

**Scoping Post 2012 Climate Instruments:  
Nationally Appropriate Mitigation Actions NAMAs  
Case Study for Opportunities in Urban Transport in Brazilian Cities**

**FINAL REPORT**

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## 1. INTRODUCTION

### 1.1. Background

Developing countries offer great climate change mitigation potential through enhanced transport systems that also support local environmental, economic, transport, social and urban development objectives (see Table 1)<sup>1</sup>.

**Table 1**  
**Sustainable Transport Projects Co-Benefit Matrix**

Benefits	Description	Transversal Health Benefits
<b>Environment</b>	<ul style="list-style-type: none"> <li>• <b>Reduced GHG emissions</b></li> <li>• Reduced air pollutants</li> <li>• Reduced Noise</li> <li>• Reduced impact in water and protected areas</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced health impacts due to global warming</li> <li>• Reduced deaths and disabilities from air pollutants</li> <li>• Reduced stress and hearing losses</li> </ul>
<b>Social</b>	<ul style="list-style-type: none"> <li>• Reduced accidents</li> <li>• Equitable accessibility</li> <li>• Increased sense of pride and belonging</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced deaths and disabilities from traffic accidents</li> </ul>
<b>Transport</b>	<ul style="list-style-type: none"> <li>• Reduced travel time (walking, waiting, transferring, in-vehicle)</li> <li>• Reduced travel time uncertainty</li> <li>• Reduced transport costs</li> </ul>	<ul style="list-style-type: none"> <li>• Reduced stress</li> </ul>
<b>Economic</b>	<ul style="list-style-type: none"> <li>• Increased economic productivity</li> <li>• Increased employment<sup>2</sup></li> <li>• Better labor conditions</li> <li>• Increased business opportunities</li> </ul>	
<b>Urban Development</b>	<ul style="list-style-type: none"> <li>• Increased density/mix uses</li> <li>• Creation of public spaces</li> <li>• Reduced cost in utility and social networks</li> </ul>	<ul style="list-style-type: none"> <li>• Increased physical activity (reduced obesity and other illnesses from sedentary lifestyles)</li> </ul>

Source: EMBARQ

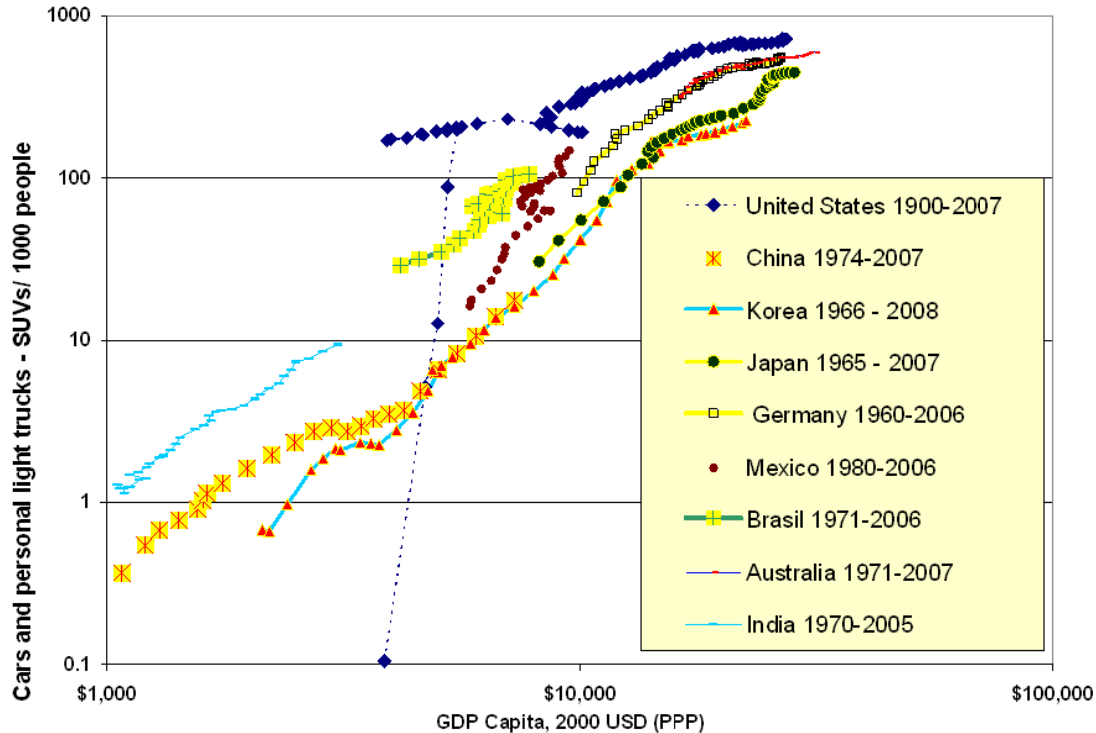
One of the main challenges faced by developing economies is the rapid rise in motorization, following the path that most developed nations experienced during the past century (see Figure 1). Business as usual in the transport sector for

<sup>1</sup> For a detailed study on the links of urban transport, health and climate change see Woodcock, et. al "Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport", The Lancet, November 25, 2009.

<sup>2</sup> While new transport systems may provide employment opportunities, the reorganization and rationalization of existing systems may lead to layoffs.

developing countries will result in greater GHG emissions from fossil fuel combustion, as well as increased congestion, pollution, accidents and reduced physical activity.

**Figure 1**  
**Motorization and GDP for Various Countries**



Source: Lee Schipper, University of California at Berkeley, 2009

Traditional “technological” approaches will help in mitigating GHG and air pollutant emissions<sup>3</sup>, but will not suffice to reduce other transport negative externalities to desired levels. Technological approaches are those addressing tailpipe emissions by improving the engines, the fuel, or introducing emission control devices. Measures may include but will not be limited to emission and energy efficiency standards, vehicle verification, fleet renovation schemes incorporating low emission engines and fuels. Since measures do not address other aspects of transport, mainly congestion, accidents and urban development, a more holistic paradigm is required.

<sup>3</sup> The principal air pollutants, mainly harmful to human health, are called criteria pollutants by the US Environmental Protection Agency. They include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), particulate matter (PM), and sulfur dioxide (SO<sub>2</sub>). There are also a large number of compounds which have been determined to be hazardous which are called air toxics. <http://www.epa.gov/air/oaqps/emissions.html>

This paradigm was defined as Avoid-Shift-Improve<sup>4</sup>: avoid the need to travel and reduce the distance traveled, mainly through integrated land use practices (sustainable transport oriented development) and use of telecommunication technologies (telecommuting and net-meeting); shift from less efficient modes (individual motor vehicles) to more efficient modes (walking, biking, and public transportation); and improve the technologies of the vehicles and fuels used in transport systems.

The Avoid-Shift-Improve paradigm has several financial and institutional barriers for implementation. Climate change mitigation instruments can contribute in removing financial barriers for such mitigation efforts by providing grants and concessionary financing to partially support transport system components development. Climate instruments can also help in improving local technical capacities and in facilitating co-ordination of activities by several agencies and government levels. At the same time, the integral transport plans and programs will address local needs, such as congestion, pollution and accidents making them very appealing for decision makers.

One of the instruments to support GHG mitigation efforts and development goals by developing countries are the Nationally Appropriate Mitigation Actions (NAMAs) as agreed under the Copenhagen Accord<sup>5</sup>. Broadly defined, NAMAs are actions voluntarily proposed by developing countries that significantly reduce emissions below business-as-usual levels.<sup>6</sup>

NAMAs can be categorized under three broad types or layers<sup>7</sup>:

1. Actions that are undertaken by developing countries and are not enabled or supported by other countries (unilateral NAMAs);
2. Actions that are supported by developed countries that could include additional financing support for capacity building and knowledge/technology transfer; and is likely to be supported by fund-type instruments (supported NAMAs);

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<sup>4</sup> See Common Policy Framework for Transport and Climate Change, Bellagio Meeting, May 2009, [http://www.sutp.org/bridgingthegap/?page\\_id=582](http://www.sutp.org/bridgingthegap/?page_id=582)

<sup>5</sup> The Fifteenth Conference of the Parties –COP 15- of the United Nations Framework Convention on Climate Change –UNFCCC- took note of the Copenhagen Accord of 18 December 2009. For reflections from the Accord and the way forward please see <http://www.wri.org/stories/2009/12/reflections-copenhagen-accord-and-way-forward>.

<sup>6</sup> <http://www.transport2012.org/bridging/ressources/files/1/613,CCAP-transport-NAMAs-paper-FINAL-DRA.pdf>

<sup>7</sup> [http://www.transport2012.org/bridging/ressources/documents/1/68,Discussion\\_Paper.pdf](http://www.transport2012.org/bridging/ressources/documents/1/68,Discussion_Paper.pdf)

3. Actions that would lead to certified emissions reductions that could be traded for revenue in a cap-and-trade scheme such as the Clean Development Mechanism CDM<sup>8</sup> (Carbon Credit NAMAs).

This study explores the use of Supported NAMAs for the development of integral urban mobility plans. The proposed NAMA structure is expected to serve as a basis for submissions by developing countries agreeing with the Copenhagen Accord.<sup>9</sup>

## 1.2. Study Objectives

This study explores needs, methodological and practical issues of application of NAMAs in the urban transport sector.

The main questions addressed as part of the study are:

- What would an Avoid-Shift-Improve oriented NAMA for integral urban mobility look like?
- How would it be organized?
- How would it be financed?
- How would it be Monitored-Reported-Verified?
- How could it be scaled up?
- Which are the GHG mitigation and co-benefit potentials of sustainable, low carbon transport in a mid size Brazilian city?

## 1.3. Importance of Developing a NAMA for Integral Mobility Plans

Urban transport is a major contributor of GHG emissions. Adequate supported policies that encourage cities to mitigate GHG while improving transport efficiency and reduce transport negative externalities -air pollution, accidents, and sedentary lifestyles, among other- are necessary.

A model urban transport NAMA is expected to help in removing barriers for implementation of integral mobility plans, namely shortage of funding and permanence over time<sup>10</sup>. The urban transport NAMA may also help in building public acceptance for the integral plan, as it will highlight the environmental and other benefits of the system.

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<sup>8</sup> [http://unfccc.int/kyoto\\_protocol/mechanisms/clean\\_development\\_mechanism/items/2718.php](http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php)

<sup>9</sup> See: <http://unfccc.int/home/items/5262.php>. For an interpretation of the meaning of being part of the accord see <http://www.wri.org/stories/2010/03/associating-copenhagen-accord-what-does-it-mean>.

<sup>10</sup> The plan may create a commitment that goes beyond a single term limit of public officials.

The NAMA will address financial barriers in three general ways: general funding from different levels of government, general international financial flows, and specific climate funding mechanisms. Since the financial requirements for urban transport infrastructure are usually sizeable, a combination of local, state and national or federal funds is customary. Making explicit the GHG reduction potential, establishing quantitative goals for GHG emissions reductions and an MRV mechanism, will eventually increase the likelihood of receiving funding from national or federal government as the local plan helps achieving national goals in limiting GHG. It will also bring additional financing from international financial flows interested in climate change and development issues in the form of grants and loans. Finally it will provide the opportunity to use climate financial instruments, very particularly supported NAMAs.

The NAMA will deal with permanence over time, as the plan will be implemented over a long period, covering several terms for local elected officials. The NAMA will provide continuity over the election cycles through the monitoring, reporting and verification MRV mechanism and the provisions adopted to assure compliance of the mitigation and co-benefit goals.

The NAMA will tackle public acceptance and support as it highlights benefits that go beyond the direct transport benefits (reduced travel time and congestion). Public health benefits due to reduced air pollutant emissions and accidents, and increased physical activity are very important for the community at large. At the same time there is a growing concern for climate change. The public is more likely to support measures that bring complementary benefits, including climate change mitigation, than projects aimed to just reduce congestion or improve connectivity. A NAMA for Urban Transport can not only make explicit the broad range of co-benefits, but provide a solid framework for following up the impacts.

Finally, a NAMA which has a common structure across cities, and uses common parameters and MRV mechanisms is also helpful in defining benchmarks and help by yardstick comparison among cities. It is expected that local urban transport NAMAs are aggregated into a national action plan.

## **2. NAMA – INTEGRAL URBAN MOBILITY**

The National Appropriate Mitigation Action on Integral Urban Mobility includes the following suggested components<sup>11</sup>:

- Policy Objective
- Description of the NAMA
- greenhouse Gas Emission Reductions Targets

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<sup>11</sup> As suggested by ECOFYS for a Model NAMA for Transport in Mexico

- Estimation of co-benefits
- Methodology for Monitoring, Reporting and Verification
- Risk Analysis
- Financing
- Institutional Settings

The following sub-sections provide suggestions on the way the NAMA on Integral Urban Mobility may be built, including methodological aspects.

## **2.1. Policy Objective**

It is a declaration of the outcomes expected, specific goals regarding GHG reductions and co-benefits, and the definition on how the plan will apply the avoid-shift-improve paradigm. It is strongly suggested that the policy objective includes:

- Specific goals regarding distribution of trips in different modes of transport in the urban area for a target year. High level modal distribution includes active transport (walking, biking), public transport (metro, bus rapid transit, buses), individual transport (private cars, motorcycles, taxi). High shares of active and public transport result in less energy consumption and harmful emissions than high shares of individual transport.
- Specific goals regarding GHG reductions defined as percent reductions as compared with a baseline scenario for a target year (e.g. % reduction from year 20xx by year 20xx).
- Specific goals regarding co-benefits as compared with a baseline scenario for a target year. As a minimum, co-benefits may include travel time reductions and criteria pollutant emissions (especially particulate matter).
- A declaration on how the plan applies the avoid-shift-improve paradigm. For example, how the plan reduces the need for travel, shift travel to the most efficient modes, and improves the energy efficiency of the transport system.

## **2.2. Description of the NAMA**

It is a list and description of the mitigation actions to be included in the urban mobility plan under different scenarios: dynamic baseline, low/medium/high investment levels. Suggested categories and types of policies may include:

- Transportation demand management (parking and congestion pricing, vehicle restrictions)
- Fiscal policy (taxes on less efficient modes, vehicles and fuels, targeted subsidies for public and active transportation)

- Land use management (mix use, densification, and growth management)
- Active transport (walk and bicycle facilities and programs)
- Transit interventions (rail, bus rapid transit, bus network optimization and transit systems integration)
- Low carbon fuels and vehicles (efficiency standards, emission verifications, vehicle scrapping programs, alternative technologies)
- Capacity building activities (improved ability to plan, measure, supervise, control transport related activities that contribute to GHG mitigation)

A critical aspect on the estimation of targets in GHG mitigation and co-benefits is the selection of the baseline. It is recommended to avoid “do-nothing” scenarios as baselines as they do not reflect the fact that local administrations continuously invest in the transport infrastructure. The baseline should reflect the historic trends in investment in the transport sector. One option for baseline definition is to project the investments that have been already committed, according to the current financial capacity.

For some examples on impacts of diverse policies for urban transport climate change mitigation and co-benefits see:

- “Saving Oil and Reducing CO<sub>2</sub> Emissions in Transport: Options and Strategies”, International Energy Agency, 2001<sup>12</sup>
- “Growing Cooler: The Evidence on Urban Development and Climate Change”, Urban Land Institute, 2009<sup>13</sup>,
- “Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport”, The Lancet, November 25, 2009<sup>14</sup>

These publications indicate the importance of bundling measures to obtain greater mitigation of CO<sub>2</sub> emissions and co-benefits. For more general sustainable transport planning and practice in developing countries see the “GTZ Sourcebook for Decision-Makers in Developing Cities”<sup>15</sup>.

### 2.3. Greenhouse Gas Emission Reduction Targets

It encompasses the quantitative definition of the emission reduction targets as compared with a baseline scenario. In NAMA on Integral Urban Mobility, greenhouse gases reduction is expected from cutbacks in the number and length

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<sup>12</sup> <http://www.iea.org/textbase/nppdf/free/2000/savingoil2001.pdf>

<sup>13</sup> <http://www.smartgrowthamerica.org/documents/growingcoolerCH1.pdf>

<sup>14</sup> A presentation of this study is available at <http://www.embarq.org/en/woodcock-james>

<sup>15</sup> [http://www.sutp.org/index.php?option=com\\_content&task=view&id=426&Itemid=189&lang=en](http://www.sutp.org/index.php?option=com_content&task=view&id=426&Itemid=189&lang=en)



of personal motorized trips due to densification (avoid), reduction of the total motorized vehicle-kilometers as the participation of public and active transport increases (shift), and enhanced efficiency of the vehicle fleet (improve).

The framework indicated in Figure 2 is used to estimate GHG emissions, and define the corresponding targets. It is also useful for the estimation and definition of other co-benefits.

### **Figure 2 – Estimation of GHG Emissions – Framework**

The steps involved in the framework are:

Step 1. Transport Model Calibration for the base year using standard transport planning techniques<sup>16</sup> and state-of-the practice modeling. We recommend doing the initial estimation using a complete transport planning process including extensive data collection and modeling. This approach is standard for good urban transport planning and its encouraged as part of a continuous, comprehensive and cooperative urban transportation planning process<sup>17</sup>.

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<sup>16</sup> See transport planning textbooks, for example Ortuzar J.D and Willumsen L.G. "Modelling Transport", Third Edition, John Wiley and Sons, England, 2001.

<sup>17</sup> See, for example, the guidelines issued by the US Department of Transport "The Transportation Planning Process: Key Issues. A briefing book for transportation decision makers, officials and staff", September 2007, <http://www.planning.dot.gov/documents/BriefingBook/BBook.htm#2BB>

It is highly recommended to use a household based origin-destination matrix (OD)<sup>18</sup>, GIS based networks (for transit and general traffic) and area-wide four step planning processes<sup>19</sup>: trip generation (e.g. cross classification or category analysis); trip distribution (e.g. gravity type models); modal split (e.g. discrete choice models); transit and traffic assignment (e.g. transit strategies and user equilibrium models). Calibration entails the estimation or adjustment of model parameters to reproduce the observed travel patterns (e.g. vehicle counts and occupancy surveys, travel and speed studies) based on the observed socio-economic characteristics of the population at the traffic zone level (population, income, trips per person).

Step 2. Obtain Vehicle-Kilometers for each mode in the base year ( $VKT_{m0}$ ). Use the calibrated model to estimate the activity in the base year. Modes are individual transport (car and light duty vehicle, taxi), public transport (metro, bus rapid transit, bus), active transport (walk, bicycle), and cargo.

Step 3. Obtain GHG Emissions in the base year ( $GHG_0$ )

$$GHG_0 = \sum_{m=1}^M VKT_{m0} * EF_{m0} \quad (\text{Equation 1})$$

Where  $M$ : is the mode  
 $EF_{m0}$ : is the emission factor per kilometer for mode  $m$ , year 0  
 $VKT_{m0}$ : vehicle kilometers for mode  $m$ , year 0

$$EF_{m0} = \sum_{t=1}^T \left[ I_{tm} * (F_{CO2t} + F_{CH4t} + F_{N2Ot}) * \left( \frac{N_{tm}}{N_m} \right) * PF_t \right] \quad (\text{Equation 2})$$

Where  $T$ : fuel type (gasoline, diesel, ethanol)  
 $I_{tm}$ : vehicle fuel efficiency for each fuel type [liters/km]  
 $F_{CO2t}$ : CO<sub>2</sub> emission factor for fuel  $t$  [gr/liter]  
 $F_{CH4t}$ : CH<sub>4</sub> emission factor for fuel  $t$  [gr CO<sub>2</sub> equivalent/liter]  
 $F_{N2Ot}$ : N<sub>2</sub>O emission factor for fuel  $t$  [gr CO<sub>2</sub> equivalent/liter]  
 $N_{tm}$ : Number of vehicles of fuel type  $t$  in mode  $m$   
 $N_m$ : Number of vehicles in mode  $m$   
 $PF_t$ : upstream emissions factor for fuel  $t$  (production and distribution)

<sup>18</sup> Collection of household based OD is recommended every 10 years. To interpolate it is useful to use the basic OD structure and update the values based on cordon and screen volume and occupancy surveys, and travel speed/time studies.

<sup>19</sup> Possibilities of using other advanced modeling techniques involving dynamic traffic assignment (see <http://cts.cs.uic.edu/event.php?m=5&ind=48>) or integrated land use and transport modeling (for example <http://tranus.com/>).

Step 4. Obtain Vehicle Kilometers for each mode and scenario in the future year ( $VKT_{mys}$ ). Use the calibrated model, the changes in socio-economic characteristics (population, income, trips per person), land use policies (densification, sprawl) and the changes in the network (roads, transit).

Step 5. Obtain GHG emissions for each scenario in the future year ( $GHG_y$ )

$$GHG_{ys} = \sum_{m=1}^M VKT_{mys} * EF_{mys} - CE_{ys} \quad (\text{Equation 3})$$

Where

$M$ : is the mode

$VKT_{mys}$ : vehicle kilometers for mode  $m$ , year  $y$ , scenario  $s$

$EF_{mys}$ : is the emission factor per kilometer for mode  $m$ , year  $y$ , scenario  $s$

$CE_{ys}$ : construction emissions for scenario  $s$  (CO<sub>2</sub> equivalent emission from construction activities and supplies such as cement, steel, vehicles)

$$EF_{mys} = \sum_{t=1}^T \left[ I_{tmys} * (F_{CO2t} + F_{CH4t} + F_{N2Ot}) * \left( \frac{N_{tms}}{N_{ms}} \right) * PF_t \right] \quad (\text{Equation 4})$$

Where

$T$ : fuel type (gasoline, diesel, ethanol)

$I_{tmys}$ : fuel consumption for each fuel type  $t$  in year  $y$  scenario  $s$  [liters/km]

$F_{CO2t}$ : CO<sub>2</sub> emission factor for fuel  $t$  [gr/liter]

$F_{CH4t}$ : CH<sub>4</sub> emission factor for fuel  $t$  [gr CO<sub>2</sub> equivalent/liter]

$F_{N2Ot}$ : N<sub>2</sub>O emission factor for fuel  $t$  [gr CO<sub>2</sub> equivalent/liter]

$N_{tms}$ : Number of vehicles of fuel type  $t$  in mode  $m$  scenario  $s$

$N_{ms}$ : Number of vehicles in mode  $m$  scenario  $s$

$PF_t$ : upstream emissions factor for fuel  $t$  (production, distribution)

Step 6. Obtain total greenhouse gas emissions ( $TGHG_s$ ) by adding year by year emissions and total greenhouse gas emission savings ( $SGHG_s$ ) for each of the four scenarios: dynamic baseline; low investment; medium investment; high investment.

$$TGHG_s = \sum_{y=1}^Y GHG_{ys} \quad (\text{Equation 5})$$

$$SGHG_s = TGHG_1 - TGHG_s \quad (\text{Equation 6})$$

Where

$TGHG_1$ : GHG emissions dynamic baseline scenario

$TGHG_s$ : GHG emissions scenario  $s$

The assumptions and sources of information for the different parameters of the formulas should be adequately presented.

## 2.4. Co-Benefits

This includes quantitative and qualitative estimation of benefits in transport efficiency, air pollution, accidents, physical activity and health.

The main transport co-benefits of an urban mobility plan are expected to be reductions in travel times (due to increased travel speeds) and travel costs (due to increased efficiency of public transport). Travel costs include the out-of-pocket expenses by the transport systems users (mainly transit fares, operational cost of private vehicles, parking and tolls). It is recommended to include the distributional effects to check for travel time and travel cost impacts for different segments of the population.

In addition to transport impacts there are expected reductions in air pollutants, accidents, increased physical activity, which result in reductions in mortality and morbidity.

Increased accessibility may also result in increased land values<sup>20</sup>, reduced costs for the distribution of goods and increased access to job opportunities<sup>21</sup>. The mobility plan may also result in increased equity, as the low income population living in the periphery will perceive larger travel time and cost reduction than higher income population living closer to the city's core. It is possible to quantify the most important co-benefits using the results of transport modeling (travel time, travel cost, air pollutant emissions), while other co-benefits (accidents, health benefits from more active lifestyles) may require separate models. We provide some suggested methods of co-benefit calculations in the following sections. The assumptions and sources of information for the different parameters of the formulas should be adequately presented.

### 2.4.1. Travel Time

The transport modeling process provides the following outputs for travel time co-benefit calculation: demand (total trips by mode  $TT_{mys}$ ), average travel time by

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<sup>20</sup> Increased land values from improved accessibility may benefit property owners, but may also result in gentrification: defined as “the restoration and upgrading of deteriorated urban property by middle-class or affluent people, often resulting in displacement of lower-income people”  
<http://www.thefreedictionary.com/gentrification>

<sup>21</sup> Increasing accessibility, especially from the low income periphery, expands the access to jobs in the city core.

mode ( $AT_{mys}$ )<sup>22</sup>. Travel time for public transport includes walking, waiting, transfer and in-vehicle time. Travel time for private vehicles includes in-vehicle time.

For the estimation of the travel time benefit it is recommended to use the difference in consumer surplus<sup>23</sup>, because there are changes in the level of demand for each mode in any given scenario. The difference in consumer surplus is given by the trapezoid shown in figure 3.

$$TVTS_{mys} = (AT_{my1} - AT_{mys}) * \left( \frac{TT_{my1} + TT_{mys}}{2} \right) \quad (\text{Equation 7})$$

Where  $TVTS_{mys}$ : Travel time savings mode  $m$ , year  $y$ , scenario  $s$   
 $AT_{my1}$ : Average travel time mode  $m$ , year  $y$ , baseline  
 $AT_{mys}$ : Average travel time mode  $m$ , year  $y$ , scenario  $s$   
 $TT_{my1}$ : Total trips mode  $m$ , year  $y$ , baseline  
 $TT_{mys}$ : Total trips savings mode  $m$ , year  $y$ , scenario  $s$

Travel time savings for each scenario can be transformed into an economic equivalent using value of time (VT). Total economic equivalent travel time savings are:

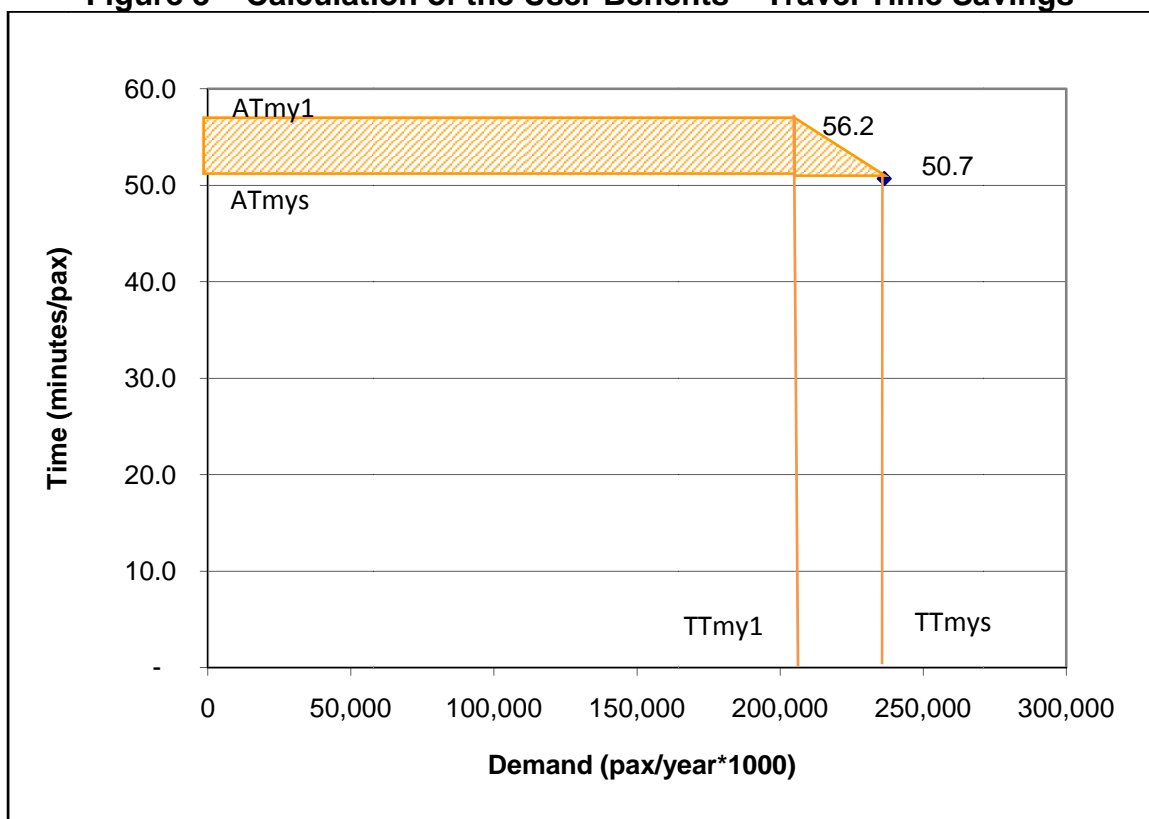
$$TETS_s = \sum_{y=1}^Y \left( \sum_{m=1}^M TVTS_{mys} * VT * \frac{1}{(1+DR)^y} \right) \quad (\text{Equation 8})$$

Where  $VT$ : value of time [monetary unit/time unit]  
 $DR$ : Socio-economic annual discount rate (e.g. 12%)

<sup>22</sup> The traditional transport modelling practices usually exclude short distance walking trips. New data collection efforts for origin and destination are increasingly including active trips (walking-biking). When possible we suggest to include active transport trips.

<sup>23</sup> "Consumer surplus is the difference between the total amount that consumers are willing and able to pay for a good or service (indicated by the demand curve) and the total amount that they actually do pay (i.e. the market price for the product). The level of consumer surplus is shown by the area under the demand curve and above the ruling market price." See <http://www.tutor2u.net/economics/revision-notes/as-markets-consumer-surplus.html>

**Figure 3 – Calculation of the User Benefits – Travel Time Savings**



### 3.4.2. Travel Costs

The transport modeling process provides the total demand (total trips by mode  $TT_{mys}$ ). The total travel cost is the result of multiplying the trips by mode by the average travel cost for each mode ( $AC_{mys}$ ).

For the calculation of the travel cost benefit it we recommended to use the same approach used in the calculation of travel time savings, that is the difference in consumer surplus as there are changes in the level of demand for each mode in any given scenario.

$$TCS_{mys} = (AC_{my1} - AC_{mys}) * \left( \frac{VKT_{my1} + VKT_{mys}}{2} \right) \quad (\text{Equation 9})$$

Where  $TCS_{mys}$ : Travel cost savings mode  $m$ , year  $y$ , scenario  $s$   
 $AC_{my1}$ : Average cost per km mode  $m$ , year  $y$ , baseline  
 $AT_{mys}$ : Average cost per km mode  $m$ , year  $y$ , scenario  $s$

$VKT_{myl}$ : Vehicle kilometers mode  $m$ , year  $y$ , baseline  
 $VKT_{mys}$ : Vehicle kilometers mode  $m$ , year  $y$ , scenario  $s$

The total travel cost savings for each scenario are:

$$TTCS_s = \sum_{y=1}^Y \left( \sum_{m=1}^M TCS_{mys} * \frac{1}{(1+DR)^y} \right) \quad (\text{Equation 10})$$

Where  $DR$ : Socio-economic annual discount rate (e.g. 12%)

### 2.4.3. Air pollutant emissions reductions

Motor vehicle tailpipe emissions are precursors of air pollutants, which can harm human health and the environment, and cause property damage<sup>24</sup>. Using a similar methodology than the one recommended for the estimation of GHG emissions, it is possible to have approximate levels of tailpipe emissions such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM). Emission factors need to include the fuel quality, fleet types (age, emission control devices, etc.), city topography and whether, congestion levels.

$$CO_{ys} = \sum_{m=1}^M VKT_{mys} * EFCO_{mys} \quad (\text{Equation 11})$$

$$HC_{ys} = \sum_{m=1}^M VKT_{mys} * EFHC_{mys} \quad (\text{Equation 12})$$

$$NOx_{ys} = \sum_{m=1}^M VKT_{mys} * EFNOx_{mys} \quad (\text{Equation 13})$$

$$PM_{ys} = \sum_{m=1}^M VKT_{mys} * EFPM_{mys} \quad (\text{Equation 14})$$

Where  $M$ : is the mode  
 $EFCO_{mys}$ : is the CO emission factor per kilometer for mode  $m$ , year  $y$ , scenario  $s$   
 $EFHC_{mys}$ : is the HC emission factor per kilometer for mode  $m$ , year  $y$ , scenario  $s$   
 $EFNOx_{mys}$ : is the NOx emission factor per kilometer for mode  $m$ , year  $y$ , scenario  $s$   
 $EFPM_{mys}$ : is the PM emission factor per kilometer for mode  $m$ , year  $y$ , scenario  $s$

$$EFCO_{mys} = \sum_{t=1}^T \left[ I_{tmys} * FCO_{tmys} * \left( \frac{N_{tms}}{N_{ms}} \right) \right] \quad (\text{Equation 15})$$

$$EFHC_{mys} = \sum_{t=1}^T \left[ I_{tmys} * FHC_{tmys} * \left( \frac{N_{tms}}{N_{ms}} \right) \right] \quad (\text{Equation 16})$$

$$EFNOx_{mys} = \sum_{t=1}^T \left[ I_{tmys} * FNOx_{tmys} * \left( \frac{N_{tms}}{N_{ms}} \right) \right] \quad (\text{Equation 17})$$

<sup>24</sup> See: <http://www.epa.gov/air/urbanair/>

$$EFPM_{mys} = \sum_{t=1}^T \left[ I_{tmys} * FPM_{tmys} * \left( \frac{N_{tms}}{N_{ms}} \right) \right] \quad (\text{Equation 18})$$

Where

- $T$ : fuel type (gasoline, diesel, ethanol)
- $I_{tmys}$ : fuel consumption for each fuel type  $t$  in year  $y$  scenario  $s$  [liters/km]
- $FCO_{tmys}$ : CO emission factor for fuel  $t$  [gr/liter]
- $FHC_{tmys}$ : HC emission factor for fuel  $t$  [gr/liter]
- $FNOx_{tmys}$ : NOx emission factor for fuel  $t$  [gr/liter]
- $FPM_{tmys}$ : PM emission factor for fuel  $t$  [gr/liter]
- $N_{tms}$ : Number of vehicles of fuel type  $t$  in mode  $m$  scenario  $s$
- $N_{ms}$ : Number of vehicles in mode  $m$  scenario  $s$

In previous sub-sections we recommended a procedure for estimating the economic value of time and cost savings. Nevertheless, in this sub-section we do not recommend estimating the economic benefits of reduced air pollutants. While these impacts are important, economic valuation requires detailed modeling and data, which may not be readily available. For instance, estimation requires area wide air quality modeling to find the level of exposure, health impacts modeling (to determine reduced deaths, illnesses, like heart or respiratory disease, limited activity days or days lost); and economic estimation of value of life, illness or work losses<sup>25</sup>.

#### 2.4.4. Other co-benefits

Other co-benefits, such as reduction in traffic accidents, increased physical activity, increased land values, reduced costs for the distribution of goods, and increased access to job opportunities are usually more difficult to quantify. They can be included as models and processes become available. We do not recommend making them mandatory in the preparation of a NAMA on Integral Urban Mobility.

### 2.5. Monitoring, Reporting and Verification

For monitoring purposes, we propose a simplified approach in which the key indicators for calculating GHG emissions and the main co-benefits are monitored.

The leading indicators are:

- Population [number]
- Gross domestic product [billion local monetary units]

<sup>25</sup> For estimations of health impacts and economic value in urban transport see for example: National Institute of Ecology -INE, Cost-Benefit Analysis: Insurgentes Corridor Mexico City, Mexico, 2007, <http://www.epa.gov/ies/mexico/brt.htm>



- Trips per person per day [number]
- Main mode of travel (walking, biking, public transport, private vehicle, taxi motorcycle)
- Average distance per trip per mode of travel [km]
- Average travel time per mode of travel [minutes]
- Average travel cost per mode of travel [local monetary units]
- Emission factors per kilometer per mode of travel
  - GHGs (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) [gm/km]
  - Tailpipe emissions (CO, HC, NO<sub>x</sub>, PM) [gm/km]
- Construction emissions GHGs [Ton/year]

Additional co-benefits monitoring (optional):

- Total deaths from traffic accidents [fatalities/year]
- Average physical activity per person per week [minutes/week]
- Trips per person per day for low income population (equity) [number]

It is also encouraged to collect a set of control variables to check consistency:

- Aggregated fuel sales (associated with transport) [liters/year]
- Air quality indicators (ambient concentrations and number of events above standards, extracted from air quality monitoring network) [average daily parts per million]

### 2.5.1 Monitoring

The suggested monitoring process involves collection of secondary and primary data inputs. Based on these inputs GHG reductions and co-benefits are reported. The monitoring framework inputs are summarized in Table 2.

In addition to data regarding the quantitative calculation of GHG emission reductions and co-benefits, it will also be important to monitor barrier removal. We recommend having clear identification on how the following barriers are removed:

- Financial barriers (how the NAMA facilitated funding from other levels of government, international financial flows and created availability of funding from climate instruments)
- Institutional barriers (how the NAMA facilitated the coordination among agencies and different government levels)
- Permanence barriers (how the NAMA helped in plan continuity after election cycles)

- Public Acceptance (how the NAMA helped in creating positive support from the community at large)

**Table 2 - Monitoring Inputs**

Variable		Source
Population year $y$	$Pop_y$ [number]	National institution in charge of demographic statistics
Gross domestic product year $y$	$GDP_y$ [monetary unit]	National institution in charge of economic statistics
Trips per person per workday year $y$	$TPP_y$ [number]	Annual survey (description below)
Equivalent workdays per year	$EWD$ [number]	Estimated in transport planning studies ~310 workdays per year
Share of each mode $m$ in year $y$	$S_{my}$ [percent]	Annual survey (description below)
Average distance for each mode $m$ in year $y$	$D_{my}$ [km]	Annual survey (description below)
Average travel time for each mode $m$ in year $y$	$TT_{my}$ [minutes/day]	Annual survey (description below)
Average travel cost for each mode $m$ in year $y$	$TC_{my}$ [monetary unit/day]	Annual survey (description below)
Emission Factors GHGs	$EF_{my}$ [CO <sub>2</sub> eq gr/ km]	Calculation based in fleet composition (type of fuel), energy intensity (liters/Km) and GHG emissions per unit of fuel (gms/liter) (see below). Local data when available or international default data.
Emission Factors Tailpipe emissions	$EF_{CO_{my}}$ [CO gr/km] $EF_{HC_{my}}$ [HC gr/km] $EF_{NOx_{my}}$ [NOx gr/km] $EF_{PM_{my}}$ [PM gr/km]	Calculation based in fleet composition (type of fuel), energy intensity (liters/Km) and GHG emissions per unit of fuel (gms/liter) (see below) Local data when available, or international default data.
Construction emissions	$CE_y$ (CO <sub>2</sub> eq gr/km)	Calculation based on the consumption of concrete and steel (see below)

### 2.5.1.1. Annual Survey

We propose using a citywide survey to monitor the activity data. To assure adequate representation the we suggest a categorized random survey with a 5% error and a 95% confidence interval. Recommended categories are main trip purpose (work, study, other), gender (male, female) and income level (high, medium, low). The suggested error and confidence level require around 300 random surveys per category, for a total of 5,400 surveys<sup>26</sup>. Approximate cost

<sup>26</sup> This number of surveys provides a good level of confidence and error size regardless of the city size if there is a random selection within the categories. The suggested number can be

per survey is USD 4-6, for a total cost of USD 21,600 to 27,000, including analysis and reporting. This is a fraction of the cost of a detailed transport planning study, usually in the range of 0.5 to 1.0 million dollars.

Proposed questions may include:

- Socio-economic characteristics
  - Gender
  - Age
  - Education
  - Occupation (worker, student, other)
  - Household size
  - Level of income
  - Vehicle ownership (car or light duty vehicle, motorcycle, bicycle)/
  - Home ownership
- Travel information
  - Number of trips per week
  - Main mode of transport
  - Travel distance one direction (could be zone of origin, zone of destination)
  - Travel time one direction
  - Travel cost (out of pocket expenses)
- Quality rating for the main mode of transport (user perception)

Appropriate expansion factors from the sampled categories to the overall population may be extracted from the city basic socio-economic characteristics (gender, income) and trip purposes (O-D survey).

### 2.5.1.2. GHGs Emission Factors

The following general formula is used to estimate the GHGs aggregated emission factor for tail pipe emissions, including upstream emissions:

$$EF_{my} = \sum_{t=1}^T \left[ I_{tmy} * (F_{CO2ty} + F_{CH4ty} + F_{N2Oty}) * \left( \frac{N_{tmy}}{N_{my}} \right) * PF_t \right] \quad (\text{Equation 19})$$

Where

- $T$ : fuel type (gasoline, diesel, ethanol)
- $I_{tmy}$ : fuel consumption for each fuel type [liters/km]
- $F_{CO2ty}$ : CO<sub>2</sub> emission factor for fuel  $t$  [gr/liter]
- $F_{CH4ty}$ : CH<sub>4</sub> emission factor for fuel  $t$  [gr CO<sub>2</sub> equivalent/liter]
- $F_{N2Oty}$ : N<sub>2</sub>O emission factor for fuel  $t$  [grCO<sub>2</sub> equivalent/liter]

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adjusted for local conditions and requires the consideration of expansion of the urban area over time.

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$N_{tmy}$ : Number of vehicles of fuel type  $t$  in mode  $m$   
 $N_{my}$ : Number of vehicles in mode  $m$   
 $PF_t$ : upstream emissions factor for fuel  $t$  (production, distribution)

The emission factors need to reflect the characteristics of the fleet, local weather, type of terrain, and congestion. Factors may be obtained from international literature (UNFCCC, International Vehicle Emission Model -IVEM), and adjusted to local conditions.

### 2.5.1.3. GHG Emissions from Construction Activities

Construction activities and the production of construction supplies (cement, steel) generate GHG emissions. It is suggested to use industry based parameters (e.g. CO<sub>2</sub>eq by ton of cement) and multiply by the units of input (e.g. m<sup>3</sup> of cement). The construction activities monitored are the actual activities in urban transportation (ex-post), including those not necessarily incorporated in the plans.<sup>27</sup>

### 2.5.1.4. Air Pollutant Emission Factors

The following formula is used to calculate the emission factors to monitor air pollutant emissions:

$$EFCO_{my} = \sum_{t=1}^T \left[ I_{tmy} * FCO_{tmy} * \left( \frac{N_{tmy}}{N_{my}} \right) \right] \quad (\text{Equation 20})$$

$$EFHC_{my} = \sum_{t=1}^T \left[ I_{tmy} * FHC_{tmy} * \left( \frac{N_{tmy}}{N_{my}} \right) \right] \quad (\text{Equation 21})$$

$$EFNOx_{my} = \sum_{t=1}^T \left[ I_{tmy} * FNOx_{tmy} * \left( \frac{N_{tmy}}{N_{my}} \right) \right] \quad (\text{Equation 22})$$

$$EFPM_{my} = \sum_{t=1}^T \left[ I_{tmy} * FPM_{tmy} * \left( \frac{N_{tmy}}{N_{my}} \right) \right] \quad (\text{Equation 23})$$

Where

- $T$ : fuel type (gasoline, diesel, ethanol)
- $I_{tmy}$ : fuel consumption for each fuel type  $t$  in year  $y$  [liters/km]
- $FCO_{tmy}$ : CO emission factor for fuel  $t$  [gr/liter]
- $FHC_{tmy}$ : HC emission factor for fuel  $t$  [gr/liter]
- $FNOx_{tmy}$ : NO<sub>x</sub> emission factor for fuel  $t$  [gr/liter]
- $FPM_{tmy}$ : PM emission factor for fuel  $t$  [gr/liter]
- $N_{tys}$ : Number of vehicles of fuel type  $t$  in mode  $m$  year  $y$
- $N_{my}$ : Number of vehicles in mode  $m$  year  $y$

<sup>27</sup> Construction activities in the transportation system, even those not considered in the plan, will affect the overall transport activity. As indicated in the MRV section, the monitoring will be done at the city level; it will not be limited to the projects included in the integral mobility plan.

Emission factors should reflect fleet characteristics (age), driving practices, presence of congestion and local weather conditions. Emission factors for monitoring may differ from those used in setting the plan goals.

### **2.5.2. Reporting**

At the city level reporting could be assigned to a joint committee of transport and environment agencies, which will generate annual report. City reports will be collected and reviewed by a designated national authority which will be in charge of reporting to the UNFCCC.

The annual report may include the following sections:

- Status of the integral mobility plan (advances)
- Monitoring data inputs (see Table 2)
  - Socio-economic characteristics
  - Annual Survey
  - Inputs for Emission Factors
  - Construction emissions
  - Control data (fuel sales, air quality network data)
- GHGs emissions
- Co-benefits
- Analysis as compared with plan
- Recommendations for further development

Funding for data collection and analysis should be assigned accordingly. Development of technical capacity to conduct the required studies and complete the reports may be considered as part of the overall plan.

### **2.5.3. Verification**

Verification can have two aspects: review of the quality of the data collection and analysis efforts, and contrast of the reports with secondary data (e.g. air quality data, fuel sales). Independent peer review of the reports is suggested as well as quality assurance certification for the reporting process (e.g. ISO 9001-2000<sup>28</sup>).

## **2.6. Risk Analysis**

Risks have two dimensions: plan implementation and monitoring, reporting and verification processes. Plan implementation depends on the local political agenda, solving natural resistance of affected parties (e.g. existing transit providers, community in the area of influence of terminals, businesses during

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<sup>28</sup> [http://www.iso.org/iso/iso\\_catalogue/management\\_standards/iso\\_9000\\_iso\\_14000.htm](http://www.iso.org/iso/iso_catalogue/management_standards/iso_9000_iso_14000.htm)

construction, etc.) and funding availability. Political and community risks can be mitigated through adequate community involvement. Funding risks can be solved through proactive involvement of other levels of government and seeking international financial flows (grants and loans by national and international funding agencies).

The monitoring, reporting and verification process is subject to problems in data collection, modeling and lack of technical expertise on data analysis. These risks can be mitigated with formalization and standardization of the procedures, and quality assurance (ISO certification).

## 2.8. Financing

An integral urban mobility plan may involve funding from several sources: local (public and private), state, national, and international (grants, loans, including development agencies). Climate funds (grants, concessional loans) can support the project as an addition to other funding sources. We suggest estimating the size of the climate funds as a direct multiplier of the expected emission reductions:

$$CLFD_s = \sum_{y=1}^Y (GHG_{y1} - GHG_{ys}) * ERC * FX * \frac{1}{(1+DR)^y} \quad (\text{Equation 24})^{29}$$

Where

- $CLFD_s$ : Climate change funding [monetary units]
- $GHG_{y1}$ : Baseline GHG emissions in year  $y$  (emissions without the NAMA funded plan, including natural growth of the city)
- $GHG_{ys}$ : Scenario  $s$  GHG emissions in year  $y$  (emissions with the NAMA funded plan, including natural growth of the city)
- $ERC$ : Emission reduction certificate market value (e.g. 13.02 Euro per ton CO<sub>2</sub>eq according to <http://www.ecx.eu/> April 15, 2010)
- $FX$ : Multiplier factor, to be defined on a country basis as part of the negotiation of the overall funding package (e.g. 2, as the emission reductions are not offsets of committed emissions in Annex 1 countries)<sup>30</sup>
- $DR$ : Annual discount rate (e.g. 12%)
- $Y$ : Period of performance (e.g. lifecycle of the infrastructure)

<sup>29</sup> Note that the equation involves the cumulative effect of emission reductions during the defined horizon. As a result it reflects the impact of different components of the plan that may have different implementation periods

<sup>30</sup> We consider that the supported NAMAs contribute to mitigation efforts of developing countries. They are not intended as a means for the developed countries to achieve their own mitigation targets. The suggested factor of two times the market prize of emission reduction certificates may be perceived as arbitrary, but actually, if defined up front, may provide a reasonable expectation and a transparent basis for the negotiation of funding.

The idea behind this concept is having the climate funding depending only on the target GHG mitigation efforts, not the size of the capital investments. We expect the climate funding to be a relatively small percentage of the overall funding package.

We suggest providing the funds up-front to support the capital investments required under the plan. We also recommend discounting the revenue from future emissions at a predefined discount rate -financial equivalent of bringing the revenue up-front. This also incentivizes activities that start reducing emissions in the short term

Under this scheme it is also recommended to create bonuses and penalties if the plan results in greater/smaller reductions than the ones committed. The monitoring, reporting and verification mechanism can be used to incorporate into the funding agreement such bonuses and penalties.

$$BOPE_y = [(GHG_{y1} - GHG_{yr}) - (GHG_{y1} - GHG_{ys})] * ERC * FX \quad (\text{Equation 23})$$

$$BOPE_y = (GHG_{ys} - GHG_{yr}) * ERC * FX \quad (\text{Equation 24})$$

Where

- $BOPE_y$ : Bonus or penalty in year  $y$
- $GHG_{ys}$ : GHG emissions reductions committed in year  $y$
- $GHG_{yr}$ : GHG emissions verified in year  $y$
- $ERC$ : Emission reduction certificate market value agreed in the negotiation of the overall funding package (e.g. 11.98 Euro per ton CO<sub>2</sub>eq according to <http://www.ecx.eu/> January 25, 2010)
- $FX$ : Multiplier factor, agreed in the negotiation of the overall funding package (e.g. 2, as the emission reductions are not offsets of committed emissions in Annex 1 countries, they correspond to supported commitments by developing countries)

For the management of the bonus and penalties it is suggested to create a trust fund with initial seed capital equivalent to a given percentage of the climate change funding. In case the GHG reductions are greater than the initial estimation, the funds deposited in the trust fund will be used to pay the bonus to the municipality. In case the GHG reductions are smaller than the initial estimation, the municipality will be required to make the deposit in the trust fund, and the initial seed capital can go to the funder plus the interest gained. Funds deposited in the trust fund by the municipality can be recovered by achieving greater reductions in subsequent years.<sup>31</sup>

<sup>31</sup> This is a preliminary proposal that needs further discussion and assessment of its actual feasibility. Alternatively, it is proposed that a percentage (i.e. 20%) of the CLFD be deposited in



It is important to indicate that adequate assessment of the CO<sub>2</sub>eq emission reductions and co-benefits of the plan can help in obtaining the required support from other levels of government and other funding agencies (barrier removal potential).

## 2.9. Institutional Frameworks

The development of an integral mobility plan requires the coordination of several activities within the municipality, and with other levels of government. The main activities are introduced in Table 3. Each activity has a single agent responsible for execution and multiple agents responsible for oversight (in support of the head of government), as well as multiple external stakeholders.

**Table 3 – Overall Institutional Framework**

Activity	Responsible for Execution	Responsible for Oversight	External Stakeholders
Planning	Transport Agency in coordination with Urban and Regional Planning Agency	<ul style="list-style-type: none"> <li>• Head of Government</li> <li>• Finance Agency</li> <li>• Environmental Agency</li> </ul>	<ul style="list-style-type: none"> <li>• Surrounding municipalities</li> <li>• State Government</li> <li>• Community at large</li> <li>• National Financing Institutions</li> <li>• International Financing Institutions</li> <li>• Community at large</li> <li>• Private transit operators</li> </ul>
Funding	Finance Agency	<ul style="list-style-type: none"> <li>• Head of Government</li> </ul>	
Project Development	Transport Agency	<ul style="list-style-type: none"> <li>• Head of Government</li> <li>• Urban and Regional Planning Agency</li> <li>• Finance Agency</li> <li>• Environmental Agency</li> </ul>	
Monitoring and Reporting	Urban and Regional Planning Agency	<ul style="list-style-type: none"> <li>• Head of Government</li> <li>• Finance Agency</li> <li>• Environmental Agency</li> </ul>	
Verification	External agent		

## 3. APPLICATION OF THE NAMA FRAMEWORK TO A MIDSIZE BRAZILIAN CITY (AN EXAMPLE)

In this section we use the NAMA framework developed in section 2 to a midsize Brazilian city in order to test its general applicability. We make several assumptions and use factors extracted from available literature, which may need review and calibration for the local conditions. In addition we recognize the intrinsic uncertainty of predictions and modeling. We consider that our preliminary calculation is subject to several improvements that go beyond the

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the trust fund as well, and not the full amount be paid up-front. In this case, the municipality will receive, at the end of the period, the remainder of the CLFD, adjusted by a penalty or a bonus.

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scope of this study; nevertheless it is very useful in understanding the data requirements and practical implementation issues.

### 3.1. Selected City

EMBARQ surveyed a series of mid-size cities in Brazil and found a good opportunity for developing the model NAMA on Integral Urban Mobility for the city of Belo Horizonte. Belo Horizonte is the capital of the state of Minas Gerais and is located in the southeastern region of Brazil. It is the third-largest metropolitan area in the country. Belo Horizonte has a population of over 2.4 million, with almost 5.4 million in the official Metropolitan Area.<sup>32</sup>

Belo Horizonte is currently developing a Comprehensive Mobility Plan – “planmobBH”<sup>33</sup>, under the new requirements established by the Ministry of Cities. The Plan summarizes the results of extensive transport data collection and modeling efforts which compare different urban mobility scenarios for the City. The indicators used in the “planmobBH” to compare the impact of the proposed scenarios include standard transport planning concepts and are limited to modal distribution (i.e. percent of travelers in each mode), travel speeds (as an easy-to-grasp surrogate of travel times, where faster speeds are better than lower speeds) and congestion levels (as an easy-to-grasp surrogate of economic efficiency, where less congestion is better than more congestion).

The proposed NAMA framework provides the tools to expand the impact assessment of the proposed plans, to quantify the greenhouse gas reductions, travel time savings, travel cost savings and air pollutant emission reductions expected from the different development scenarios which include various combinations of public transport investment and travel demand management policies.

### 3.2. Sample Policy Objective for the Belo Horizonte NAMA

The NAMA for integral urban mobility seeks an increase in active and public transport shares of total trips, to generate reductions in GHG emissions from urban transport and to improve transport conditions and the local environment. The NAMA seeks to avoid unnecessary or very long motorized trips, shift passenger and cargo movements to more efficient modes, and improve the energy efficiency of the vehicle fleet. Actions under the plan are also expected to increase the city competitiveness, the population’s health and the quality of life in the city. Specific Goals are presented in Table 4.

<sup>32</sup> [http://en.wikipedia.org/wiki/Belo\\_Horizonte](http://en.wikipedia.org/wiki/Belo_Horizonte)

<sup>33</sup> Logit, BHTRANS, Prefeitura de Belo Horizonte “Plano de Mobilidade Urbana de Belo Horizonte: Diagnóstico, Cenários e Resultados”, October 2009.

**Table 4 – Policy Targets Regarding Modal Shares, GHG, Travel Time, Travel Cost and Particulate Matter**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
<b>Modal Share Bicycle</b>													
Baseline	0.0%	0.03%	0.05%	0.08%	0.10%	0.13%	0.15%	0.18%	0.20%	0.23%	0.25%	0.28%	0.30%
Integral Mobility Plan	0.0%	0.5%	1.0%	1.6%	2.1%	2.6%	3.1%	3.6%	4.1%	4.7%	5.2%	5.7%	6.2%
Change	0.0%	0.5%	1.0%	1.5%	2.0%	2.5%	3.0%	3.4%	3.9%	4.4%	4.9%	5.4%	5.9%
<b>Modal Share Public Transport</b>													
Baseline	54.2%	53.7%	53.1%	52.6%	52.1%	51.5%	51.0%	50.5%	49.9%	49.4%	48.9%	48.3%	47.8%
Integral Mobility Plan	54.2%	53.2%	52.2%	51.1%	50.1%	50.1%	50.0%	50.0%	49.9%	49.9%	49.8%	49.8%	49.7%
Change	0.0%	-0.5%	-1.0%	-1.5%	-2.0%	-1.5%	-1.0%	-0.5%	0.0%	0.4%	0.9%	1.4%	1.9%
<b>Modal Share Private Transport</b>													
Baseline	45.8%	46.3%	46.8%	47.3%	47.8%	48.3%	48.9%	49.4%	49.9%	50.4%	50.9%	51.4%	51.9%
Integral Mobility Plan	45.8%	46.3%	46.8%	47.3%	47.8%	47.4%	46.9%	46.4%	46.0%	45.5%	45.0%	44.6%	44.1%
Change	0.0%	0.0%	0.0%	0.0%	0.0%	-1.0%	-2.0%	-2.9%	-3.9%	-4.9%	-5.9%	-6.8%	-7.8%
<b>GHG Emissions (thousand tons CO<sub>2</sub>eq / year)</b>													
Baseline	1,315	1,375	1,432	1,489	1,546	1,604	1,661	1,718	1,775	1,833	1,897	1,954	2,010
Integral Mobility Plan	1,315	1,473	1,577	1,678	1,868	1,704	1,650	1,595	1,540	1,632	1,578	1,523	1,468
Change	0.0%	7.1%	10.2%	12.7%	20.8%	6.3%	-0.7%	-7.2%	-13.2%	-10.9%	-16.8%	-22.0%	-26.9%
<b>Travel Time (million hours / year)</b>													
Baseline	989	1,025	1,061	1,098	1,137	1,176	1,216	1,257	1,299	1,342	1,385	1,430	1,476
Integral Mobility Plan	989	1,072	1,158	1,247	1,340	1,313	1,287	1,260	1,234	1,208	1,182	1,157	1,131
Change	0.0%	4.6%	9.1%	13.5%	17.9%	11.7%	5.8%	0.3%	-5.0%	-10.0%	-14.7%	-19.1%	-23.3%
<b>Travel Cost (USD million hours / year)</b>													
Baseline	1,564	1,612	1,660	1,710	1,760	1,811	1,863	1,916	1,969	2,024	2,079	2,135	2,192
Integral Mobility Plan	1,564	1,687	1,815	1,946	2,082	2,046	2,010	1,974	1,938	1,902	1,866	1,831	1,795
Change	0.0%	4.7%	9.3%	13.8%	18.3%	13.0%	7.9%	3.0%	-1.6%	-6.0%	-10.2%	-14.3%	-18.1%
<b>Particulate Matter PM (ton/year)</b>													
Baseline	171	179	186	194	201	208	216	223	231	238	246	253	260
Integral Mobility Plan	171	180	189	198	212	205	199	192	185	178	172	165	158
Change	0.0%	0.8%	1.6%	2.3%	5.5%	-1.5%	-8.0%	-14.1%	-19.8%	-25.1%	-30.1%	-34.9%	-39.3%

Source: Modal shift from extracted from “Plano de Mobilidade Urbana de Belo Horizonte: Diagnóstico, Cenários e Resultados”, Prefeitura de Belo Horizonte, BHTRANS, prepared by Logit, October 2009. Calculations GHG Appendix C and Cobenefits Appendix D.

**Table 4 – Policy Targets Regarding Modal Shares, GHG, Travel Time, Travel Cost and Particulate Matter (cont.)**

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Modal Share Bicycle</b>										
Baseline	0.33%	0.35%	0.38%	0.40%	0.43%	0.45%	0.48%	0.50%	0.52%	0.5%
Integral Mobility Plan	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%	6.2%
Change	5.9%	5.9%	5.8%	5.8%	5.8%	5.8%	5.7%	5.7%	5.7%	5.7%
<b>Modal Share Public Transport</b>										
Baseline	47.3%	46.7%	46.2%	45.7%	45.1%	44.6%	44.1%	43.5%	43.0%	42.5%
Integral Mobility Plan	49.7%	49.7%	49.7%	49.7%	49.7%	49.7%	49.7%	49.7%	49.7%	49.7%
Change	2.4%	3.0%	3.5%	4.0%	4.6%	5.1%	5.6%	6.2%	6.7%	7.2%
<b>Modal Share Private Transport</b>										
Baseline	52.4%	52.9%	53.4%	53.9%	54.4%	55.0%	55.5%	56.0%	56.5%	57.0%
Integral Mobility Plan	44.1%	44.1%	44.1%	44.1%	44.1%	44.1%	44.1%	44.1%	44.1%	44.1%
Change	-8.3%	-8.8%	-9.3%	-9.8%	-10.3%	-10.9%	-11.4%	-11.9%	-12.4%	-12.9%
<b>GHG Emissions (thousand tons CO<sub>2</sub>eq / year)</b>										
Baseline	2,059	2,116	2,174	2,231	2,288	2,345	2,403	2,460	2,517	2,575
Integral Mobility Plan	1,354	1,387	1,420	1,453	1,486	1,519	1,552	1,585	1,618	1,651
Change	-34.2%	-34.5%	-34.7%	-34.9%	-35.1%	-35.3%	-35.4%	-35.6%	-35.7%	-35.9%
<b>Travel Time (million hours / year)</b>										
Baseline	1,522	1,569	1,618	1,667	1,717	1,768	1,820	1,873	1,926	1,981
Integral Mobility Plan	1,164	1,197	1,231	1,265	1,300	1,336	1,372	1,409	1,446	1,484
Change	-23.5%	-23.7%	-23.9%	-24.1%	-24.3%	-24.4%	-24.6%	-24.8%	-24.9%	-25.1%
<b>Travel Cost (USD million hours / year)</b>										
Baseline	2,250	2,308	2,368	2,428	2,489	2,551	2,614	2,678	2,742	2,807
Integral Mobility Plan	1,841	1,888	1,936	1,984	2,033	2,082	2,132	2,183	2,234	2,286
Change	-18.1%	-18.2%	-18.2%	-18.3%	-18.3%	-18.4%	-18.4%	-18.5%	-18.5%	-18.6%
<b>Particulate Matter PM (ton/year)</b>										
Baseline	268	275	283	290	298	305	312	320	327	335
Integral Mobility Plan	162	167	171	176	180	185	189	194	198	203
Change	-39.3%	-39.3%	-39.4%	-39.4%	-39.4%	-39.4%	-39.4%	-39.4%	-39.4%	-39.4%

By 2020 the integral mobility plan seeks reductions of 27% in GHG, 23% in travel time, 18% in transport costs, and 40% in particulate matter. By 2030 the expected reductions are 36% in GHG, 25% in travel time, 19% in transport costs and 39% in particulate matter.

### 3.3. Sample Description of the NAMA

The proposed NAMA on integrated urban mobility includes enhancement of public transport (BRT and Metro), metropolitan fare integration, construction of infrastructure and promotion of non-motorized transportation (NMT) (walking and cycling), and combined land use and parking policies. Table 5 describes the types of activities and the physical goals.

**Table 5 – NAMA Integral Urban Mobility Plan**

<b>Component</b>	<b>Committed Investments (Base Line) Current Budget</b>	<b>Complete Development (BRT + Metro 1, 2, 3)</b>
Roadways Improvements	Limited Interventions VIURBS	Complete interventions in VIURBS and Central Area Plan
Bus Rapid Transit Implementation	9 corridors with reserved bus-lanes only	9 corridors with full BRT and 6 corridors with reserved bus-lanes
Metro Expansion	Headway reduction to 4 minutes and train expansion to 6 cars in Line 1. New Metro Station	All lines with 4 min headways. Expansion L1, L2, L3
Integration	12 Integration stations including 2 metropolitan stations	All integration stations, 5 connections
Bicycle Infrastructure	110 Km bikeways	365 Km bikeways
Pedestrian Facilities	Improved sidewalks in downtown and the 9 corridors with bus-lanes	Improved connections in downtown, sub-centers and BRT corridors
Land Use	No action	Transit Oriented Development regulations along transit corridors
Parking Policies	No action	Increase in median daily parking charges in Central area to R\$15,00/dia

Source: "Plano de Mobilidade Urbana de Belo Horizonte: Diagnóstico, Cenários e Resultados", Prefeitura de Belo Horizonte, BHTRANS, prepared by Logit, October 2009.

### 3.4. Travel Demand Data

Data for 2008, 2012 and 2020 are the result from the travel demand modeling completed for the “planmobBH” process<sup>34</sup>. Data for the years between the 2008 and 2020 was generated by a linear interpolation. We extrapolate the data to year 2030, by assuming that the modal shares remain constant and the VKT grows at a vegetative rate. Travel demand data assumptions are presented in Appendix A.

The transport mode categories used in the analysis are private transport, which includes only automobiles, and public transport which includes both the existing municipal bus system and the new BRT corridors. Outputs of the model include travel time and vehicle kilometers travel for each transport mode. Outputs are presented in Appendix A (Travel Demand),

In the integral mobility scenario year 2012, overall VKT is expected to exceed VKT in the baseline year 2012, while by year 2020, the urban mobility scenario will reduce overall VKT. A summary of VKT for the baseline and urban mobility scenario is presented in Appendix A Travel Data.

### 3.5. Greenhouse Gas Emission Reductions

Estimates of the greenhouse gas emissions were made for each of the baseline and integral mobility scenario years, from 2008 to 2030, for private and public transport (Table 4). The net cumulative GHG emission savings over the 22 year period 2008-2030 will be 9 million CO<sub>2</sub>eq Tons. Note that during the first years there is an increase in emissions due to construction of infrastructure and increased VKT.

Automobiles in Brazil use gasoline, alcohol and flex fuels which are a mix of gasoline and alcohol. According to a 2006 GHG emissions inventory report by the National Ministry of Science and Technology, 67% of the automobile fleet utilizes gasoline and 33% alcohol. Public transport vehicles on the other hand use diesel almost exclusively. Belo Horizonte’s current fleet were assumed to be Euro 3 buses using D500 diesel, while BRT buses were assumed to be Euro 3 running on S50 diesel since a 2009 law requires all Brazilian cities to supply diesel 50ppm sulfur.

The emission factor per kilometer was calculated for each fuel type and each mode. For private transport, a gasoline and alcohol emission factor (g/km) was

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<sup>34</sup> “Plano de Mobilidade Urbana de Belo Horizonte: Diagnóstico, Cenários e Resultados”, Prefeitura de Belo Horizonte, BHTRANS, prepared by Logit, October 2009.

derived, while for public transport and BRT only the diesel emission factor (g/km) was calculated. As per Equation 2, the emission factors were calculated based on the fuel consumption (l/km) of each fuel type, GHG emission factors for each fuel type (g/l), proportion of vehicles utilizing the fuel and an upstream emission factor which accounts for production and transport of the fuel.

We used Brazilian fuel consumption and fuel type emission when available. In some cases default factors were sourced from the Clean Development Mechanism's Approved Methodology AM0031 which incorporated IPCC factors. A default upstream emissions factor of 14% was used for all fuel types<sup>35</sup>. The inputs and resulting emission factors are presented in Appendix B Emission Factors.

In the base year 2008, the greenhouse gas emissions for each mode of transport are the product of the emission factor and the vehicle kilometers traveled (VKT) for that mode.

In future years, the greenhouse gas emissions also include construction emissions from the construction of bus lanes, BRT corridors, rail corridors, bike lanes and bus manufacturing. The model does not include estimates for emissions attributed to rail car manufacturing nor bus scrapping. The overall construction emissions per year were estimated based on assumptions about the phased implementation of transportation infrastructure and default construction quantities and emission factors.

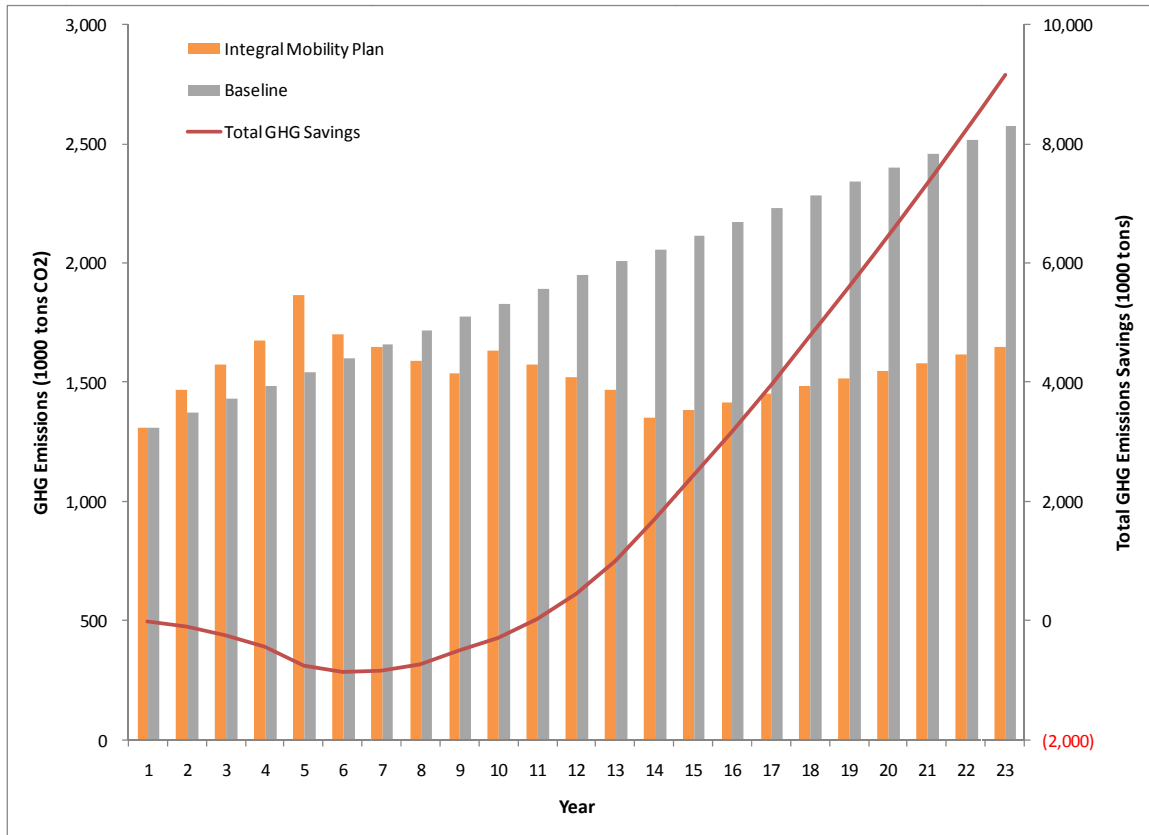
In the baseline (business as usual) scenario, the bus fleet is expected to grow by 726 buses between 2008 and 2030 and 14 kms of new bus lanes will be constructed. Alternatively, in the urban mobility scenario, new bus lanes, BRT trunk lanes, rail lines and bike lanes were constructed in two phases – leading up to 2012 (year 5) and again leading up to the final year 2020. 1386 new BRT buses will need to be manufactured by year 5 while 693 of the vehicles will be scrapped by 2020 since the BRT fleet is reduced as the new Metro lines become operational. The assumptions and inputs to the construction emission estimates are presented in Appendix B Emission Factors

We estimate the GHG emissions (tons CO<sub>2</sub>eq) for each year in the baseline and for the integral mobility scenario. By the final year 2030, the urban mobility scenario will save an estimated 1 million tons CO<sub>2</sub>eq as compared to the baseline. Figure 1 presents the estimates of the GHGs emissions in the integral mobility scenario relative to the baseline. By 2030, the urban mobility scenario achieves a cumulative GHG savings of 9 million tons of CO<sub>2</sub>eq.

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<sup>35</sup> Clean Development Mechanism, Approved Methodology AM0031 suggests a default factor of 14% to account for fuel production and transport.

**Figure 1: Estimated GHG Emissions and Savings Compared to Baseline**



### 3.6. Co-Benefits

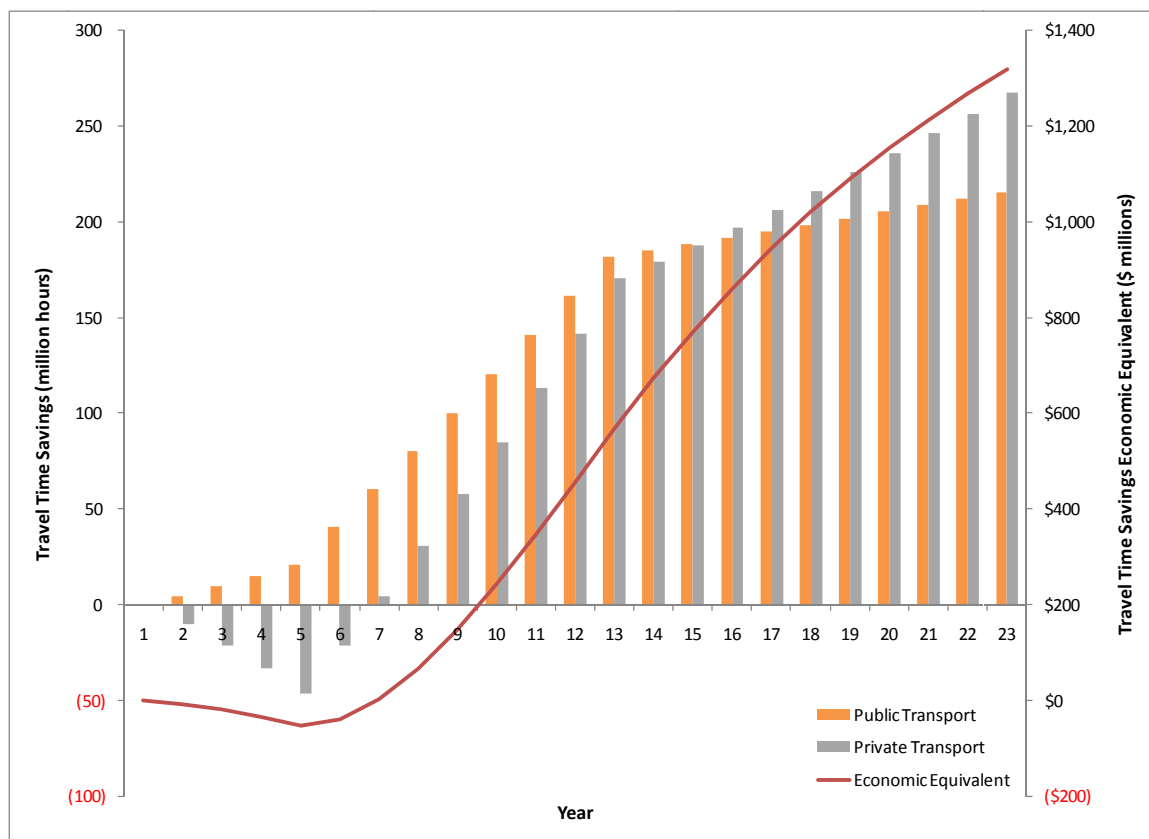
We estimate the potential of the integral mobility plan to reduce travel time, travel costs and emissions of air pollutants. Further analysis could explore the impact on public health and safety with respect to the number of accidents and amount of physical activity by the population, among other co-benefits.

#### 3.6.1. Travel Time Savings

The planmobBH transport modeling process provides the inputs needed to calculate travel times savings realized under the integral mobility scenario: total number of trips and average travel time for private and public transport including BRT. For each mode, the number of morning peak hour trips was transformed into an estimate of annual trips. The travel time for private transport includes in-vehicle time, while for public transport modes it includes walking, waiting and in-vehicle time.

For each year in the integral mobility scenario, the travel time savings compared to the corresponding baseline year was calculated. As seen in Figure 2, during the first few years the travel time savings for private transport is negative (travel times are longer compared to the baseline) as increasing VKT causes increased congestion. Once trips are shifted from private to public transport in 2012 with the introduction of the first BRT corridors, there is a net positive travel time savings for private transport. The results indicate increasing travel time savings for public transport from 2008 to 2020. In the final year there is an estimated travel time savings of 182 million hours for public transport and 170 million hours for private transport.

**Figure 2: Travel Time Savings**



An estimate of the economic value of the travel time savings achieved by the integral mobility scenario was calculated using a value of time of \$1.41/hour and a socio-economic annual discount rate of 12%. The value of time was approximated as one half of the average hourly Brazilian wage. By year 2030 of the integral mobility scenario, the economic equivalent of the travel time savings is nearly \$1,300 million.



### 3.6.2. Travel Cost

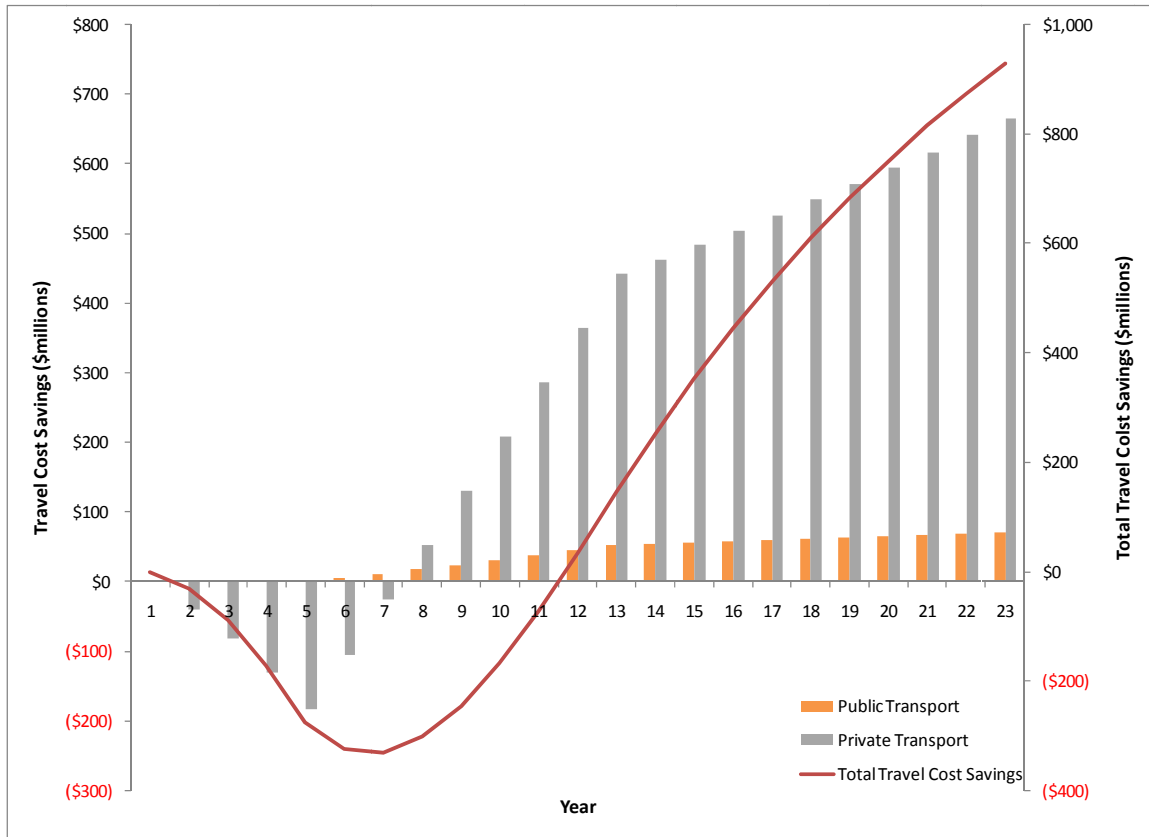
Calculating the total travel cost savings of the integral mobility scenario compared to the baseline required total trips and an average travel cost by mode.

The National Association of Urban Transport Brazil reports \$2.72 travel cost for public transport, but this value includes the cost of capital. The marginal cost per km excluding capital was estimated as half of \$2.72. Estimates of projected costs for future years were made based upon the VKT for that year and a factor to account for congestion (higher VKT results in more congestion which increases the public transport operational costs due to higher fuel consumption and increased labor costs related to the larger fleet).

In the baseline year 2008, average travel costs of \$0.41 for private transport and \$1.36 for public transport are used. The projected travel costs for each year in the baseline and scenario are available in Appendix A Travel Data.

The travel cost savings per mode per year are presented in Figure 3. In the integral mobility scenario, after initial losses prior to the 2012 public transport investments, by year 2030 both private and public transport users benefit from travel cost savings resulting from reduced congestion and increased system efficiency. By the 2030, the economic value of the cumulative travel cost savings achieved by the integral mobility scenario exceeds \$900 million in present value at a discount rate of 12%.

**Figure 3: Travel Cost Savings**



### 3.6.3. Air Pollutant Emissions

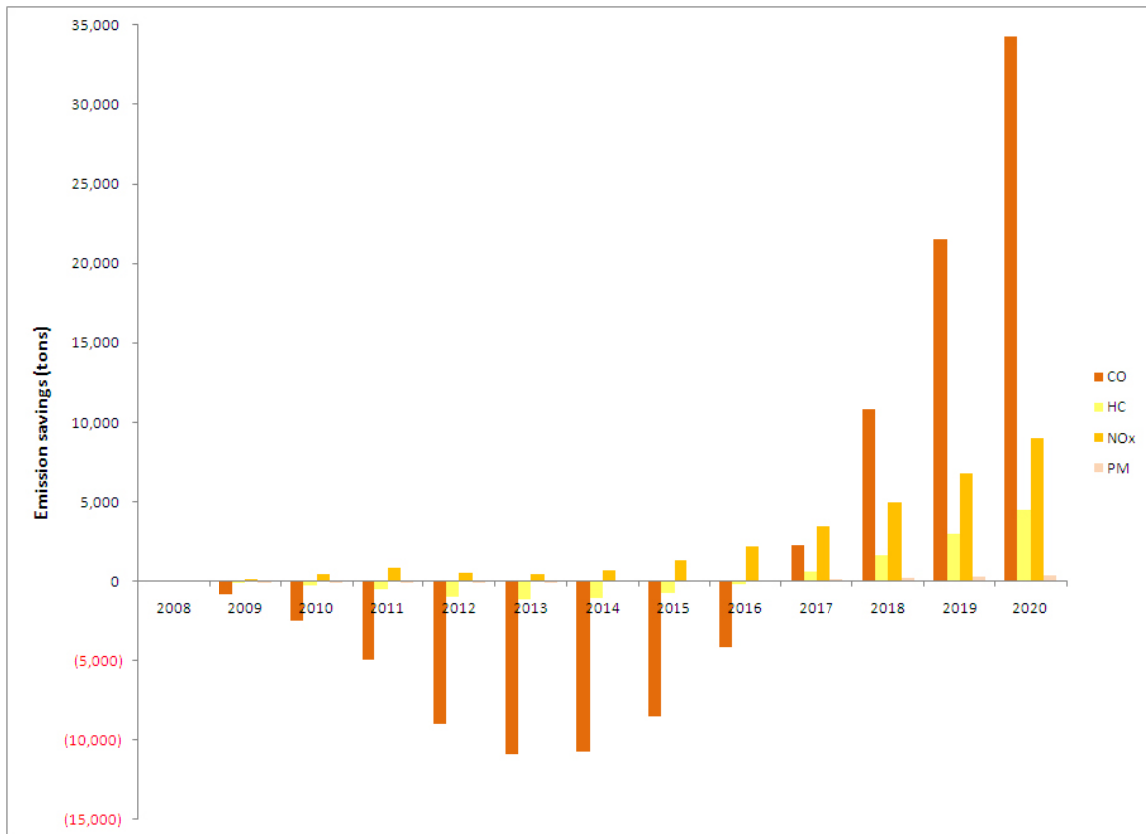
Based on the vehicle-km and using emission factors, it is possible to estimate criteria pollutant emissions for the baseline and integral mobility scenarios. The relative differences in Carbon Monoxide (CO), Hydrocarbons (HC), Nitrogen Oxides (NOx) and Particulate Matter (PM) emissions were estimated.

We used the Brazilian fuel consumption (l/km) and fuel type emission factors (g/l) for each mode to calculate the per kilometer emission factor (g/km). Otherwise per kilometer emission factors published in the 2006 National GHG emission inventory or from a World Resources Institute publication, “Measuring the Invisible” were used. Finally if no other data was available, default factors from the Clean Development Mechanism’s Approved Methodology AM0031 which incorporated IPCC factors, were utilized. The inputs and resulting emission factors are presented in Appendix B Emission Factors.

The air pollutant emissions from private and public transport were calculated for each year in the baseline and integral mobility scenarios. The full time series results are presented in Appendix D Co-Benefits.

While the estimation of local emissions has significant uncertainty, the calculated savings of the integral mobility scenario with respect to the baseline scenario indicates that the public transport investment has a positive impact by reducing CO, HC, NOx and PM emissions. The air pollutant emissions savings are presented in Figure 4.

**Figure 4: Air Pollutant Emission Reductions**



We do not calculate economic benefits from the reduced tailpipe emissions. As indicated in the methodology, economic valuation requires detailed modeling and data, which may not be readily available. Appropriate estimation requires area wide air quality modeling to find the level of exposure, health impacts modeling to determine reduced deaths, illnesses, like heart or respiratory disease, limited

activity days or days loss and economic estimation of value of life, illness or work losses<sup>36</sup>.

### 3.6. Financing

The estimated marginal cost of the Integrated Urban Mobility Plan is USD 2.7 billion (Table 6). Monetary units are calculated in present value with a 12% discount rate. The cash flow for 2008-2030 is presented in Table 7, along with the assumptions. Source of information is “planomobBH”<sup>37</sup> and information from consultants developing the plan for the city of Belo Horizonte.

**Table 6. Physical goals and financial cost Baseline and Integral Mobility Plan**

	Baseline	Integral Mobility Plan	Difference
Bikeways (km)	14	300	286
Buslanes (km)	14	72	58
BRT (km)	0	80	80
Metro (km)	29	65	36
Road Investment USD Million	38.4	982.8	944.4
Capital Cost USD Million	1,551.7	4,215.2	2,663.5
Total GHG Emissions (CO <sub>2</sub> eq Ton)	44,775,918	35,624,604	-9,151,315

Total emission savings between 2008 and 2030 are 9 million CO<sub>2</sub>eq ton (Table 6). We use Equation 24 to calculate the potential income from a supported NAMA.

$$CLFD_s = \sum_{y=1}^Y (GHG_{y1} - GHG_{ys}) * ERC * FX * \frac{1}{(1+DR)^y} \quad (\text{Equation 24})$$

Where  $CLFD_s$ : Climate change funding [USD]  
 $GHG_{y1}$ : Baseline GHG emissions in year  $y$  (without the NAMA)  
 $GHG_{ys}$ : Scenario  $s$  GHG emissions in year  $y$  (with the NAMA)

<sup>36</sup> For estimations of health impacts and economic value in urban transport see for example: National Institute of Ecology -INE, Cost-Benefit Analysis: Insurgentes Corridor Mexico City, Mexico, 2007, <http://www.epa.gov/ies/mexico/brt.htm>

<sup>37</sup> Logit, BHTRANS, Prefeitura de Belo Horizonte “Plano de Mobilidade Urbana de Belo Horizonte: Diagnóstico, Cenários e Resultados”, October 2009.

*ERC*: Emission reduction certificate market value (13.02 Euro equivalent to 17.58 USD per ton CO<sub>2</sub>eq according to <http://www.ecx.eu/> April 15, 2010)  
*FX*: Multiplier factor, we assume a value of 2.  
*DR*: Annual discount rate (e.g. 12%)  
*Y*: Period of performance (e.g. lifecycle of the infrastructure 2030)

Total expected income for a supported NAMA with the assumptions provided here is USD 36 Million (1.4% of the marginal cost of the urban mobility plan). While this amount is small as compared with the funding requirements of the plan, it provides very attractive conditions: it will be either a grant or a concessional loan (i.e. with low interest and long repayment period). Having this funding up front is expected to facilitate the plan implementation.

Funding for the Integral Mobility Plan may come from several sources: local, state and federal budgets, credit from commercial and export banks, and loans from multilateral development organizations, among other. Further development of the funding conditions is required, as well as agreements and approvals from the designated agencies in Brazil.

### 3.7. Institutional Frameworks

A suggested assignment of responsibilities at the local level is presented in Table 7. NAMAs from individual cities will be presented, reviewed and approved by the designated national authority (Ministry of the Environment) and submitted to UNFCCC or other internationally defined climate mitigation mechanisms.

**Table 7 – Suggested Assignment of Responsibilities at the City Level**

Activity	Responsible for Execution	Responsible for Oversight	External Stakeholders
Planning	<ul style="list-style-type: none"> <li>Transport Planning Agency – BHTRANS in coordination with the Urban and Regional Planning Agency (Secretaria Municipal de Planejamento, Orçamento e Informação)</li> </ul>	<ul style="list-style-type: none"> <li>Head of Government (Prefeito Municipal de BH)</li> <li>Finance Agency (Secretaria Municipal de Finanças)</li> <li>Environmental Agency (Secretaria Municipal de Meio Ambiente)</li> </ul>	<ul style="list-style-type: none"> <li>Surrounding municipalities</li> <li>State Government</li> <li>Community at large</li> <li>National Financing Institutions</li> <li>International Financing Institutions</li> <li>Community at large</li> <li>Private transit operators</li> </ul>
Funding	Finance Agency - Secretaria Municipal de Finanças	<ul style="list-style-type: none"> <li>Head of Government (Prefeito Municipal de BH)</li> </ul>	

Activity	Responsible for Execution	Responsible for Oversight	External Stakeholders
Project Development	Transport Agency - BHTrans	<ul style="list-style-type: none"> <li>• Head of Government (Prefeito Municipal de BH)</li> <li>• Urban and Regional Planning Agency (Secretaria Municipal de Planejamento, Orçamento e Informação)</li> <li>• Finance Agency (Secretaria Municipal de Finanças)</li> <li>• Environmental Agency (Secretaria Municipal de Meio Ambiente)</li> </ul>	
Monitoring and Reporting	Urban and Regional Planning Agency – Secretaria Municipal de Planejamento, Orçamento e Informação	<ul style="list-style-type: none"> <li>• Head of Government (Prefeito Municipal de BH)</li> <li>• Finance Agency (Secretaria Municipal de Finanças)</li> <li>• Environmental Agency (Secretaria Municipal de Meio Ambiente)</li> </ul>	
Verification	External agent	Ministry of the Environment UNFCCC	

The international mechanism for registration, financing, reporting, monitoring and verification for NAMAs is expected to be an evolution of the current UNFCCC procedures, under the considerations of the Copenhagen Agreement of December 2009. These mechanisms are expected to be defined and refined by the Conference of the Parties COP 16 in December 2010 in Mexico,

#### 4. SCALE UP FOR A NATIONAL PROGRAM ON SUSTAINABLE AND LOW CARBON URBAN MOBILITY

Brazil has 40 cities with more than 500,000 inhabitants and an aggregated population of 57 million (see Table 8). Using the reductions per capita estimated for Belo Horizonte<sup>38</sup> it is possible to extrapolate potential GHGs reductions of 1.4 - 10.1 million ton of CO<sub>2</sub>eq (low investment to high investment).

A suggested process to scale up the local urban mobility plan to a national strategy is:

1. Create a mechanism to support integral mobility plans based on adequate transport planning practices (data collection, modeling, impact estimation). The estimated cost of appropriate urban transport planning studies is in

<sup>38</sup> Low 0.025 Ton/person/year, Medium 0.101 Ton/person/year, High 0.176 Ton/person/year

the range of USD 0.5 to 1.0 million per city. Total cost for 40 cities is in the range of USD 20 to 40 million.

2. Estimate the impacts of the integral urban mobility plans on GHGs reductions and co-benefits (using the proposed methodology or an improved adaptation).
3. Expand existing funding facilities to support a national program to develop sustainable, low carbon integral mobility plans. Required total investments are in the order of USD 6,300 to 63,000 million. The support required from climate instruments is estimated in the range of USD 110 – 860 million<sup>39</sup>.
4. Define the national monitoring, reporting, and verification framework, including a mechanism to provide bonuses and penalties for actual/verified increased/reduced emissions when compared to estimated values

**Table 8 – List of Brazilian Cities and GHG Mitigation Potential from Urban Transport (CO<sub>2</sub>eqTon/year)**

Rank	City	State	Population 2009	Low	Medium	High
1	São Paulo	São Paulo	11,037,593	270,884	1,109,512	1,948,109
2	Rio de Janeiro	Rio de Janeiro	6,186,710	151,834	621,896	1,091,939
3	Salvador	Bahia	2,998,056	73,578	301,368	529,150
4	Brasília	Distrito Federal	2,606,885	63,978	262,047	460,109
5	Fortaleza	Ceará	2,505,552	61,491	251,861	442,224
6	Belo Horizonte	Minas Gerais	2,452,617	60,192	246,540	432,881
7	Curitiba	Paraná	1,851,215	45,432	186,086	326,735
8	Manaus	Amazonas	1,738,641	42,670	174,770	306,866
9	Recife	Pernambuco	1,561,659	38,326	156,980	275,629
10	Belém	Pará	1,437,600	35,282	144,509	253,733
11	Porto Alegre	Rio Grande do Sul	1,436,123	35,245	144,361	253,472
12	Guarulhos	São Paulo	1,299,283	31,887	130,605	229,320

<sup>39</sup> Ranges are proportional to the values obtained for Belo Horizonte. Total capital cost divided by the population of Belo Horizonte, multiplied by the population of the 40 largest Brazilian cities. Total revenue from climate instruments divided by the population of Belo Horizonte multiplied by the population of the 40 largest Brazilian cities. Low level estimated as a proportion of high investment (divided by 10 in the case of capital cost, divided by 8 in the case of climate instruments). Numbers provided as a general reference, further analysis recommended.

Rank	City	State	Population 2009	Low	Medium	High
13	Goiânia	Goiás	1,281,975	31,462	128,866	226,266
14	Campinas	São Paulo	1,064,669	26,129	107,022	187,912
15	São Luís	Maranhão	997,098	24,471	100,229	175,985
16	São Gonçalo	Rio de Janeiro	991,382	24,330	99,655	174,977
17	Maceió	Alagoas	936,314	22,979	94,119	165,257
18	Duque de Caxias	Rio de Janeiro	872,762	21,419	87,731	154,040
19	Nova Iguaçu	Rio de Janeiro	865,089	21,231	86,960	152,686
20	São Bernardo do Campo	São Paulo	810,979	19,903	81,521	143,136
21	Natal	Rio Grande do Norte	806,203	19,786	81,040	142,293
22	Teresina	Piauí	802,537	19,696	80,672	141,646
23	Campo Grande	Mato Grosso do Sul	755,107	18,532	75,904	133,275
24	Osasco	São Paulo	718,646	17,637	72,239	126,839
25	João Pessoa	Paraíba	702,235	17,234	70,590	123,943
26	Jaboatão dos Guararapes	Pernambuco	687,688	16,877	69,127	121,375
27	Santo André	São Paulo	673,396	16,526	67,691	118,853
28	Uberlândia	Minas Gerais	634,345	15,568	63,765	111,960
29	Contagem	Minas Gerais	625,393	15,348	62,865	110,380
30	São José dos Campos	São Paulo	615,871	15,115	61,908	108,700
31	Feira de Santana	Bahia	591,707	14,522	59,479	104,435
32	Sorocaba	São Paulo	584,313	14,340	58,736	103,130
33	Ribeirão Preto	São Paulo	563,107	13,820	56,604	99,387
34	Cuiabá	Mato Grosso	550,562	13,512	55,343	97,173
35	Aracaju	Sergipe	544,039	13,352	54,687	96,022
36	Juiz de Fora	Minas Gerais	526,706	12,926	52,945	92,962
37	Aparecida de Goiânia	Goiás	510,770	12,535	51,343	90,150
38	Londrina	Paraná	510,707	12,534	51,337	90,139
39	Ananindeua	Pará	505,512	12,406	50,815	89,222
40	Belford Roxo	Rio de Janeiro	501,544	12,309	50,416	88,521
		<b>Total</b>	<b>57,342,590</b>	<b>1,407,299</b>	<b>5,764,146</b>	<b>10,120,829</b>

Source: Population data from Instituto Brasileiro de Geografia y Estadística (IBGE) Calculations by the authors.



## CONCLUSIONS

We develop a framework for the presentation of Nationally Appropriate Mitigation Actions for Integrated Urban Mobility. The framework is intended for “Supported NAMAs”, that is actions that are supported by developed countries and are likely to be supported by fund-type instruments. The framework provides guidance on the content of different sections:

- Policy Objective
- Description of the NAMA
- Greenhouse Gas Emission Reductions Targets
- Estimation of co-benefits
- Methodology for Monitoring, Reporting and Verification
- Risk Analysis
- Financing
- Institutional Settings

The framework provides a detailed methodology to define the targets regarding GHG remissions and Co-benefits (travel time, transport cost, air pollutant emissions). The methodology uses a bottom up approach, based on estimated activity and emission factors. The methodology extensively uses urban transport models to get define activity and relies on external information on emission factors.

The framework also proposes a monitoring, reporting and verification scheme, based on annual surveys and follow up of emission factors, as well as a method to define the financial support.

We apply the framework to a midsize Brazilian city for which an ambitious integral mobility plan has been proposed. The plan includes the construction of 286 km of bikeways, 58 km of bus lanes, 80 km of Bus Rapid Transit, 36 km of metro and several road improvements, with a total investment of USD 2,663.5 million (present value 12%). The plan also promotes land use changes and includes parking policies to manage travel demand to the city center.

We do an evaluation for the 2008-2030 period, and estimate a total of 9.2 million ton of CO<sub>2</sub>eq saved (20% less cumulative emissions and 36% reduction in annual emissions as compared with the business as usual scenario). We also estimate co-benefits equivalent to USD 1.3 billion in travel time savings and USD 0.9 billion in transportation costs, as well as reductions in air pollutants (e.g. 39% annual reductions in particulate matter).

Application of the framework to a specific case study shows its practical feasibility. We were required to get information on activity from a fairly sophisticated transport model, and used emission factors available for Brazil. We recognize that there is important room for improvement on the quality of the data inputs, and also acknowledge the uncertainty involved with projections for a 22 year period (2008-2030). Nevertheless, we feel the overall calculations provide a good initial estimate of GHG reduction potential and co-benefits.

We recommend the framework developed in this study for the preparation and submission of NAMAs on integral urban mobility under the evolving procedures of the UNFCCC and the Copenhagen Accord of December 2009. We encourage further development and enhancement of this framework.

We understand that city level NAMAs will require aggregation for the national level, review and submission by national authorities (Ministry of the Environment). We observe an interesting potential for urban centers in Brazil: 1 to 10 million CO<sub>2</sub>eq tons per year.

Regarding financing we perceive that climate instruments will provide a relatively small percentage of the total costs required for urban mobility plans, but that this funding will be critical in removing implementation barriers.

## ACKNOWLEDGEMENTS

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## About EMBARQ

**EMBARQ — the WRI Center for Sustainable Transport** — works with cities in the developing world to catalyze and help implement sustainable solutions to the problems of urban mobility and the environment. EMBARQ is a program of the World Resources Institute (WRI), an environmental think tank that goes beyond research to find practical ways to protect the earth and improve people's lives. WRI carries out policy research and analysis on global environmental and resource issues and their relationship to population and development goals, which are both scientifically sound and politically practical.

EMBARQ founded CTS-Mexico in 2002 and has subsequently created a network of Centers for Sustainable Transport in Brazil, Turkey, India and the Andes. The EMBARQ Network employs some 60 experts in fields ranging from architecture to air quality management; geography to journalism; and sociology to civil & transport engineering.

## Appendix F – Capital Cost and Potential Income from Supported NAMA

	Total km/ Present Value	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Baseline												
Bikeways km	14	0	0	7	7	0	0	0	0	0	0	0
Buslanes km	14	0	0	7	7	0	0	0	0	0	0	0
BRT km	0	0	0	0	0	0	0	0	0	0	0	0
Metro km	29	0	0	7.25	7.25	7.25	7.25	0	0	0	0	0
Road Investment USD Mil	\$38.40	0	0	28.5	28.5	0	0	0	0	0	0	0
Total USD Million	\$1,551.70	\$ -	\$ -	\$ 657.55	\$ 657.55	\$ 619.88	\$ 619.88	\$ -	\$ -	\$ -	\$ -	\$ -
Integral Urban Mobility												
Bikeways km	300	0	0	60	60	60	60	60	0	0	0	0
Buslanes km	72	0	0	12	12	12	12	12	12	0	0	0
BRT km	80	0	0	13.33	13.33	13.33	13.33	13.33	13.33	0	0	0
Metro km	65	0	0	7.25	7.25	7.25	7.25	7.20	7.20	7.20	7.20	7.20
Road Investment USD Mil	\$982.81	0	0	342	342	342	342	342	0	0	0	0
Total USD Million	\$4,215.17	\$ -	\$ -	\$ 1,147.54	\$ 1,147.54	\$ 1,147.54	\$ 1,147.54	\$ 1,143.27	\$ 797.85	\$ 615.60	\$ 615.60	\$ 615.60
Total Capital Investment	\$2,663.47	\$0.00	\$0.00	\$489.99	\$489.99	\$527.67	\$527.67	\$1,143.27	\$797.85	\$615.60	\$615.60	\$615.60
GHG Emissions (tons CO2)Baseline												
Scenario	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Variable \ Year	1	2	3	4	5	6	7	8	9	10	11	
GHG Emissions	GHGyb	1,314,786	1,374,587	1,431,847	1,489,107	1,546,367	1,603,627	1,660,888	1,718,148	1,775,408	1,832,668	1,896,551
Cum GHG Emissions	TGHGb	1,314,786	2,689,373	4,121,220	5,610,328	7,156,695	8,760,323	10,421,210	12,139,358	13,914,766	15,747,433	17,643,585
GHG Emissions (tons CO2)Integral Mobility Plan												
Scenario	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Variable \ Year	1	2	3	4	5	6	7	8	9	10	11	
GHG Emissions	GHGys	1,314,786	1,472,613	1,577,454	1,677,953	1,867,741	1,704,234	1,649,580	1,594,926	1,540,272	1,632,330	1,577,679
Cum GHG Emissions	TGHGs	1,314,786	2,787,399	4,364,853	6,042,806	7,910,547	9,614,781	11,264,362	12,859,288	14,399,560	16,031,889	17,609,568
GHG Emissions Savings		0	-98,025	-145,607	-138,846	-321,373	-100,607	11,307	123,222	235,136	200,338	318,872
Cum GHG Savings	\$GHGs	0	-98,025	-243,633	-432,479	-753,852	-854,459	-843,151	-719,930	-484,794	-284,456	34,417
Climate Change Funding	\$35,897,984	\$ -	\$ (3,445,987)	\$ (5,118,673)	\$ (6,638,697)	\$ (11,297,552)	\$ (3,536,733)	\$ 397,498	\$ 4,331,730	\$ 8,265,961	\$ 7,042,689	\$ 11,209,643
Assumptions												
ERC	13.02 Euros/ton					1.35		17.577 USD/Ton				
FX	2					0.57						
DR	12%											
Cost per Km	Million Reals	Million US										
Bikeway	\$ 0.10	\$ 0.06										
Buslane	\$ 2.20	\$ 1.25										
BRT	\$ 22.00	\$ 12.54										
Metro	\$ 150.00	\$ 85.50										

## Appendix F – Capital Cost and Potential Income from Supported NAMA (cont.)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
<b>Baseline</b>												
Bikeways km	0	0	0	0	0	0	0	0	0	0	0	0
Buslanes km	0	0	0	0	0	0	0	0	0	0	0	0
BRT km	0	0	0	0	0	0	0	0	0	0	0	0
Metro km	0	0	0	0	0	0	0	0	0	0	0	0
Road Investment USD Mil	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total USD Million</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
<b>Integral Urban Mobility</b>												
Bikeways km	0	0	0	0	0	0	0	0	0	0	0	0
Buslanes km	0	0	0	0	0	0	0	0	0	0	0	0
BRT km	0	0	0	0	0	0	0	0	0	0	0	0
Metro km	0	0	0	0	0	0	0	0	0	0	0	0
Road Investment USD Mil	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total USD Million</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>	<b>\$ -</b>
<b>Total Capital Investment</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>	<b>\$0.00</b>
<b>GHG Emissions (tons CO2)</b>												
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	12	13	14	15	16	17	18	19	20	21	22	23
GHG Emissions	1,953,811	2,009,747	2,059,167	2,116,427	2,173,687	2,230,947	2,288,208	2,345,468	2,402,728	2,459,988	2,517,248	2,574,508
Cum GHG Emissions	19,597,796	21,607,542	23,665,709	25,783,137	27,955,824	30,187,772	32,475,975	34,821,447	37,224,175	39,684,163	42,201,410	44,775,918
<b>GHG Emissions (tons CO2)</b>												
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	12	13	14	15	16	17	18	19	20	21	22	23
GHG Emissions	1,523,024	1,468,370	1,354,401	1,387,184	1,423,005	1,452,863	1,485,757	1,518,687	1,551,652	1,584,652	1,617,686	1,650,754
Cum GHG Emissions	19,132,592	20,600,963	21,955,364	23,342,547	24,762,552	26,215,415	27,701,172	29,219,859	30,771,512	32,356,164	33,973,850	35,624,604
GHG Emissions Savings	430,787	541,376	704,767	729,243	753,683	778,085	802,451	826,781	851,075	875,336	899,562	923,754
Cum GHG Savings	465,203	1,006,579	1,711,346	2,440,589	3,194,272	3,972,357	4,774,807	5,601,588	6,452,663	7,327,999	8,227,560	9,151,315
<b>Climate Change Funding</b>	<b>\$ 15,143,874</b>	<b>\$ 19,031,540</b>	<b>\$ 24,775,363</b>	<b>\$ 25,635,821</b>	<b>\$ 26,494,957</b>	<b>\$ 27,352,792</b>	<b>\$ 28,209,347</b>	<b>\$ 29,064,644</b>	<b>\$ 29,918,703</b>	<b>\$ 30,771,546</b>	<b>\$ 31,623,191</b>	<b>\$ 32,473,660</b>

Source: Calculation by the author

