integration to reduce costs and enhance competitiveness for commodities.

However, there are some factors that create barriers for the government actions, especially considering the tax regime and strong structure of automotive industry, which have been consolidating the "road culture" in the country. In this regard, some facts should be stressed:

• The country is the 5th largest producer of trucks in the world. In 2008, the transport media in Brazil announced:
  - The biggest trucks exporter of the country Volkswagen Trucks and Buses, inaugurated in April 2008, the Logistics Center and the third part of the plant in Resende, in the Vale do Paraíba. The chairman of the assembly plant in Brazil, Roberto Cortes, and world president of Volkswagen Commercial Vehicles, Stephan Schaller, announced investments of $1 billion by 2012 and the generation of 1,300 direct jobs with uninterrupted production (Resende, 2009);
  - The Brazilian truck and bus industry has provided investment of $4.4 billion, to increase capacity, modernize systems and produce new products. The industry has expanded its production capacity by almost 80%, reaching more than 300 thousand vehicles per year. This volume places the country among the world’s largest manufacturer, behind countries like China and India. Today, Brazil is the sixth largest producer of trucks and buses (Portal PRC, 2009).

• The fuel for the maritime coast transport is 30% more expensive than road fuel and about 40% more than the one used in long distance, e.g., for overseas travel (Barbosa, M., 2008). This fact is counterproductive to modal integration and a barrier to the navigation in the country.

• While not officially stated, diesel fuel is subsidized because of its importance for the Brazilian economy; the taxes applied to diesel are smaller than those applied to gasoline. Diesel fuel is responsible for the movement of more than 90% of freight transport and all buses for public transportation. Thus, an increase in the diesel price causes inflation in the economy, causing negative distributional effects for those with lower incomes (Schaeffer, et all, 2008).

• Brazil has a fleet for road freight transport of 1.9 million trucks, of which 43% belong to independent drivers. Their fleet has an average age of over 20 years. (Real et all, 2008). Several factors contribute to barriers in integrated logistics in Road Cargo Transportation (RCT) (AEB, 2005), namely:
  - there is very little regulation for the technical performance of the RCT market;
  - there is excess supply of vehicles and freelance services, which leads to degradation of freight and unfair competition;
  - many carriers are not qualified, which promotes a lack of quality in service;
  - the old fleet is obsolete, leading to low productivity, increased costs, high fuel consumption, greater local pollution, a high accident rate and increased emission of greenhouse gases;
4.3. Reinforce the Regulatory Framework of Transportation Agencies

According to Fernandes el al (2009), who has studied the main obstacles to the flow of agricultural crops in the country, there are significant barriers to be overcome in the regulatory framework in order to increase the Brazilian participation in world trade:

- The transport sector is lacking a regulatory framework capable of promoting adjustments in the port system in order to liberate and provide security to private investment;
- There is no harmony between the land transport regulatory agencies (ANTT) and waterways (ANTAQ), which affect the inter-modality of export logistics;
- There is no regulation for stable private investment. To attract the participation of private capital, Brazil needs:
  - To eliminate regulatory bottlenecks and policy uncertainties that still exist in certain sectors;
  - To promote planning of infrastructure concessions to avoid the excess of renegotiations,
  - To ensure an adequate rate of return for investors, and hence protect the welfare of consumers;
  - To improve the functioning of regulatory agencies, so that decision-making processes are consistent and technically safe;
  - It is necessary revamp the regulatory framework of waterways transport in order to provide legal certainty and, consequently, investment insurance, to avoid conflicts between carriers and other users of the river basin;
  - Also, reform of the regulatory framework of the railway is required, to improve matters such as the right rail pass and contours.

There are many significant internal barriers to the consolidation of intermodal transportation. Therefore, stakeholder will and policy making at all governmental levels is required to ensure that these barriers will be overcome. The evidence above illustrates that integrated government action is important, particularly with regard to political, tax and regulatory issues. These statements are in agreement with the measures recommended by the participants of a Rio workshop, which considered measures of political context more important than regulatory ones.

5. Indicators

As mentioned previously, there are many domestic needs and barriers to overcome in order to effectively achieve the goals of the PNLT in 2025. There is no doubt that implementation of the plan would have advantages and lasting benefits for sustainable development and greenhouse gas mitigation. The sets of indicators below could be recommended to provide information on assessment of the implementation of the plan.

<table>
<thead>
<tr>
<th>Type of indicator</th>
<th>Indicator</th>
</tr>
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</table>
| Input             | 1) End double taxation  
  2) Institutionalization of PNLT |
| Process           | 1) % works for each planned or completed infrastructure within a specified period of time:  
  2) % of financial resources spent or planned per year  
  3) % of works planned or completed |
| Output            | 1) Intermodal terminals in operation  
  2) Quantity and type of cargo transferred per terminal |
5.1 Input indicators

This first set of indicators shall be used to signal whether the most important barriers have been overcome. These indicators are related to overcoming domestic barriers, and their purpose is to assess the initial stages of implementation of the plan. The indicators proposed are qualitative and relatively easy to obtain.

- **End double taxation:** The national council of policy finances – (Conselho Nacional de Política Fazendária - CONFAZ), shall harmonize the state taxes, establishing a system by which service tax is charged only once in the case of multimodal transport. This requires actions from CONFAZ in order to create a mechanism to free the multimodal transport of double taxation.

- **Institutionalization of PNLT:** When the plan is institutionalized in the National Council for Integration of Transport Policies (CONIT), which is linked to the Presidency of the Republic, it will be a state plan, which reduces the possibility of its discontinuation with the end of the current administration.

5.2 Process indicators

To assess the implementation of the plan, the use of process indicators will help to monitor the execution of the works. In this case, the use of quantitative indicators is recommended, for which the data can be easily acquired.

- **Percentage of works for each planned or completed infrastructure within a specified period of time:** The indicator is periodic, depending on the availability of reports, and expresses the relationship between the planned works and completed infrastructure of each mode of transport. These figures can be monitored through the number of completed works documented in Accelerated Growth Plan reports (Plano de Aceleração do Crescimento - PAC).

- **Percentage of financial resources spent or planned per year:** As with the previous indicator, this metric intends to evaluate how financial resources are spent under the planned works of the PNLT. These figures can be monitored through the reports on financial implementation of the PAC.

- **Percentage of works planned or completed:** This indicator can monitor the execution of the work planned. This could be accompanied by an assessment of the physical progress of works in the PAC reports; for example, by visits to the places where works are performed.

5.3. Output and Outcome indicators

To monitor the success of PNLT, the use of quantitative performance indicators is recommended. Two sets of indicators for evaluation can be established:

<table>
<thead>
<tr>
<th>Outcome</th>
<th>1) Tonnes carried (t)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2) Tonnes-km (t.km)</td>
</tr>
<tr>
<td></td>
<td>3) Total consumption of energy in transport</td>
</tr>
<tr>
<td></td>
<td>4) Total energy consumption in the transport/GDP</td>
</tr>
<tr>
<td></td>
<td>5) Total energy consumption by mode of transport</td>
</tr>
<tr>
<td></td>
<td>6) Average consumption of diesel per vehicle used in cargo transportation</td>
</tr>
<tr>
<td></td>
<td>7) Average consumption of diesel per tonne.km</td>
</tr>
</tbody>
</table>
a) **Output:** the acquisition of data is relatively simple and indicators can be used to monitor the evolution of the modal integration;

b) **Outcome:** this approach is more complex, as it will monitor the detailed evolution of modal shift, energy efficiency, and mitigation of GHGs in freight.

### a) Output Indicators

These indicators can be a powerful tool for evaluating the efficiency of domestic cargo transport systems; as greater use of less energy-intensive means of transport makes freight systems more efficient. The greater or lesser availability of intermodal terminals will depend on the geography of the area. The acquisition of data depends on the economy and the size of the national transport system, and whether complete census information is available. Special data collection for subsequent statistical processing of information from each unit would be interesting in the case of large systems.

#### Number of intermodal terminals in operation:
This is a quantitative indicator that periodically assesses the number of public or private intermodal terminals. The terminals allow cargo to be transferred from one mode of transport to another. It would also be interesting to take into account the relationship between terminals in operation and new terminals deployed, so it would be possible assess the evolution of modal integration. This assessment is especially relevant since in Brazil there are currently many terminals that are not operating due to double taxation. The acquisition of this data is relatively simple, since it can be obtained through research at railways and waterways companies, as well through multimodal transport operators.

#### Quantity of cargo transferred per terminal:
This is a quantitative operational indicator that can be applied to both public and private terminals. The indicator allows assessment of whether the terminals are operational and the annual productivity of a terminal. Over time such a measure can permit the establishment of a benchmark to compare the operational performance of the terminals, both for cargo loading and unloading. Data acquisition must be performed regularly, ideally monthly or at least annually, through the application of questionnaires answered by the administration of the terminals.

#### Type of cargo handled by terminal:
An intermodal terminal can operate with bulk or general cargo, such as general cargo in containers. Terminals with equipment for handling general cargo are more modern and more flexible because they can operate with any type of load, provided that it can be transported through containers. This measure can also be used as an indicator of economic development of a region. As with the previous indicator, data acquisition must be carried out by research within the administration of the terminals.

### b) Outcome Indicators

To assess the evolution of modal transfer, energy efficiency and mitigation of GHGs in freight transport, indicators traditionally used in evaluating energy efficiency in transport can be used. Energy indicators are used to describe the relationship between energy use and human activity, including energy consumption in the transport sector. These indicators are similar to economic measures used to evaluate the performance of the economy.

Energy Indicators are derived from basic data from structure and economic activities, which can be used to examine changes in energy consumption, due to changes in the economic, technological and/or social environment. Furthermore, indicators can be used to assess the effects of official economic policies, or the use of new energy technologies, through an assessment of how each variable influences the structural use of energy. This type of assessment is not normative, but rather uses descriptive and analytical tools, the interpretation of which may lead to regulatory actions.

Analytical indicators can follow an internationally harmonized methodology, so it may be possible to compare a set of relevant indicators; however, this may not be always the case.
for a variety of reasons. For the selection of the indicators presented below, some basic criteria were considered, which were taken from the project prepared by Real et al (2004):

**Be relevant to Transport, Energy and Environment policies:**

- Provide a representative picture of the conditions of use of transport;
- Be simple, easy to interpret and show trends over time;
- Be sensitive to change;
- Provide a basis for international comparisons;
- Have a reference value, to allow comparisons.

**Analytical Potentiality:**

- be theoretically well founded in technical and scientific thought;
- be based on international standards, and be valid internationally;
- be able to be used in economic models, forecasting and information systems.

**Measurement**

- The data required to support the indicators shall be:
  - Available, or can be obtained at reasonable cost;
  - Well documented and of good quality;
  - Updated at regular intervals by the use of reliable methods.

The movement of people and goods is a direct measurement of "work" achieved by transport systems. When associated with the consumption of energy and fuels, energy indicators allow assessment and comparison of the efficiency and energy intensity of different transport systems. In this context, the following indicators are proposed for all modes of transport:

* **Tonnes carried (t):** Corresponds to the total volume of cargo transported, in tonnes, for a period of time, per transportation mode.
* **Tonnes-km (t.km):** Corresponds to the total load transported by the extension of journeys undertaken in a period of time, depending on the type of travel undertaken.

Decisions concerning energy consumption in transportation are directly related to the level of economic development in the region, the income per capita, the age of the fleet, the infrastructure available per transportation mode, and the flow of trade. It is proposed that the focus of indicators for energy per mode of transport, in Brazil, must be regionally segmented by state, especially:

* **Total consumption of energy in transport:** is the total energy consumption of each mode of transport in a given period. In turn, the power consumption of each mode of transport can be obtained from the consumption of fuel, converted to units of energy through a reference unit, such as toe (tonnes of oil equivalent).
* **Total energy consumption in the transport/GDP:** the total known energy consumption in transport, described in previous item, divided by the country's GDP over the same period.
* **Total energy consumption by mode of transport:** is the fuel consumption of each mode, converted to a unit of energy for a given period.

* **Average consumption of diesel per vehicle used in cargo transportation:** This indicator is derived from data on fuel consumption of transport, and when this information is not available, can be obtained from the total distance traveled by the fleet of vehicles and the average specific consumption.
Average consumption of diesel per tonne.km: To obtain this indicator it is necessary to obtain the total consumption of diesel fuel as calculated in the previous item, divided by the total tonne.km produced by a fleet.

6. Conclusion

The energy consumption related to the transportation sector has increased 75% from 1990 to 2007, which corresponds to an annual average increase of 3.3% (for the roadway mode this increase is even higher, with road holding an annual average of 3.5%). As the IPCC has indicated in an assessment of end-use sectors, the transportation sector corresponds to one of the largest growth areas in GHG emissions from 1970 to 2004. Therefore, it is important to identify effective potential mitigation measures related to the transportation sector, both for passenger and freight transport.

The National Plan for Logistics and Transport (PNLT), which was recently adopted by the Brazilian Federal government, aims at inducing a change in the modal shares of road, rail and inland waterway transport, by increasing the share of the rail and waterway transport. Although climate change concerns have not been taken into account in the elaboration of the plan, effective implementation of the PNLT has the potential to lower the projected GHG emissions trajectory of Brazil (by 40%, based on a 2025 trajectory).

Nevertheless, many important barriers must be overcome during the plan’s implementation. A workshop that has been held in the scope of this research, attended by specialists in the transportation sector (including representatives from Ministries, governmental agencies, academic sector, etc), helped to identify the main barriers and opportunities that need to be taken into consideration for the effective implementation of the PNLT.

The actions contained in the plan must be translated into GHG emission reductions. However, the current lack of reliable indicators that could allow measurement and verification is a significant barrier to be faced. This paper suggests the establishment of a series of indicators, which could facilitate the necessary quantification of emission reductions. This is an important step if international resources are to be mobilized to support domestic actions, as is discussed in the current negotiation process within the multilateral climate change regime.
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Contact Details
UK - Managing Director: Jon Price (jon.price@climatestrategies.org)
US - Research Director: Thomas L. Brewer
Secretariat: Climate Strategies c/o University of Cambridge
13-14 Trumpington Street Cambridge, CB2 1QA, UK
+44 (0) 1223 748812
www.climatestrategies.org

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