



# Calculating the potential climate value of Non-Motorised Transport projects in African Cities

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# Executive summary

In most African cities, populations are increasing rapidly and the reliance on Non-Motorised Transport (NMT) is high, but dedicated NMT infrastructure remains very limited. Private vehicle use is rising steadily, congesting these cities, poisoning the air and killing NMT users at unacceptably high rates. African cities have a dire need for substantial NMT infrastructure investment, but municipal budgets are constrained and there are many other needs that must be met. Trying to rationalise the allocation of resources in such constrained environments highlights the importance of evidence-based decision-making, to maximise the societal benefit from every municipal investment. Historically, it has been difficult to demonstrate the benefit of NMT, due to the diversity and complexity of its positive impacts, and in many countries that remains true. The ability of NMT to mitigate climate change has remained difficult to measure, in large part due to the lack of appropriate tools. The same was true for the measurement of the health value of NMT before the advent of tools such as HEAT (World Health Organisation, 2014). The climate value of investments and infrastructure in cities is becoming critically important, but to date, has been a woefully neglected and underfunded sector under climate finance programmes.

Determining the climate value of NMT is a relatively new concept and the research is still in a nascent stage. One of the first studies to estimate a climate value of NMT, Massink et al., (2011), calculated that the 3.3% mode share of cycling in Bogotá, Colombia has a climate value of 55,115 avoided tons of CO<sub>2</sub> per year. To attempt a similar climate valuation of NMT projects in African cities, a specific Project Assessment Tool (PAT) was developed. Before applying PAT in a data-scarce, African city, a data-rich, ex-post pilot case was conducted in Bogotá, to validate the tool. NMT projects or scenarios in two African cities, Cape Town, South Africa and Nairobi, Kenya were tested in PAT to determine their potential climate value. To overcome a lack of data necessary to accurately model the changes in mode share resulting corresponding to the scenarios, an opinion poll was disseminated to local experts within the field requesting estimations based on a description of the future scenario being tested. A scenario that was tested across all three cities was a 370km NMT network similar to Bogotá's CicloRuta system. PAT revealed that the climate value of a network like this could be substantial in both Cape Town and Nairobi. Transport planners at the City of Cape Town predict that cycling mode share would increase from 1% to 8%, saving 3.26 million tons of CO<sub>2</sub> over the 15-year life of the project. Experts in Nairobi expect a network like this to be able to not only stem the current decrease in pedestrian mode share but increase it 3% higher to 43%. The avoided trips in cars and minibus taxis could contribute to petrol usage being 7% lower across the city. PAT was also used to evaluate the social benefit-cost ratio of these two scenarios, returning ratios of 16.3 and 12.6 for Cape Town and Nairobi respectively. The climate value of NMT in African cities is considerable and should not be taken for granted. It presents an incredible opportunity for African cities, and the global community, to achieve our collective climate-related goals, and should be integrated into climate finance initiatives in order to spur systemic investment.





# 1 Introduction

Effective transport systems are vital for people to carry out their everyday tasks, and for providing access to many of the goods and services that constitute a modern society. In turn, each transport mode has associated effects on people's health, the environment and the economy as a whole. The ability to fully appraise these direct and indirect effects is integral to utilising evidence-based policy-making. Impact appraisal and evaluation is especially important for Non-Motorised Transport (NMT) as a significant proportion of the benefit it generates for a society is outside of its function as a provider of access, unlike most other modes. Historically, the techniques for quantifying the benefits of NMT have not been applied as systematically as the simpler appraisal techniques used to assess the costs and benefits of motorised transport infrastructure and projects. However, recent advances in the development of tools that quantify NMT benefits has provided a valuable capability to evaluate transport projects more holistically and more equitably. One of the benefits of NMT that is most abstract to its use is the global impact it has on the environment. The climate value of NMT is seldom considered when appraising local transport projects despite its significant cumulative potential.

Climate change is an increasingly important topic of discussion in African cities as they begin to suffer its effects. From pervasive droughts in urban areas of Southern Africa to flooding in those of Eastern Africa, cities are looking to create transport systems that are more resilient and lower in emissions. NMT is usually a zero-emission form of transport, with considerable societal co-benefits, and deserves to be central to urban planning departments' strategic thinking the world over.

This study involves the use of an NMT Project Assessment Tool (PAT) developed by UN Environment's Share the Road programme, to evaluate the potential climate value of different NMT intervention scenarios in two African cities: Cape Town, South Africa and Nairobi, Kenya. This comparative analysis aims to provide meaningful insight into the potential for NMT to assist African cities, and the global community, in achieving their climate-related goals.

The availability of data is often a constraint to equitably valuing interventions in the urban space. However, this inability to accurately appraise impacts should not restrict decision-makers from discussing or considering these effects. The level of uncertainty related to the valuation of NMT benefits in data-scarce environments is high, but tools like PAT can begin to hint at the magnitude of societal gain that could be created when NMT is invested in. This publication aims to start a conversation around the climate value of transport projects in African cities, a conversation that is becoming more important as each day passes. African cities have the opportunity to embrace their high levels of NMT use and leapfrog the car-dependent cities to achieve environmentally sustainable mobility systems.

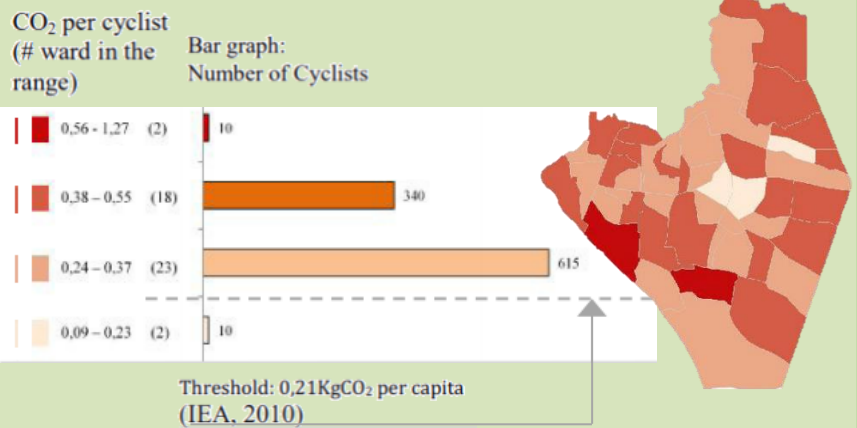


## 2 Climate value of NMT around the world

Determining the climate value of NMT is a relatively new concept and the research is still in a nascent stage. This study follows the approach pioneered by one of the first studies to estimate a climate value for NMT, Massink et al., (2011), which uses the fact that cycling is a zero-emission transport mode to estimate the CO<sub>2</sub> that would have been created had it not been an option. The opportunity cost of the avoided CO<sub>2</sub> emissions is calculated by substituting the cycling trips with those of the most likely alternative mode (Massink et al., 2011). This accumulation of avoided emissions is based on current modal splits, cycling's inter-modal competition and CO<sub>2</sub> emissions factors. Under the assumption that these avoided emissions are transferable for carbon tax credits, Massink et al. (2011) suggest that a monetary value can be placed on the environmental benefits of cycling. In a case study of Bogotá, Colombia, the 3.3% mode share of cycling is calculated to have a climate value of 55,115 avoided tons of CO<sub>2</sub> per year and an economic value of between 1 and 7 million US dollars' worth of carbon credits (Massink et al., 2011). In recognition of the climate value of NMT projects, the UNFCCC published a new methodology in 2018 for monitoring and calculating emissions reductions from cycling infrastructure interventions.

### Box 1: Examples of climate value studies related to NMT use around the world

The Unguja Island of Zanzibar had a cycling mode share of 41% in 2009. The climate value of this cycling in the wards of Stone Town was estimated to be 1062.4 tonnes of CO<sub>2</sub> per annum, which corresponds to between US\$ 7 076 and US\$ 20 994, if it were traded on the carbon markets (Mendiate, 2016).



One person switching five journeys of under 2km a week from the car to walking would reduce their carbon footprint by 86kg a year, which is 1.39 times the weight of the average person on earth (Potter 2004).



Barcelona's public bike share system, Bicing, was estimated to reduce annual carbon dioxide emissions by 9 062 tonnes per annum in 2011 (Rojas-Rueda, de Nazelle, Tainio & Nieuwenhuijsen, 2011).

In a five-year period, Dutch people avoided 1.41 million tonnes of CO<sub>2</sub> each year through cycling. This saving is equivalent to 54.4 million trees being planted each year (Chen, 2012).

# 54,4 MILLION TREES



### 3 Estimating the climate value of NMT

Non-motorised transport research is a vital issue, especially in the current dialogues on sustainability and climate change. However, the availability of NMT related data is still very limited in most African cities. In order to calculate the climate value—and the value of other benefits—of NMT projects in African cities, UN Environment’s Share the Road programme commissioned the development of the NMT Project Assessment Tool (PAT). It was developed in order for stakeholders and decision-makers to be better informed regarding the potential improvements that NMT projects can have in a low- or middle-income city context. PAT is a spreadsheet-based, open source tool that evaluates the primary costs and benefits associated with walking and cycling projects.

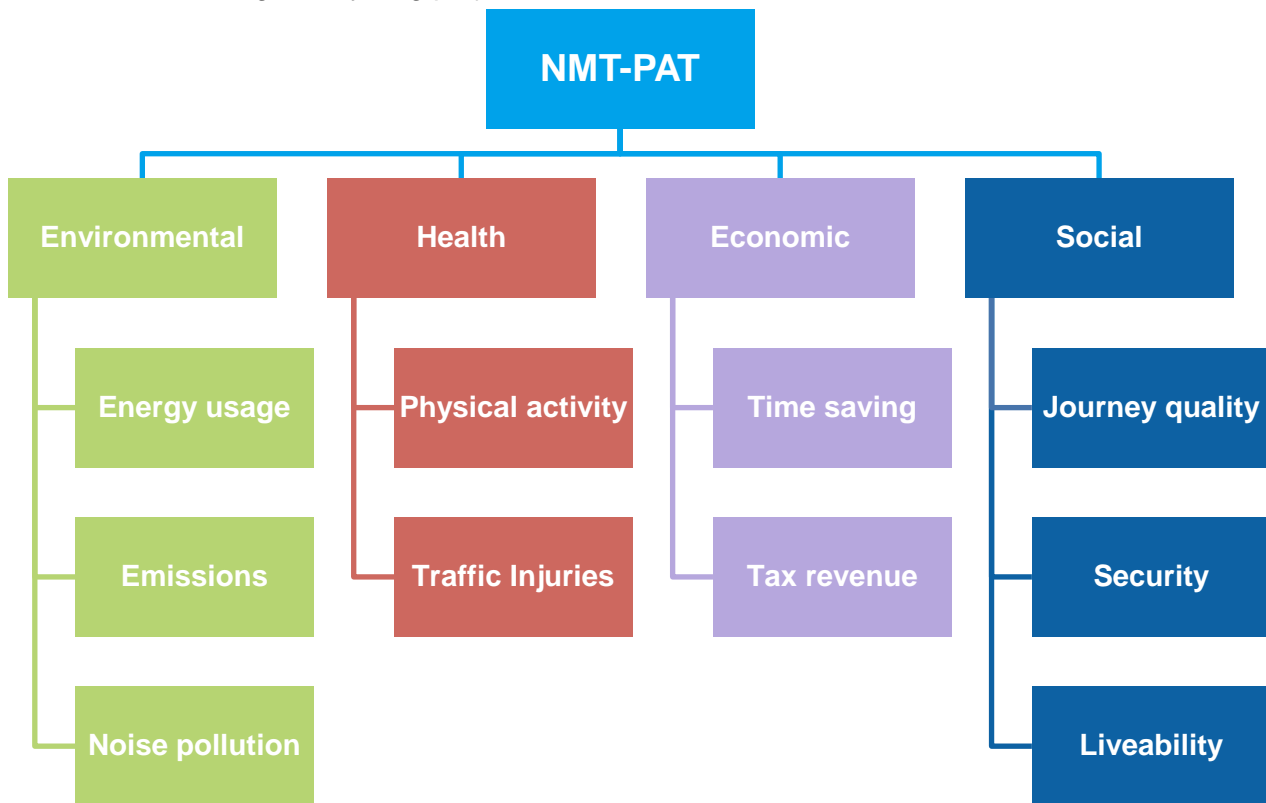


Figure 1: Architecture of UN Environment’s Share the Road Project Assessment Tool (PAT)

PAT has four key categories of benefits, or disbenefits, that are considered relevant to non-motorised transport projects: environmental, health, economic and social. To effectively utilise the quantitative and monetary functionality of PAT, data for a certain number of necessary indicators is required. Though, as PAT is designed for data scarce and institutionally under-developed contexts, the ease of which the data was sourced is not an accurate representation of NMT data availability, generally. Through the validation exercises and case studies, it was revealed that the area for which necessary data is least often available is in the prediction of the travel behaviour effects of future scenarios. To overcome the dearth of this critical NMT data, an opinion poll was disseminated to local experts within the field. The panel of experts in each city consisted of a combination of transport engineers within the local government, consultants with transport or urban planning expertise and civil society advocates with technical backgrounds. The poll requested estimations of modal splits based on a description of the future scenario being tested. The poll allowed more detailed analysis of each case study scenario, but the variance in the responses did increase the level of uncertainty in the predictions. However, when coupled with the ability of PAT to test the sensitivity of the results to the uncertain estimates, the opinion poll became a significant and useful tool for the substitution of unavailable data.

For a detailed description of the emission and energy usage algorithms used in PAT refer to Appendix 1: Climate valuation method. The carbon price used in this study is \$8.57/tCO<sub>2</sub>, which is the South African carbon tax, Africa’s first, legislated to come into effect in 2019.

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# Case studies



# 4 Climate value of NMT: Bogotá

Estimating the climate value of NMT is a nascent science. Therefore, before applying PAT in a data-scarce, African city, a data-rich, ex-post pilot case was needed to validate the tool. The seminal study by Massink et al. (2011) highlighted Bogotá, Colombia as a logical candidate. In 1995, approximately 9 million transport trips were undertaken in the city each day, of which 22.5% were pedestrian trips and less than 0.4% were trips using a bicycle (Wright & Montezuma, 2004). The total number of trips grew to 12.5 million in 2015, with pedestrian trips decreasing marginally to 21% and cycling trips increasing significantly to 5% (Nterés et al., 2017). The rapid increase in cycling has been attributed, in large part, to the CicloRuta network constructed within this 20-year period (Verma, Lopez and Pardo, 2015).



**CicloRuta**

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**\$1.1 billion**

**370 km**

**CBCR: 8.7 (-0.1)**

The CicloRuta network is a lattice of dedicated bicycle paths that permeate through the city of Bogotá. They were the brainchild of Enrique Penalosa—who was Mayor of Bogotá from 1998 to 2001 and re-elected in 2016—and formed part of his five urban megaprojects to create a more liveable city. Figure 2 illustrates the coverage of the bicycle path network and the average distance that residents need to travel to access it (Teunissen et al., 2015).

A critical impact of the CicloRuta network for Bogotá is the positive effect that cycling has had reducing Greenhouse Gas (GHG) emissions and significantly improving air quality. Illustrated below are the estimates that PAT has calculated for these impacts during a 15-year project assessment period of 1995 to 2010. The estimation of CO<sub>2</sub> savings by PAT is 57 078 tons per year, which is only 3.6% higher than the value that the Massink et al. (2011) study calculated for a modal shift of similar magnitude. Including all four NMT benefit categories, PAT estimates that the Social Benefit-Cost Ratio (SBCR) on this project is 8.8, but it would be -0.1 if travel time reduction was the only benefit valued as has often been the case in the past.

**CO<sub>2</sub> savings: 856 kilotons**      **PM savings: 490 tons**      **NO<sub>x</sub> savings: 5 240 tons**



**Petrol savings: 240 megalitres**

**Diesel savings: 108 megalitres**

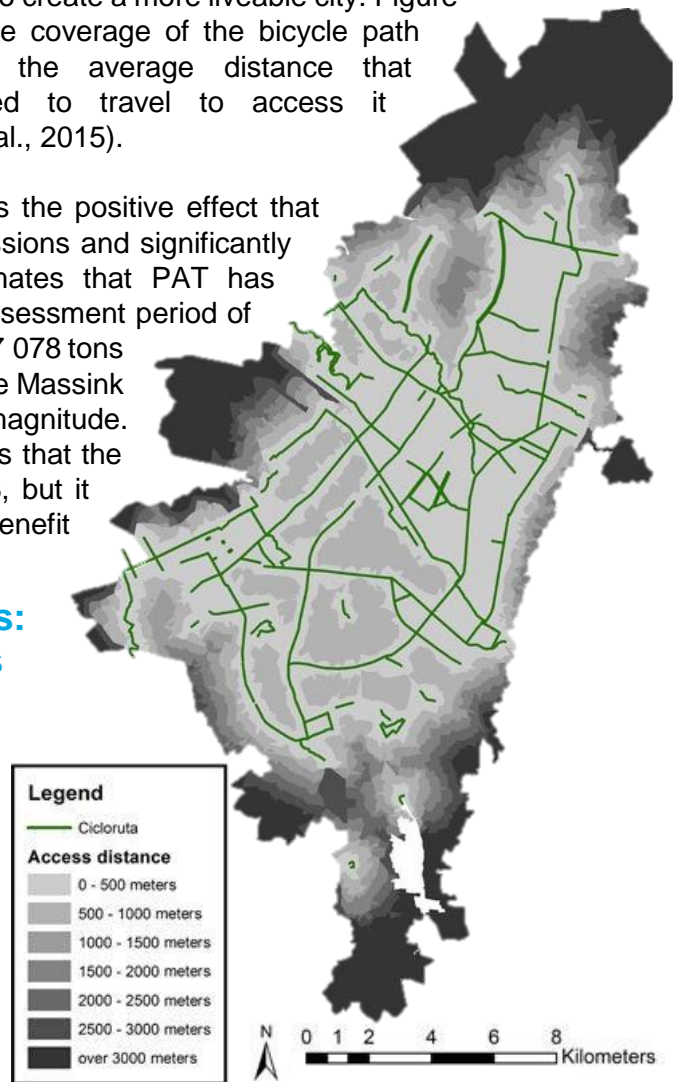


Figure 2: Access to CicloRuta per access distance  
Source: Teunissen et al. (2015)



# 5 Climate value of NMT: Cape Town

Cape Town is one of the largest cities in South Africa, with a population that was estimated to be 3.74 million in 2011 (City of Cape Town, 2014). While Cape Town has a significant NMT mode share, it is struggling to provide adequate facilities for its NMT users (Vanderschuren et al., 2014). NMT is battling for priority with an increasing demand for motorised transport infrastructure, due to a rapid increase in the number of vehicles on the roads (Merven et al., 2012). As a result, Cape Town suffers from high levels of congestion, as well as high levels of road fatalities and injuries (Peden, M, Kobusingye and Monono, 2013).



The City of Cape Town government acknowledges the urgent need for adequate NMT facilities and its

*Cycling Strategy* proposes an ambitious goal of increasing cycling mode share from 1% to 8% by 2030 (City of Cape Town, 2017). At the metropolitan level, a number of NMT projects are being rolled out in three-year phases under the *NMT City Wide Plan*. On a national level, the need to address the inadequate levels of facilities for NMT users has also received attention, with the drafting of the *NMT Facility Guidelines* (Vanderschuren et al., 2014). Two case study scenarios were chosen for Cape Town—one smaller scale, newly constructed project and one larger, theoretical NMT network—in order to test the climate value of NMT projects with varying scale and context.

## 5.1 NMT facility upgrades in the Cape Town CBD



Various NMT projects were implemented in the City of Cape Town’s CBD during 2012 and the total length was approximately 4.53 km. The upgrades included both cyclist and pedestrian infrastructure, as well as universal access improvements, landscaping of NMT facilities and the provision of street furniture. The NMT upgrades may be small in cumulative length, but they provide significant opportunities for the effective distribution of the pedestrians arriving at Cape Town Train Station, the primary ingress point to the central city. The cost of the upgrades was approximately \$2.5 million, in 2019 dollars.

According to the experts that were polled, the NMT improvements around the CBD are expected to result in a small but significant mode shift of 3% to both walking and cycling by 2027, the end of the specified 15-year project assessment period. It has been projected that the majority of the new NMT trips will be shifted away from cars, currently the dominant transport mode in the area, and the project will also increase the usage of the both the bus and minibus modes. Due to the strategic location of these upgrades, PAT estimates that the SBCR on this project will be 20.8.

**NMT upgrades**

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**\$2.5 million**

 **4.5 km** 

**SBCR: 20.8 (-0.1)**

**CO<sub>2</sub> savings:**  
166 kilotons



**PM savings:**  
-6 tons

**NO<sub>x</sub> savings:**  
841 tons



**Petrol savings:**  
70 megalitres



**Diesel savings:**  
-1 megalitre



The graphics show that the potential modal shift of the trips, due to the CBD NMT upgrades, would result in substantial Carbon Dioxide (CO<sub>2</sub>) and Nitrogen Oxides (NO<sub>x</sub>) savings. Whereas, Particulate Matter (PM) is expected to increase due to the higher proportion of trips utilising the more PM-intensive diesel buses. However, this scenario assumes that the buses used in 2034 are no cleaner nor more efficient than the buses used currently.

## 5.2 Metropolitan Cape Town NMT network scenario


The metropolitan NMT network scenario explores the effects of having an extensive walking and cycling network throughout the Cape Town metropolitan area. The network would provide dedicated NMT infrastructure on major NMT routes and allow safe, expedient access to most activities. This scenario is based on the CicloRuta NMT network in Bogotá, Colombia, which has already been tested using PAT and is extremely popular with the citizens of the city. The population of Cape Town is roughly one third of Bogotá's, but so is its population density, meaning that a 370km network would still have a similar coverage to CicloRuta. The network in this scenario is not extensive but would form the backbone of a comprehensive, hierarchical NMT structure.

The potential effect of the Cape Town Metropolitan NMT network on local modal splits is difficult to measure as each segment of the network would have a unique modal split. Therefore, the experts polled were questioned over the possible effect of the network to the overall modal split of the Cape Town Metropolitan area. In accordance with the city *Cycling Strategy*, the experts believed that a metropolitan NMT network would have a substantial effect on the number of cyclists in Cape Town in 2034. Bogotá's experience with creating a safe, protected, coherent network of cycling infrastructure has demonstrated the ability to considerably increase cycling mode share. The additional NMT users would predominantly come from those currently using private vehicles and buses, which would increase their level of physical activity. When the environmental, health, economic and social benefits of this NMT network are evaluated the Social Benefit-Cost Ratio (SBCR) could be as high as 16.3 but would be considered a poor investment if travel time savings is the only metric of value creation.


NMT network

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\$860 million



370 km



SBCR: 16.3 (0.3)

The shift in trips toward NMT modes would result in CO<sub>2</sub> savings of 3 260 kilotons by 2034, across the whole of Cape Town, which is 5% of the total carbon footprint of the city's passenger transport sector. This is equivalent to 58 kilograms of CO<sub>2</sub> being saved for every person in the city, per year. The PM and NO<sub>x</sub> levels are also expected to decrease by 5%. These emissions savings could be compounded if other measures are utilised to promote NMT use and to pass the environmental cost of motorised transport on to the users. The decrease in private motorised transport use would also result in petrol and diesel savings of

**CO<sub>2</sub> savings:** 3 260 kilotons      **PM savings:** 511 tons      **NO<sub>x</sub> savings:** 16 786 tons



**Petrol savings:** 1 254 megalitres      **Diesel savings:** 89 megalitres



approximately 5% respectively. Cape Town simultaneously has high levels of car use and NMT use, meaning that the burden of the one on the other is especially high. The favourable SBCR derives predominantly from the potential for NMT infrastructure to reduce pedestrian fatalities. NMT often draws together different spatial scales of value creation, the global value of its environmental benefits with the local value of its safety benefits. This spatial and thematic diversity of NMT's positive impacts has contributed to its systemic undervaluing. Holistic valuation tools provide the ability to assess these diverse benefits in common terms.

# 6 Climate value of NMT: Nairobi

Metropolitan Nairobi, the capital of Kenya, has a population of about 7 million, but rapid urbanisation is expected to substantially increase this in the next decade. The city has a diverse transport ecosystem which is comprised of matatus, private cars, boda bodas, walking, taxis and bicycles among others. About 6.7 million trips were estimated to have been carried out each day in 2005 and 47% were exclusively by NMT (JICA , 2006). Despite a substantial reliance on NMT, the city's rapid growth and rising motorisation has seen congestion soaring to among the highest levels in the world (Klopp, 2015). It has been claimed that this costs the government close to \$18.8 million every year (Gachanja, 2015).



In 2015, the Nairobi City County Government passed the first ever NMT Policy in the country, with support and guidance from UN Environment. It is an exemplar of NMT policy for African cities, particularly in its development of clear indicators and goals, its intensive stakeholder engagement and its linking of measurable outputs and outcomes to objectives (Nairobi City County Government, 2015). As in Cape Town, two case study scenarios were chosen for Nairobi.



## 6.1 Nairobi NMT Policy network

The Nairobi NMT Policy set out a 'short term action plan' to kick-start the investment in NMT and address the immediate challenges facing NMT users. The action plan recommends two NMT infrastructure packages. The 'Quick Wins' package is applied to the roads with the highest numbers of NMT fatalities in the city and the 'Pilot Projects' package focuses on the integration of NMT with Nairobi's planned Mass Rapid Transit (MRT) as well as the pedestrianisation of the CBD. Together, the packages would form a preliminary NMT network. The selected MRT links include two road links, Jogoo and Juja, which have been at the forefront of discussions with regards to NMT fatalities and casualties. A study by Mitullah et al. (2013) on the traffic accidents occurring on the two roads indicated that 71.7% of the accidents involved pedestrians, 10.7 % involved cyclists and 6.9 % involved handcarts. The roads have few safe crossing opportunities and limited space for NMT users despite being important access corridors to the CBD. Implementation or improvement of NMT facilities on these road links will go a long way in addressing some of these issues.

### NMT Policy

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**\$103 million**

 **116 km** 

**SBCR: 7.1 (0.3)**

The experts that were polled estimated that improved access to the new, bus-based MRT system and the addition of cycle lanes would result in mode share increases in both modes due to the NMT Policy infrastructure packages. Interestingly, they believe that the number of pedestrians will remain unchanged if the projects are implemented but decrease if the status quo remains. PAT shows that the environmental

<b>CO<sub>2</sub> savings:</b> 312 kilotons	<b>PM savings:</b> 125 tons	<b>NO<sub>x</sub> savings:</b> 1 295 tons	<b>Petrol savings:</b> 113 megalitres	<b>Diesel savings:</b> 15 megalitres
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effect of the Nairobi NMT Policy network could be substantially positive over the 15-year lifespan of the project. The CO<sub>2</sub> savings of 312 kilotons is equivalent to over 12 million trees being planted; almost two trees for every resident in Nairobi.

## 6.2 Metropolitan Nairobi NMT network scenario


Similar to the metropolitan Cape Town NMT network scenario in section 5.2, this scenario explores the effects of having an extensive walking and cycling network throughout the Nairobi metropolitan area. The network would provide dedicated NMT infrastructure on major NMT routes and allow safe, expedient access to most activities. For comparability, the scenario tests the same 370km of NMT infrastructure, modelled on the CicloRuta network in Bogotá. Nairobi’s metropolitan population and density are approximately equal to that of Bogotá in 1995, when the CicloRuta network commenced construction. This scenario imagines a cohesive NMT network, roughly three times the size of the network prescribed by the NMT Policy.

A metropolitan-wide NMT network would have a far greater effect on the modal split of Nairobi than the NMT Policy network. The network is expected to increase the mode share of pedestrians by 3% in Nairobi, to 43% by 2034. Whereas, without the project, the pedestrian mode share is predicted to decrease to 34%. This significantly higher is a significantly higher effect than was anticipated for the NMT Policy network. It is likely due to the fact that the number of opportunities a pedestrian would be able to access, without having to leave the spatially protected routes, increases exponentially with the scale of the NMT network. The additional NMT users would predominantly come from those currently using the minibus taxi mode. Interestingly, the proportion of car trips are expected to decrease and that of metered taxis will increase. This prediction may suggest that cars will be more optional and technologically integrated on-demand taxi services would meet the need, as is observed in many wealthy cities currently.


NMT Network

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\$272 million



370 km



SBCR: 12.6 (1.0)

**CO<sub>2</sub> savings:**  
1 147 kilotons



**PM savings:**  
320 tons



**NO<sub>x</sub> savings:**  
5 292 tons



**Petrol savings:**  
431 megalitres



**Diesel savings:**  
40 megalitres

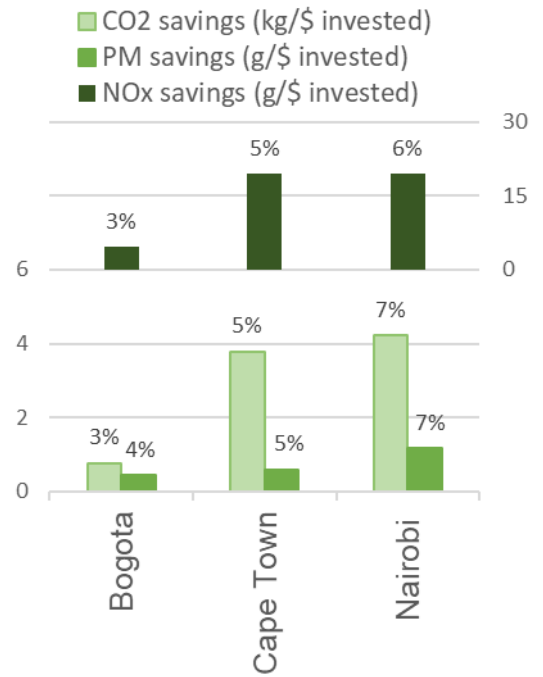


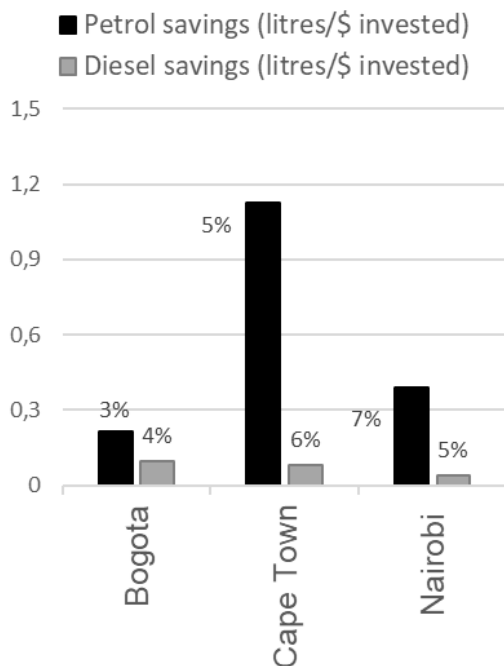
The shift in trips toward NMT modes would result in CO<sub>2</sub>, PM and NO<sub>x</sub> savings of 7%, 7% and 6% respectively by 2034 across the whole of Nairobi. The savings in emissions are significant but won't fundamentally change the carbon footprint of the transport sector in Nairobi. The provision of NMT infrastructure is clearly of high environmental importance but these emissions savings could be compounded if other measures are utilised to promote NMT use, and the environmental cost of motorised transport was passed on to the users. The decrease in motorised transport use could result in Petrol and Diesel savings of approximately 8% and 5% respectively due to the NMT infrastructure.

# 7 Case study scenario comparison

The case study scenarios analysed using PAT in each city are very diverse in scale and, therefore, their comparison is difficult. The magnitude of benefits derived from a project can be inherently linked to the scale of the project and its cost. Hence, the comparison is confined to the similarly scaled metropolitan NMT network scenario tested in all three cities. Furthermore, to account for the variance in the cost of implementing the network in Bogotá, Cape Town and Nairobi, the chosen medium for the comparison of benefits is magnitude per monetary unit of project cost. Due to the varied magnitude of the benefit measurements for each criterion and indicator, the magnitude of the monetary unit changes between indicators but not between cities.

**Error! Reference source not found.** shows the Carbon Dioxide (CO<sub>2</sub>), Particulate Matter (PM) and Nitrogen Oxides (NO<sub>x</sub>) savings in kilograms or grams per US dollar invested in the project. Despite significant differences in the expected modal shift due to the NMT networks in Cape Town and Nairobi, the level of CO<sub>2</sub> savings is similar at around 4 kg/\$ invested. This potential CO<sub>2</sub> saving is approximately five times that estimated for Bogotá's highly-valued CicloRuta network, per dollar invested. The estimated change in PM levels in Bogotá is comparable to that which is predicted for Cape Town but half of the prediction for Nairobi. The NO<sub>x</sub> savings follow a similar trend to the CO<sub>2</sub> savings. Despite the success of the NMT network in Bogotá, the mode shift to NMT over the past two decades, from its low base, has been limited. In contrast, both African cities currently have high NMT mode shares and the polled transport experts predict a NMT network would be able to significantly stem the erosion of this mode share. Therefore, the immense emission savings represent the opportunity for mode share retention rather than a mode shift.





The context of the motorised transport system within which these three NMT networks are being proposed is also alluded to in the resultant fossil fuel savings. The substantial petrol savings in Cape Town are the result of avoided private vehicle trips, whereas in Nairobi it is the result of avoided minibus trips. The mode shift toward NMT in Bogotá has come from larger buses, which is reflected in its relatively high diesel savings.

Calculating these emissions and energy savings demonstrate that the climate value of NMT projects may be similar in magnitude across different cities, but the way in which the value is generated is unique to each city. The climate valuation of transport projects can provide critical insight into the environmental footprint of a city's mobility system. These insights will provide a greater understanding of how to prioritise transport interventions in order to achieve the greatest environmental benefit for the least cost. Even if data scarcity or uncertainty restricts the degree to which the results of a climate valuation exercise can be utilised in project evaluation, the process itself has the potential to substantially change decision-making within a city.



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# Appendices

# 9 Appendix 1: Climate valuation method

The UN Environment's Share the Road Project Assessment Tool (PAT) utilises elements of the Transport Emissions Evaluation Model for Projects (TEEMP), a tool created by the Global Environment Facility (GEF), in order to calculate the emission and energy savings of NMT projects. TEEMP uses the following equations to estimate the avoided emissions and avoided energy in a similar method to that used by Massink et al., (2011).

$$VKT_m = \frac{MS_m * N * \bar{L}_m}{\overline{OCC}_m} \quad \forall m$$

**Equation 1: Average number of Vehicle Kilometres (VKT) per day per mode**

The modal split ( $MS_m$ ), number of trips per day (N), the average trip length per mode ( $\bar{L}_m$ ) and average occupancy ( $\overline{OCC}_m$ ) are used to calculate the Vehicle Kilometres Travelled ( $VKT_m$ ) per mode per day utilising Equation 1. Three options are given for the dominant fuel type, in order to utilise different default values for emissions produced per unit used. Three types of emissions are calculated: Carbon Dioxide (CO<sub>2</sub>), Particulate Matter (PM) and Nitrogen Oxides (NO<sub>x</sub>). The amount of these emissions produced each day is calculated by multiplying the VKT per day with fuel efficiency ( $f_m^{ef}$ ) and emission factors ( $f_m^{CO_2}$ ), shown for CO<sub>2</sub> emissions per day in Equation 2.

$$E_{CO_2} = \sum_m \frac{f_m^{CO_2} * VKT_m}{f_m^{ef}}$$

**Equation 2: Average amount of CO<sub>2</sub> produced per day per mode**

$$E_e = \sum_m f_m^e * VKT_m \quad \forall e$$

**Equation 3: Average amount of emissions (e={PM, NO<sub>x</sub>}) produced per day per mode**

The mass of emissions produced per day is then predicted for two future scenarios in each case using Equation 3: Business-as-usual (BAU) and With project (WP). The emissions produced for all modes are summed over the period of assessment and the difference between the BAU and WP scenarios are proposed to be potential emissions savings from a particular NMT intervention.

The amount of energy used per mode per day ( $\varepsilon$ ) is similarly calculated in Equation 4 by multiplying the  $VKT_m$  by an energy intensity factor ( $f_m^{ed}$ ). The energy usage for all modes are also summed over the period of assessment and the difference between the BAU and WS scenarios are proposed to be potential energy savings.

$$\varepsilon = \sum_m \frac{f_m^{ed} * VKT_m}{f_m^{ef}}$$

**Equation 4: Average amount of energy used per day per mode**

To accurately model the two future scenarios, and calculate the impact of an NMT project on travel patterns, a transport model would be required for each city. Unfortunately, few African cities have functioning transport models, nor the data necessary to create trustworthy predictions. However, for the purposes of calculating the climate value of NMT in a city, which is a more conceptual analysis, institutional knowledge and sensitivity testing has been shown in previous studies to approximate a reasonable estimate. Therefore, an experts' opinion poll will be created that requests local experts to provide estimates for the unavailable data related to the NMT intervention scenarios in each city.



