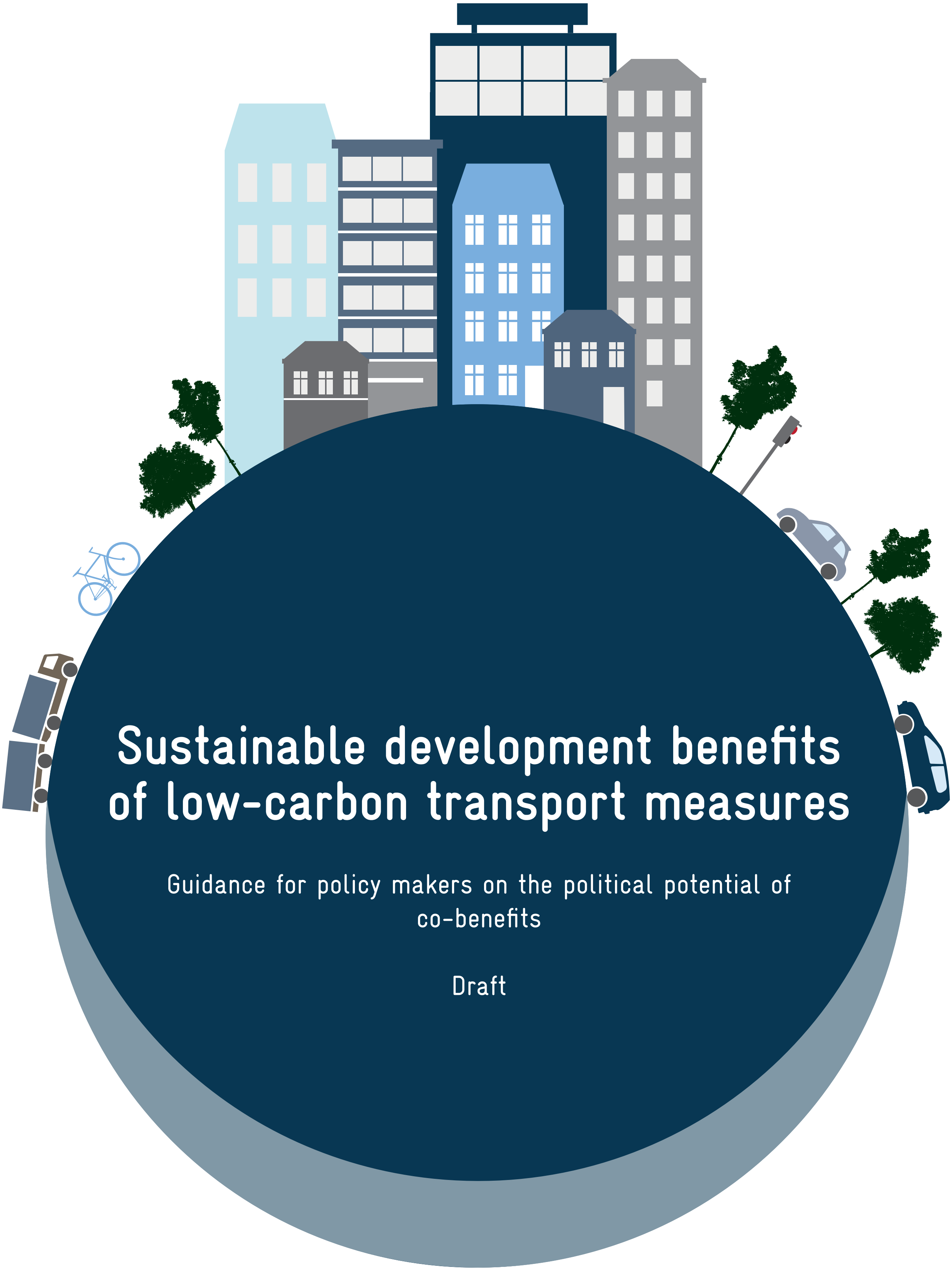


Sustainable development benefits of low-carbon transport measures

Guidance for policy makers on the political potential of co-benefits

Draft

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

The Project Context

The TRANSfer project is run by GIZ and funded by the International Climate Initiative of the German Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Its objective is to support developing countries to develop and implement climate change mitigation strategies in the transport sector as „Nationally Appropriate Mitigation Actions“ (NAMAs). The project follows a multi-level approach:

- At country level, TRANSfer supports selected partner countries in developing and implementing NAMAs in the transport sector. The NAMAs supported by the project cover a broad variety of approaches in the partner countries Indonesia, the Philippines, South Africa, Peru and Colombia.
- At international level and closely linked to the UNFCCC process, the project helps accelerate the learning process on transport NAMAs with a comprehensive set of measures (events, trainings, facilitation of expert groups, documents with guidance and lessons learned).

To encourage NAMA development worldwide, TRANSfer has set out to develop a first set of so-called MRV blueprints for transport NAMAs – a description of the MRV methodology and calculation of emission reductions for different NAMA types in the transport sector.

Activities at country and international level are closely linked and designed in a mutually beneficial way. While specific country experience is brought to the international stage (bottom-up) to facilitate appropriate consideration of transport sector specifics in the climate change regime, recent developments in the climate change discussions are fed into the work in the partner countries (top-down).

For more information see: www.transport-namas.org

Acknowledgement

Author: Oliver Lah with inputs from Todd Litman (Executive Director, Victoria Transport Policy Institute), Manfred Breithaupt (Senior Transport Advisor, GIZ Germany), Tilman Hohenberger (Transport and Climate Policy, GIZ Germany), Daniel Bongardt (Senior Advisor Transport and Climate Policy, GIZ China), Stefan Bakker (Advisor Transport and Climate Policy, GIZ Germany), Ralph Sims (Professor, Massey University, New Zealand), Danielle Guillén (GIZ)

Manager: Frank Krämer (Advisor Transport and Climate Policy, GIZ Germany) and Carolin Capone (Advisor Transport and Climate Policy, GIZ Germany).

Contents

Sustainable development benefits of low-carbon transport measures

Many low-carbon transport strategies can help achieve other economic, social and environmental objectives. These include improving access to mobility, reducing traffic and parking congestion, saving consumers money, supporting economic development, increasing public health and safety, and reducing air and noise pollution. Based on Avoid-Shift-Improve approaches and case studies from Germany, Colombia, India and Singapore, the author shows that aiming for low-carbon transport does have significant and quantifiable co-benefits.

Estimates suggest that currently available and cost effective measures can reduce transport energy consumption by 40-50% lower compared to the 2010 demand. Yet, a number of barriers affect the optimal exploitation of this potential. Considering the possible economic, social and environmental benefits of sustainable transport, the shift towards a low-carbon pathway of this sector can be a win-win situation for climate protection and local development goals. This paper aims to make a contribution to understand these win-win opportunities by presenting case studies and useful figures. Further, it will also explore assessment methodologies and tools that can help practitioners to assess sustainable development benefits (SDB) and providing evidence for policy-makers to make more informed decisions on transport investments and polices.

Guidance for policy makers on the political potential of co-benefits

This document looks at sustainable development benefits of low-carbon transport from two perspectives:

- The potential to address multiple policy objectives at the same time and support the creation of coalitions, which will be particularly relevant for **policy makers**;
- Examples and tools for the quantification of social, environmental and economic benefits of climate change mitigation actions in the transport sector, which will be especially relevant for **policy advisors and consultants**.

Terminology: from co-benefits to sustainable development benefits

With regard to the terminology, this paper evolves from using the well established term co-benefit that describes positive side-effects of climate change mitigation actions, towards using the term sustainable development benefits to highlight the fact that diverse environmental, economic and social impacts are equally important from a societal perspective. The paper also explores the risks and uncertainties of some impacts of mitigation measures that may lead to trade-offs and negative side-effects. This aim will help to inform priority-setting for decision makers.

From a climate change mitigation perspective, the term co-benefits may make sense, as for example safety or air quality improvements are a (positive) by-product of the primary objective. However, from a wider political perspective it would be wiser to refer to these effects as sustainable development benefits. This will give a clear indication on the equal importance of all pillars of sustainable development and may facilitate coalition building between sector ministries and stakeholders from the environmental field, such as the environment ministries and NGOs. As the relevant sector institutions (e.g. the transport ministry or local transport departments) may have other primary policy objectives, such as improving air quality, access or safety it is important to emphasize and measure social, economic and environmental benefits of climate change mitigation measures beyond the greenhouse gas emission reductions in order to motivate actors from these groups by showing the synergies in goal achievement and the benefits a given mitigation action will have in terms of the ministry's priorities.

While of course, political and institutional structures are very different from country to country and equally on the local level, some of the key priorities and perspectives of institutions are likely to be somewhat similar depending on the mandate of the institution. As a result, it is important to tailor advice to reflect the needs and resources of the target audience, and to communicate these concepts in ways that effectively resonate with different stakeholders and interest groups.

1. Low-carbon transport as enabler for sustainable transport policy coalitions

This report analyses synergies between low-carbon transport strategies and other economic, social and environmental objectives, as these can substantially increase the measure´s cost-effectiveness and help build political support for their implementation. Low-carbon transport measures, by avoiding trips, reducing demand, shift to low-carbon modes and improving vehicle efficiency can help achieve various further planning objectives including reduced traffic and parking congestion, public infrastructure and service cost savings, consumer savings and affordability (savings targeting lower-income households), increased safety and security, improved mobility options for non-drivers (and therefore reduced chauffeuring burdens for motorists), and improved public fitness and health, in addition to their pollution emission reductions. Sector officials and many other stakeholders place a high value on these benefits, which creates opportunities for join forces to support their implementation. This report examines the possibilities for such win-win situations. It explores the linkages between climate change and typical sector objectives, and provides guidance on ways to use co-benefits to promote climate change mitigation measures and achieve an overall more sustainable development, optimizing economic, social and environmental objectives.

Guidance for policy makers on the political potential of co-benefits

The first section of this document explores the political potential of sustainable development benefits by identifying the linkages between policy objectives.

Key messages

- Identify potential synergies with other policy objectives
- Combine measures to maximise synergies
- Build coalitions and overcome barriers

1.1 Identify potential measures

Low-carbon transport strategies that – in addition to reducing Greenhouse Gas (GHG) emissions - help achieve further economic, social and environmental policy objectives, can have a far more extensive overall impact on sustainable development and count with more political support, than mitigation measures that solely focus on the reduction of GHG emissions (Eckermann et al. 2013). Only a few studies have actually examined the total cost of transport including congestion, air pollution, accidents, and noise, and therefore the total potential benefits of polices and programs that reduce these negative impacts. One example of the results of an estimation of positive impacts are the overall reductions of transport expenditures of a balanced sustainable transport policy in a 2 Degree Pathway that were assessed by the International Energy Agency of being up to USD 70 trillion by 2050 (IEA 2012). In another example from the local level, the combined benefits were assessed for Beijing to be between 7.5% to 15% of GDP annually (Creutzig and He, 2009).

The NAMA Handbook (Navigating Transport NAMAs – A practical handbook on Nationally Appropriate Mitigation Actions (NAMAs) in the transport sector developed by GIZ) identifies a range of potential sustainable development benefits (Figure 1), which are described in more detail in the following section.

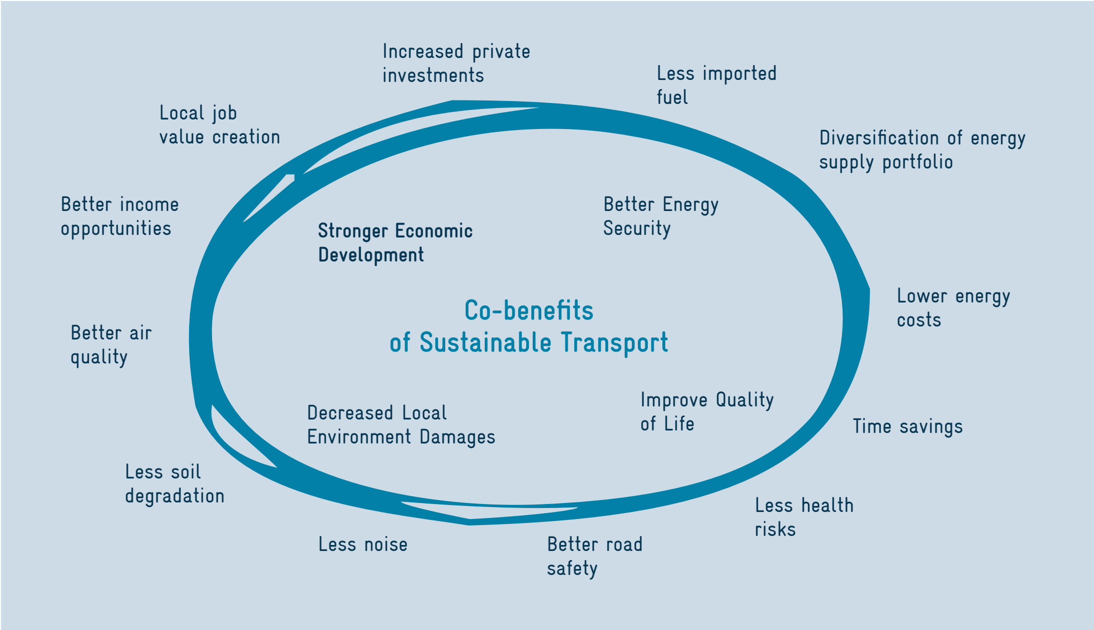


Figure 1: Co-benefits/ Sustainable Development Benefits Source: GIZ, 2015

When preparing arguments for a transport climate change mitigation measure it may help thinking about additional benefits that may be high on the agenda of important policy actors and stakeholders. Energy security, transport access and affordability, air quality, health and safety are all powerful policy objectives that need to be taken into account when designing integrated climate change mitigation strategies and Nationally Appropriate Mitigation Actions (NAMAs) that are geared towards a high level of synergies and co-benefits. The following section provides a short overview with some key messages related to each major sustainable development benefit (based on IPCC 2014):

Access and mobility are vital for individuals and businesses. Many transportation emission reduction strategies also reduce costs by improving affordable travel options including walking, cycling, ridesharing and public transit, and by creating more compact communities with shorter travel distances. Households living in automobile-dependent communities often spend 15-20% of their household budget on motor vehicles, but only 5-10% if they are located in more accessible and multi-modal communities (Isalou, Litman and Shahmoradi 2014; Mahadevia, Joshi and Datey 2013).

Air quality is another major issue to which low-carbon transport can make a positive contribution by reducing vehicle engine emissions such as sulphur oxides (SOx), nitrous oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), volatile organic compounds (VOC), toxic metals, and particulate matter (PM), the finer particles of which can cause cardiovascular, pulmonary and respiratory diseases.

Noise pollution affects individual health and quality of life. Noise is second only to air pollution in the impact it has on human health, creating hearing loss, heart disease, learning problems in children and sleep disturbance. In Europe alone noise generated by traffic is linked to more than 50,000 premature deaths every year (T&E 2008).

Congestion is a major issue in many urban areas and creates substantial economic cost. For example, it accounts for around 1.2% of GDP as measured in the UK (Goodwin 2004); 3.4% in Dakar, Senegal and 4% in Metro Manila, Philippines (Carisma and Lowder 2007); 3.3% to 5.3% in Beijing, China (Creutzig and He 2009); 1% to 6% in Bangkok, Thailand (World Bank 2002) and up to 10% in Lima, Peru (Kunieda and Gauthier 2007). Re-allocating space from roads and parking to more people centred-activities can further significantly improve the quality of live in cities.

Employment and economic impacts relate to a number of direct and indirect effects of sustainable transport, such as direct employment opportunities, e.g. in public transport or improved access to jobs and markets. Improved reliability of travel times for both people and freight can also contribute substantially to the attractiveness of cities and the ease of doing business.

Energy security is a key policy objective on the national level and transport plays a major role in this due to its almost complete dependence on petroleum products. Low-carbon transport can improve energy security for individuals, businesses and national economies (Leiby 2007; Shakya and Shrestha 2011). By improving affordable transport options, such as walking, cycling and public transit, low-carbon mobility also improves overall accessibility (people's ability to reach desired services and activities), particularly for physically and economically disadvantaged groups, as well as commuters, tourists and businesses (Banister 2011; Boschmann 2011; Sietchiping, Permezel, and Ngomsi 2012).

Public health benefits result from more active transport (cycling and walking). This is increasingly important due to increasingly sedentary lifestyles and resulting health problems such as diabetes. Although these modes incur risks, these tend to be offset by their health benefits, particularly if cities improve active transport conditions (Rabl and de Nazelle 2012; Rojas-Rueda et al. 2011). While some strategies towards modal shifts will have a direct mitigation effect, others such as the introduction of environmental zones may cause trade-offs, as they may ban efficiency, but polluting Diesel vehicles or re-direct traffic, which may increase trip length.

Road safety is also a major transport policy objective that many integrated climate change mitigation strategies can help achieve. Road accidents are estimated to kill around 1.27 million and injure between 20 to 50 million annually, mostly in developing countries (WHO 2011).

The IPCC (2014) pointed out that an integrated approach that addresses transport activity, structure, intensity and fuels is required for a transition towards a 2°C stabilisation pathway as well as generating sustainable development benefits (Table 1). Different types of mitigation actions tend to bring along different impacts and benefits. Policy makers interested in the implementation of mitigation actions and looking for specific co-benefits should take this into consideration when selecting and prioritizing mitigation actions for implementation. Mitigation actions in the transport sector can be grouped roughly into three categories. Strategies that **avoid** total motor vehicle travel, e.g. by creating more compact, multimodal communities, and providing incentives for travellers to **shift** from automobile to more resource-efficient modes (walking, cycling, ridesharing, public transit, telecommunications that substitute for physical travel, and delivery services) tend to provide the greatest total benefits, reflecting the high costs (both, internal and external) of motor vehicle travel and the road and parking facilities it requires. **Improving** motor vehicle fuel efficiency and shifting to alternative fuels, on the other hand, provides fewer co-benefits. Table 1 gives an overview of the three categories and the respective development benefits they bring along.

Table 1 A high-level overview of mitigation strategies and their potential economic, social and environmental co-benefits (based on IPCC, 2014)

Interven-tion level	Emission reduction approach	Sustainable development benefits (and risks for trade-offs)		
		Economic	Social	Enviromental
Activity	**Avoid** Reduce total vehicle travel by reduced trip distances e.g. by developing more compact, mixed com-munities and telework.	Reduced traffic and parking congestion (6,7). Road and parking cost savings Consumer sa-vings Energy security (1,2). More efficient freight distribution (14). Reduced stormwater management costs	Improved access and mobility, particularly for non-drivers, which improves their economic opportunities and productivity (9) Affordability (savings for lower-income households) Accident reductions	Ecosystem and health benefits due to reduced local air pollution (20). Reduced land consumption (7, 9). Potential risk of damage to vulnerable ecosystems from shifts to new and shorter routes (15,16).
Structure	**Shift** to low-carbon transport modes, such as public transport, walking and cycling	Improved productivity due to reduced urban congestion and travel times across all modes (6,7). Improved energy security (1,2).	More equitable mobility access and safety, particularly in developing countries (8). Reduced accident rates from improved walking and cycling conditions, and shifts from automobile to public transit (7,11). Total accidents can increase if extra safety measures for cyclists are not introduced (22). Reduced exposure to air pollution (7). Health benefits from shifts to active transport modes (7,12).	Ecosystem and health benefits due to reduced local air pollution (20).
Intensity	**Improve** the efficiency of the vehicle fleet and use	Reduced transport costs for businesses (4,5). Improved energy security (1,2).	Reduced fuel cost for individuals and transport operators (1,2). Health benefits due to reduced urban air pollution (20).	Ecosystem and biodiversity benefits due to reduced urban air pollution (20).
Fuels	**Reduce** the carbon content of fuels and energy carriers	Some measures may reduce the costs for businesses; others may increase (4). Improved energy security (reduction of oil dependency) (1,2). Reduce trade imbalance for oil-importing countries (3).	Lower exposure to oil price volatility risks (1,2). Electric and fuel cell powered vehicles give air quality improvements (13,20) and noise reduction (10) Potential increase in accidents due to electric vehicles (2-wheelers, cars, buses, trucks) being silent at low speeds (24). CNG and biofuels have mixed health benefits (19,20). A shift to diesel can improve efficiency, but tends to increase air pollution (23).	Electric and fuel cell vehicles Air quality improvements (13,20). Biofuels: Potential adverse effects on biodiversity, water and nitrification (24). Potential issues associated with sustainable supply of biofuels (21). Unsustainable mining of resources for technologies e.g. batteries and fuel cell (17,18).

References: 1: (Greene 2010); 2: (Costantini et al. 2007); 3:(Kaufmann, R.K., Dees, S., Karadeloglou, P., Sánchez 2004); 4: (Boschmann 2011); 5: (Sietchiping, Permezel, and Ngomsi 2012); 6: (Cuenot, Fulton, and Staub 2012, Lah 2014); 7: (Creutzig, Mühlhoff, and Römer 2012); 8: (David Banister 2008); 9: (D. Banister 2008; Geurs and van Wee 2004); 10: (Creutzig and He 2009); 11: (Tiwari and Jain 2012); 12: (Rojas-Rueda et al. 2011); 13: (Sathaye et al. 2011); 14: (Olsson and Woxenius 2012); 15: (Garneau et al. 2009); 16: (Wassmann 2011); 17: Eliseeva and Bünzli 2011; 18: Massari and Ruberti 2013; 19: (Takeshita 2012); 20: (Kahn Ribeiro et al. 2012). 21: (IEA 2011a), 22: (Woodcock et al. 2009) , 23: (Schipper and Fulton 2012), 24: (Sims et al. 2014,)

1.2. Combine measures to maximise synergies

Decision making on transport policy and infrastructure investments is as complex as the sector itself. Rarely ever will a single measure achieve comprehensive climate change impacts and also generate economic, social and environmental benefits. Many policy and planning decisions have synergistic effects, meaning that their impacts are larger if implemented together. It is therefore generally best to implement and evaluate integrated programs rather than individual strategies. For example, by itself a public transit improvement may cause minimal reductions in individual motorized travel, and associated benefits such as congestion reductions, consumer savings and reduced pollution emissions. However, the same measure may prove very effective and beneficial if implemented with complementary incentives, such as efficient road and parking pricing, so travellers have both **push and pull incentives** to shift from automobile to transit. In fact, the most effective programs tend to include a combination of qualitative improvements to alternative modes (walking, cycling, ridesharing and public transit services), incentives to discourage carbon-intensive modes (e.g. by efficient road, parking and fuel pricing; marketing programs for mobility management and the reduction of commuting trips ; road space reallocation to favour resource-efficient modes), plus integrated transport planning and land use development, which creates more compact, mixed and better connected communities with less need to travel.

A vital benefit of the combination of measures is the ability of integrated packages to deliver synergies and minimise rebound effects. For example, the introduction of fuel efficiency standards for light duty vehicles may improve the efficiency of the overall fleet, but may also induce additional travel as fuel costs decrease for the individual users. This effect refers to the tendency for total demand for energy decrease less than expected after efficiency improvements are introduced, due to the resultant decrease in the cost of energy services (Sorrell 2010; Gillingham et al. 2013, Lah 2014). Ignoring or underestimating this effect whilst planning policies may lead to inaccurate forecasts and unrealistic expectations of the outcomes, which, in turn, lead to significant errors in the calculations of policies' payback periods (WEC 2008, IPCC 2014). The expected rebound effect is around 0-12% for household appliances such as fridges and washing machines and lighting, while it is up to 20% in industrial processes and 10-30% for road transport (IEA 1998, 2013). The higher the potential rebound effect and also the wider the range of possible take-back, the greater the uncertainty of a policy's cost effectiveness and its effect upon energy efficiency (Ruzzenenti and Basosi 2008).

A number of studies emphasize that an integrated approach is vital to reduce transport-sector greenhouse gas emissions cost-effectively (IPCC 2014, Figueroa Meza et al. 2014). While emissions reductions can be achieved through several means, such as modal shift, efficiency gains and reduced transport activity, it is apparent that the combination of measures is a key success factor to maximise synergies and reduce rebound effects. For example, overall travel demand reduction and modal shifts would need to be substantially stronger if not accompanied by efficiency improvements within the vehicle fleet and vice-versa (Figueroa Meza et al. 2014; Fulton, Lah, and Cuenot 2013). Vital element for this strategy is a policy package as summarised in the table below.

Table 2: Elements of a multi-modal, multi-level sustainable transport package

Examples measures	Complementarity of measures
National Measures • Fuel tax • Vehicle fuel efficiency regulation • Vehicle tax based on fuel efficiency and/or CO2emissions	• Vehicles standards and regulations ensure the supply of efficient vehicles and taxation helps steering the consumer behaviour • Fuel tax encourages more efficient use of vehicles, which helps minimising rebound effects that might occur if individuals and businesses drive more or not as efficient as they would have driving a vehicles with lower efficiency standards
Local Measures • Compact city design and integrated planning • Provision of public transport, walking and cycling infrastructure and services • Road User Charging, parking pricing, access restritions, registration restrictions and number plate auctions, eco-driving schemes, urban logistics	• Compact and policy-centric planning enable short trips and the provision of model alternatives provides affordable access • Complementary measures at the local level help managing travel demand and can generate funds that can be re-disributed to fund low-carbon transport modes

1.3. Build coalitions for sustainable transport and climate change mitigation

An integrated policy approach can help to overcome implementation barriers, minimize rebound effects and create the basis for coalitions among key political actors and societal stakeholders.

It is sometimes claimed that transport is the hardest sector to decarbonise (ECMT 2007; IEA 2011b). However, cities, regions and countries around the world are successfully implementing polices and projects which provide substantial emission reductions in addition to other benefits. While currently implemented measures cannot by themselves achieve the established emission reduction targets, they can make important contributions. According to a recent IPCC Assessment Report, only an integrated approach can achieve the levels of reduction needed to shift to a 2°C pathway. This is true not only for the achievement of emission reduction goals, but also for the fulfilment of other sustainable development goals.

Reductions in traffic and parking congestion, increased energy security and traffic safety, affordability of transport services, public fitness and health, economic productivity, mitigation of climate change, and the reduction of local air pollution are positive impacts of transport policy that can help motivate people, businesses and communities to implement **comprehensive policies and integrated transport** programs to reduce transport greenhouse gas emissions and generate sustainable development benefits. Different people, groups and institutions may have different priorities, for example, some may be motivated by economic objectives and others by social equity or environmental objectives. The diverse benefits offered by a comprehensive or integrated measure can help build broad community support. The nature of integrated sustainable, low-carbon transport policies is that they address several objectives simultaneously, which generates synergies and helps creating coalitions.

Vital for the success of long-term policy and infrastructure decisions is support from diverse political actors, stakeholders and the public. A societal perspective and the incorporation of sustainable development objectives is a vital step in forging coalitions and building public support. Policy and infrastructure measures and the combination thereof are an important element in generating sustainable development benefits with low-carbon transport as they provide the content of a low-carbon transport strategy. But vital for the success of the take-up and implementation of measures is the policy environment – the context in which decisions are made (Justen et al. 2014). This context includes not only socio-economic, but also political aspects, taking into account the institutional structures of countries. The combination of policies and policy objectives can help building coalitions, but can also increase the risk of the failure of the package if one measure faces strong opposition, which, however, can be overcome if the process is managed carefully (Sørensen et al. 2014). A core element of success is the involvement at an early stage of potential veto players and the incorporation of their policy objectives in the agenda setting (Tsebelis and Garrett 1996).

Veto players are political actors who have a distinctive role in the policy process and put a hold to an initiative. Typical veto players are finance ministries and parliaments with legislative prerogatives. This is a substantially different role from **stakeholders**, who have a vested interested in a particular policy process, but do not have the (legal) power stop it. However, both groups need to be involved in the process to successfully implement a measure. **Public participation** can help ensuring durability and support beyond political parties.

1.4. Conclusion and recommendations

Considering that significant and diverse benefits can be gained from policies and projects that increase transport system efficiency, their uptake is far lower than economically justified. Shifting to a low-carbon development pathway requires substantial transport sector reforms. Many of these are options that provide significant economic, social and environmental co-benefits and so can conserve energy and reduce emissions at low or event negative costs. Because of their significant and diverse benefits, they offer opportunities to build coalitions involving many different stakeholders with various interests. This can help build support and strengthen the political case for the shift towards a low-carbon mobility pathway. Successful strategies need to be integrated across policy areas, regions and levels of government. One way of incorporating objectives of key players and include them in the process is to establish a cross-cutting working group (first in the department and then across departments and then across levels or government and including key business and civil society players). The table below provides some examples of linkages between climate change mitigation approaches, their linkages to some economic, social and environmental implications and examples of potential veto players and stakeholders. This matrix is mainly an illustrative example and needs to be amended for the specific context.

Coalition building: examples of potential linkages between climate and other sustainable development policy objectives and actors

Climate change mitigation approach and objective	Economic implications and actors	Social implications and actors	Environmental implications and actors
Avoid vehicle travel by reduced trip distances e.g. by developing more compact, mixed communities and telework.	**Reduced congestion:** Local authorities (v) ↑ **More efficient freight distribution:** Businesses and associations ↑ Economic development ministry (v) ↑	**Improved access and mobility** Social development ministry ↑ **Accident reductions** Health Ministry ↑	**Reduced land consumption** Local planning authority (v) ? →
Shift to low-carbon transport modes, such as public transport, walking and cycling	**Improved productivity due to reduced urban congestion and travel times across all modes** Local authorities (v) ↑	**Reduced exposure to air pollution** **Health benefits from shifts to active transport modes** Local authorities (v) ↑	**Ecosystem benefits due to reduced local air pollution.** Local environmental department & national ministry ↑
Improve the efficiency of the vehicle fleet and use	**Reduced transport costs for businesses and individuals** Local authorities (v) **and Economic and Social development ministries** ↑	**Health benefits due to reduced urban air pollution** Health Ministry ↑	**Ecosystem and biodiversity benefits due to reduced urban air pollution** Local authorities (v) ↑
Reduce the carbon content of fuels and energy carriers	**Improved energy security** Economic development Ministry ↑ **Reduce trade imbalance for oil-importing countries** Finance Ministry (v) ↑	**A shift to diesel can improve efficiency, but tends to increase air pollution** Health and Environment Ministries (v?) ↓	**Potential adverse effects of biofuels on biodiversity and land-use** Environment and agriculture (v) ↓

The selection is not exhaustive and depends on the policy environment. Key: positive ↑ negative ↓ uncertain → , (v) potential Veto

2. Policy advice and evidence on sustainable development benefits of low-carbon transport

Guidance for policy advisors and consultants

This section provides examples of the potential of sustainable development benefits of several low-carbon mobility actions and provides an overview on available tools that can help assessing these benefits

Key messages:

- Learn from the success (and failure) of others
- Assess all relevant impacts to maximise synergies and avoid trade-offs and show this evidence to the policy makers

2.1. Learn from others: case studies and examples

This section describes specific examples where sustainable development benefits have been evaluated. This will provide some relevant insights that can be used by decision makers and advisors as reference points for future projects that can be developed into a NAMA.

Congestion charging in Singapore

A congestion charging system was introduced in 1975 in Singapore, which boosted public transport patronage almost immediately and led to a 45% reduction in traffic, a 25% decrease in road site accidents, and an increase in average travel speeds from about 20 km/h to over 30 km/h (OECD & ECMT 2007). The system has been constantly upgraded and a number of supporting measures introduced. This led to public transport having a modal share of over 60% in daily traffic, an increase of nearly 20% (Ang 1990). The success of the system in improving infrastructure capacity, safety and air quality and reducing travel demand, fuel use and greenhouse gas emissions inspired the congestion charge systems in London and Stockholm and plans for similar systems in a number of other cities (Prud'homme & Bocarejo 2005).

Eco-tax and vehicle tax in Germany

Germany has implemented a number of relevant measures in recent years that combine fuel and vehicle taxation to improve the efficiency of the vehicle fleet, reduce frequency of journeys and influence modal choice. The following sections explore briefly the key policies that shape Germany's vehicle fleet and use. As part of the Ecological Tax Reform, petrol and diesel prices increased from 1999 to 2003 by € 0.0307 per litre and year (totalling an increase of € 0.1534 /l as of 2003). This internalized a part of the external costs and increased energy efficiency in the transport sector. By 2012 the energy tax on transport fuels was € 0.6545 /l on petrol, EUR 0.4704 /l on diesel and € 0.18 /kg on CNG and LNG (BMF 2012). Since January 2009, the motor-vehicle tax (annual circulation tax) includes a CO2 based calculation, but only applied to automobiles newly registered since then. It takes account of typical CO2 emissions for vehicles and has lower rates for automobiles that have especially low emissions. Additional to a taxation based on the engine size, there is a CO2 tax of € 2.0/g CO2 above 95 g. It was estimated that the implementation of the CO2 based motor-vehicle taxation will lead to GHG emission reduction of about 3 Mt CO2-eq per year by 2020. A key feature of fiscal policy measures is the ability to generate funds that directly contribute to other (non-environment related) objectives. In addition to the CO2 emission reduction benefits a number of other positive effects are being generated by the Eco-tax, for the measure was estimated to have contributed to the generation of over 250,000 jobs (Ecologic 2005). It has been assessed that over 70% of all vehicle users drive more efficiently and 20% are occasionally changing travel modes, which has direct safety, energy security and air quality benefits (Ecologic 2005).

TransMilenio in Bogota, Colombia

Bogotá's TransMilenio bus rapid transit (BRT) system is one of the most successful BRTs moving up to 36,000 passengers per hour in each direction. The implementation of TransMilenio was supported by a number of additional measures that formed an integrated package, which helped explain the high level of benefits across a number of policy areas. As well as nearly 1 million tCO2 saved annually, the system created substantial travel time savings, reduced operating cost for the bus company, and fewer crashes and injuries on two of the system's main corridors (Bocarejo et. al. 2012). Air quality improved substantially in the city since implementation with emission reductions of 43% in SO2 emissions, 18% in NOx, and a 12% in PM (Turner et. al. 2012). Road fatalities were reduced by over 80% and average travel times by 30% (Carrigan et al. 2013).

Metro in Delhi and Bangalore

High capacity public transport systems are a vital step towards a sustainable, efficient and livable city. Metro systems are currently being developed in a number of cities to create a backbone for efficient public transport systems. Compared to BRT systems MRT systems require higher investments, but can provide higher capacities and frequencies. The MRT systems in Delhi and Bangalore have been assessed for their potential to contribute to a number of objectives. The Bangalore Metro Rail Corporation estimated the combined benefits of the Bangalore Metro Rail to amount to Rs11,550 million (EUR 150M) of which traffic decongestion was estimated to contribute 33%, savings in travel time 28%, reductions in accidents 7.6%, reduced fuel consumption, 24%, and the reduction in local air pollution 5.8% (TERI/WBCSD 2009). The metro in Delhi was estimated to lead to an overall reduction of 2.3% (about 115 ktCO2-eq.) in CO2 emissions in the initial phase, with the potential of reductions up to 10% (463 ktCO2-eq) if full ridership could be achieved. At the lower end of the scenario the reduction in air pollution was estimated to amount to lower emissions of NOx (1143t to 2887t), PM (163t to 325t), CO (6545t to 13,089t) and HC (1951t to 3902t), thereby making a substantial contribution to local air quality.

Health benefits of active modes

The Health Economic Assessment Tool (HEAT) evaluated the financial returns of investments in cycling infrastructure through reduced mortality due to increased physical activity from walking and cycling. For example, in the Czech Republic, 2% of respondents in Pilsen would take up regular cycling and therefore increased annual mortality savings by €882,000. In Estonia, infrastructure improvements would create a new cycling route encouraging people to begin regular cycling. Consequently, avoidable deaths would be reduced by 0.17% per year. With the country-specific value of statistical life of € 1,430,000, a current average annual benefit would amount to €12,000 per year. The University of Auckland, New Zealand, estimated on the basis of HEAT, the benefits from 1,000 additional adult cyclists commuting regularly in the city. In result, a 17.5% lower mortality was estimated, saving €464,000, annually (Dora, et al., 2011).

Emissions standards for Heavy Duty Vehicles

A key policy focus for heavy duty vehicles is the reduction of local air pollutants, in particular NOx and PM10 emissions, which also ha implications to the fuel efficiency. The International Energy Agency estimated that the European, Japanese and US standards since the 1990s had a negative impact on heavy-duty vehicles leading to a 7% to 10% lower fuel economy (IEA 2009). A number of European countries have introduced environmental zones, which bans vehicles with high levels of particulate emissions from entering the city. To improve local air quality several cities have introduced truck routing systems, which, if planned properly, can potentially lower fuel consumption and local pollutant emissions (Suzuki 2011). However, depending on the design these systems may also increase trip length and hence greenhouse gas emissions (Bektas and Laporte 2011). Currently, only Japan has fuel efficiency standards for heavy vehicles in place, the US has proposed standards for trucks and buses, the EU, however has no standards in place for heavy-duty vehicles (Atabani et al. 2011).

Low-carbon fuel standards

Fuel standards can help managing the carbon content of alternative fuels. Examples include the Californian low-carbon fuel standard and the EU fuel quality directive (Sperling and Nichols 2012). While the shift towards low-carbon modes of transport is associated only with very limited risks with regard to unintended consequences, technology based options require a more comprehensive regulatory framework to avoid trade-offs with other policy objectives (Sims et al. 2014). Hence, setting standards for the carbon content to achieve the actual carbon emission reduction targets via biofuels, hydrogen and electricity (e.g. 10% for California and 6% for EU by 2020) and to ensure that, in particular biofuels meet wider sustainability standards to avoid trade-offs woth other policy objectives, such as food security and land-use. This requires life-cycle analyses, which can be very challenging to carry out in a reliable manner (Lutsey and Sperling 2012).

Overview of sustainable development impacts

The examples above provide some insights on the possible costs and benefits of specific mitigation measures. Some more facts and figures of assessments of policy and infrastructure measures are provided below to give a broader picture of available assessments of CO2 emission reduction and the sustainable development potentials. Although economic assessments of transport programs can vary significantly in their scope and analysis methods some illustrative examples are provided below in Table 2.

Table 2, Climate change mitigation measures, their CO2 emission reduction potential, and their contribution to other sustainable development objectives for the transport sector.

Strategy	Good practice cities/ projects	CO2 emission reduction	Sustainable development benefits (and risks for trade-offs)		
			Economic	Social	Environmental
Avoid					
Road user charging	Road charge in Peking: €0.14 /km (4)	London: 25% CO2 reduction	Travel time reductions: €0.17 mio.	Social costs : reduction: €144 million / year	Road tolls can be used for environmentally friendly projects
Avoid motorized trips	Trans-Jogja bus system, between 2010-2024 (6)	1.3 Mt CO2	Lower costs for transportation	Congestion and accident reduction, cost reduction for consumers	Estimated to avoid 3362 t PM10, 61,288 t CO, 10,645 t NOx, 1423 t SO2
Shift					
MRT	Metro in Delhi (3)		Time Savings: ~EUR 80,000	Value of air-pollution reduction (2011-2012): ~EUR 92 Mio.; Rate of return: 1.4%	Vehicles reduction in 2020: 381,006 cars, 2,521,685 2-wheelers, 17,374 buses
BRT	Trans Milenio Bogotá (2)	Reduction of carbon dioxide emission by 200.000 tons (in 3 years)	Rationalised bus system, 32% commuting times reduction, Increases employment	Access for disabled and poor, 90% lower accidents in BRT corridors	Air quality improvements
BRT	Trans Milenio Bogotá (7)	CO2 reduction 2006-2012 = 1.7 M tons	Monetarization of present benefits (2012): € 3,410 Mio	Fewer accidents: €263 Mio., Reduced travel times: €1,533 Mio.	Avoided CO2: €98 Mio.
BRT	Metrobús Line 3 Mexico City (7)		Monetarization of present benefits (2012): €177 Mio.	Fewer accidents: €21 Mio., Reduced travel times: €129 Mio.	Avoided CO2: €4.5 Mio.
BRT	BRT Cebu, feasible benefits over 20 years(10)	1.19 Mt CO2	Fuel saving: €537 Mio., Emissions reduction: €31 mio.	Time saving: 357 mio. hours, Reduction 960 fatalities, 14407 injuries	Reduced PM 232 t, NOx 1779 t, BC 109 t
BRT	BRT Line C-5 Manila (11)	Reduced CO2 / year:: ~ €60,000	Vehicle operating cost savings: ~€2.7 mio.	Time savings per year: ~ EUR 24 mio., Reduced loss of traffic accidents: ~ EUR 940,000	Reduced air pollution: NOx ~ EUR 1,100, PM ~ EUR 880
BRT	BRT Bangkok	Reduced CO2 / year: ~ €2.3 mio.	Vehicle operating cost savings: ~ €117 mio.	Time savings per year: ~ €78 mio.; Reduced loss of traffic accidents: ~ EUR 34 mio.	Reduced air pollution: NOx ~ 10,000 EUR, PM ~ 300 EUR
MRT	Walking and Cycling in Copenhagen: Cycle-friendly city (1)	Overall GHG emission reductions not quantified	Faster transport, Green jobs (650 full time in Copenhagen)	Increased physical activity, Reduced health impacts: 5.51 DDK/km (annually €268 million), reduced road accidents	Zero air pollutants, Less noise
Improve					
Emissions standards	Use EURO II norm in Delhi (3)	Emission reduction not quantified	Rs Mio 40,37 (~EUR 500,000) / year	Low emission zones: Less traffic, especially heavy duty vehicles in the city	Less emissions, less congestion
Vehicle replacement	Old buses with new ones (EURO IV) with ratio 2:1 in Trans-Jogja (6)	17874 t CO2 / year	Efficient vehicle (9-liter-per-100-kilometre) will reduce fuel by 1/3	Reduce congestion and delays	Reduction of 123 t NOx /year, 2 t PM10/ Year

Strategy	Good practice cities/ projects	CO2 emission reduction	Sustainable development benefits (and risks for trade-offs)		
			Economic	Social	Environmental
Heavy duty vehicle efficiency	Improved heavy duty trucks in Guangdong Province, China (8)	37.9 t /year / truck due to better tyres and aerodyna-mics	Lower costs		NOx: 0.239 tons, PM: 0.016 tons reduction /year / truck
Fuel switch	Shengyang Pu-blic Transport: Switch from old diesel bus to CNG, new diesel bus and hybrid/electric bus (9)	Medium to high potential for CO2 savings (no overall quantification)		Emission reduction, reduce congestion delays	Increase in CO2 and SO2 emissions if switch to hybrid/electric bus; decrease of emissions if switch to CNG, new diesel bus
Improved bike facilities	Bike infrastructure in University Novi Sad, Serbia (12)	Reduction of 1,845.9 kg CO2 per year	Income of ~ EUR 400 through adver-tisement on the bike parking infrastruc-ture	Supporting long-term behaviour	Lower ownership of vehicles and reduction of driving by 20-60%
Mixed approaches					
Sustain-able Low carbon transport concept	Indian Trans-port Sector (5)	CO2 Avoidance: ~1000Mt CO2 until 2050		Improvement of quality of life	Avoidance of an increase in PM levels

1: Copenhagen Bicycle Account (2010) 2: CDM Project Co-benefits in Bogotá, Colombia (2010) 3: Social Cost-Benefit Analysis of Delhi Metro (Murty, Dhalvala & Singh, 2006) 4: Creutzig & He (2009) Climate change mitigation and co-benefits of feasible transport demand policies in Beijing 5: Dhar & Shukla (2015) Low carbon scenarios for transport in India:Co-benefits analysis 6: Dirgahayani (2013) Environmental co-benefits of public transportation improvement initiative: the case of Trans-Jogja bus system in Yogyakarta, Indonesia 7: Embarq (2013) Social, Economic, Environmental impacts of BRT systems 8: Fabian (2008) Co-benefits: Linking low carbon transport to sustainable development 9: Geng et al (2013) Co-benefit evaluation for urban public transportation sector e a case of Shenyang, China 10: Gota & Mejia (2013) Assessing Co-benefits from BRT Projects 11: IGES (2011) Mainstreaming Transport Co-benefits Approach 12: Mrkajic et al (2015) Reduction of CO2 emission and non-environmental co-benefits of bicycle infrastructure provision: the case of the University of Novi Sad, Serbia. 12: Stompen et al. 2012, Reducing Carbon Emissions through Transport Demand Management Strategies.

2.2. Assess all relevant impacts to maximise synergies

There is significant potential for cost efficient emission reductions in the transport sector. Estimates suggest that, considering all benefits and costs, urban transport energy consumption and emissions could be reduced by 40-50% compared to current trends using currently available and cost effective measures (Eads 2010; IEA 2014; ITF 2013). The implementation of these transport measures would generate substantial efficiency gains, greenhouse gas emissions reductions and improved air quality and energy security (Leiby 2007; Mazzi and Dowlatabadi 2007). Yet, these strategies are not fully utilised, despite the large potential co-benefits and high cost efficiency.

One factor that affects the uptake of low-carbon transport measures is the inadequacy of economic evaluation advice that includes all relevant aspects of sustainable development. Compared to large-scale transport projects, such as highway construction, small but more sustainable concepts often lack the critical mass to allow for a thorough cost-benefit analysis. This section provides a short overview of economic evaluation methodologies, followed by an overview of tools that are available to assess the potential of urban mobility policies and projects.

Traditional impact assessment methodologies

To make informed decisions about transport infrastructure and policy options, local authorities with limited resources need clear guidance on costs, benefits and overall impacts. There is often insufficient knowledge of the costs and benefits of low-carbon transport measures which can affect the take-up of those measures. Socio-economic benefits of low-carbon transport measures may be underestimated and this uncertainty may be perceived as a risk since it can lead to decisions in favour of more traditional and often unsustainable transport infrastructures. Classic cost-benefit analysis (CBA) is a well-established methodology for infrastructure appraisal. However, since it requires substantial efforts with regard to data and analysis CBAs are usually only carried out for large-scale infrastructure measures such as road or rail construction projects. CBA has often been criticised for failing to incorporate important sustainable development objectives (Jacoby and Minten 2009).

One of the main advantages of CBA is its ability to describe the costs and benefits of a measure in a single cost-benefit ratio (CBR). As such CBA becomes a very useful tool for decision-making based on economic efficiency. However, CBA usually fails to properly incorporate all relevant environmental, social and economic benefits as not all of them can easily be monetised. As it is highly challenging to properly measure social factors such as quality of life, these issues are usually neglected in CBAs. Another disadvantage of CBA is the extensive data requirements and relative complexity. The lack of transparency and acknowledgements of interactions of policy objectives and distributional effects is another element that affects the reliability of CBA as a decision making tool. As an additional guidance tool for decision making processes multi-criteria analysis (MCA) can be useful. It allows the incorporation of qualitative evidence as opposed to CBA which can only process quantitative data (Beria, Maltese, and Mariotti 2012). Hence factors in decision making processes that may be harder to measure but are equally important can be included.

Tools to assess sustainable development benefits

A number of tools can help guide decision making processes for sustainable transport policies and infrastructures. These apply some of the approaches from traditional appraisal methodologies, but with lower data requirements and with a specific focus to highlight the ability of measures to contribute to sustainable development. The following section provides a short description of a selection of such tools that can help assess some of the co-benefits of sustainable urban mobility measures.

To assess the direct and indirect CO2 emission reduction potential the Transportation Emissions Evaluation Model for Projects (TEEMP) is a useful and relatively easy to use spreadsheet based tool, which also highlights some linkages to other sustainable development benefits, but does not provide proper assessments of those. The Rapid Assessment Tool, by UN-Habitat and ITDP builds on the TEEMP tool, aiming to add some further analysis on the wider costs, benefits and overall impacts of possible transport measures. The Co-benefits Calculator for Transport Projects developed by IGES provides a detailed step-by-step guidance also building on the TEEMP model.

Developed by the Wuppertal Institute for an EU- funded project, the TIDE impact assessment tool for urban transport innovations aims to combine the advantages of the quantitative and qualitative evidence to assess the impact of urban mobility measures. The methodology was designed to assess small-scale innovative projects. The TIDE handbook provides eight key steps from the project description, to the identification, analysis and testing of key performance indicators, to the visualisation and communication of the results. TIDE is Excel spreadsheet based and requires a number of standard input data, but also provides reference data based on other assessments

Table 3: A comparison of tools available to help assess economic, social and environmental benefits of low-carbon transport policies, technologies and infrastructures, and their climate and sustainable development objectives.

	Sustainable development benefits				
Tool and link	Data needs	CO2 emissions	Economic	Social	Enviromental
NAMA SD Tool (UNDP)	√ √		√	√	√
Co-Benefits calculator for Transport Projects (IGES)	√	√	√	√	√
Health Impact Assessment (HIA) in Transport Planning (CDC)	√ √ √		√ √ √		
The Co-benefits Evaluation Tool for the Urban Transport Sector (UNU-IAS)	√ √	√ √	√	√ √	√
Health economic assessment tool (HEAT) for cycling and walking (WHO)	√ √ √			√ √	
Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO)	√ √ √	√ √	√ √	√ √	√ √
Transport Emissions Evaluation Model (TEEMP) Clean Air Asia / ITDP	√ √	√ √ √			
Rapid-Assessment Tool (UN-Habitat)	√	√ √	√ √	√ √	√ √
CIVITAS cba tool (CIVITAS DYN@MO)	√		√	√ √	√
TIDE Impact Assessment Tool (Wuppertal Institute / TIDE project)	√ √	√ √	√ √	√ √	√ √
JOAQUIN (EU project)	√		√	√	√
Konsult (ITS Leeds)	√	√	√	√	√ √

Level of coverage of CO2 or SD benefits and data needs: high √√√, medium √√, low √, not covered –

2.3. Conclusion and recommendations

There is great economic, social and environmental potential in low-carbon transport. Providing advice with evidence on all those aspects is important to make informed decisions about all potential synergies, but also trade-offs with other sustainable development policy objectives. Using examples of cities that have tried comparable measures can help to illustrate the basic concepts of a policy or infrastructure measure. For this some of the examples provided in this paper may help. However, transferability remains a key issue in this regard and policy makers may have diverging views on which cities or countries are comparable. Ex-ante impact assessments can provide another important input into the decision making process. Vital for this is transparency on the data and assumptions that formed the basis for an assessment. Most of the tools explored in this paper are intended to provide advice during the policy process, which is what this publication is focusing on, but they can also be used to assess the impacts of measures ex-post. This is vital to sustain support for a particular measure or to make the case for an extension in scope or time and of course it is also an important source of information to others to take-up measures.

Bibliography

- An, F. et al. 2007. *Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update.* ICCT.
- Banister, D. 2008. “The sustainable mobility paradigm.” *Transport Policy* 15(2): 73–80.
- Banister, David. 2011. “Cities, mobility and climate change.” *Special section on Alternative Travel futures* 19(6): 1538–1546.
- 2008. “The Sustainable Mobility Paradigm.” *Transport Policy* 15(2): 73–80.
- Beria, P., I. Maltese, and I. Mariotti. 2012. “Multicriteria versus Cost Benefit Analysis: a comparative perspective in the assessment of sustainable mobility.” *European Transport Research Review:* 1–16.
- Boschmann, E.Eric. 2011. “Job access, location decision, and the working poor: A qualitative study in the Columbus, Ohio metropolitan area.” *Geoforum* 42(6): 671–682.
- Carisma, B., and S. Lowder. 2007. “Estimating the Economic Costs of Traffic Congestion: A Review of Literature on Various Cities & Countries.”
- Costantini, Valeria et al. 2007. “Security of energy supply: Comparing scenarios from a European perspective.” *Energy Policy* 35(1): 210–226.
- Creutzig, Felix, and Dongquan He. 2009. “Climate change mitigation and co-benefits of feasible transport demand policies in Beijing.” *Transportation Research Part D: Transport and Environment* 14(2): 120–131.
- Creutzig, F., R. Mühlhoff, and J. Römer. 2012. “Decarbonizing urban transport in European cities: four cases show possibly high co-benefits.” *Environmental Research Letters* 7(4): 044042.
- Cuenot, Francois, Lew Fulton, and John Staub. 2012. “The prospect for modal shifts in passenger transport worldwide and impacts on energy use and CO2.” *Energy Policy* 41: 98–106.
- Eads, G. 2010. 64 *50by50 Prospects and Progress Report for Global Fuel Economy Initiative.* Global Fuel Economy Initiative. http://www.globalfueleconomy.org/Documents/Publications/prospects_and_progress_lr.pdf.
- Eckermann, André et al. “Navigating transport NAMAs: a practical handbook on Nationally Appropriate Mitigation Actions (NAMAs) in the transport sector.”
- ECMT. 2007. *Cutting Transport CO2 Emissions: What Progress?* Paris: OECD. http://www.internationaltransportforum.org/Pub/pdf/07CuttingCO2.pdf.
- Figueroa Meza, Maria J. et al. 2014. “Energy for Transport.” *Annual Review of Environment and Resources* 39(1): null.
- Fulton, Lewis, Oliver Lah, and François Cuenot. 2013. “Transport Pathways for Light Duty Vehicles: Towards a 2° Scenario.” *Sustainability* 5(5): 1863–1874.
- Garneau, Marie-Ève et al. 2009. “Importance of particle-associated bacterial heterotrophy in a coastal Arctic ecosystem.” *Journal of Marine Systems* 75(1–2): 185–197.
- Geurs, Karst T., and Bert van Wee. 2004. “Accessibility evaluation of land-use and transport strategies: review and research directions.” *Journal of Transport Geography* 12(2): 127–140.
- Goodwin, P. 2004. *The economic costs of road traffic congestion.* London, UK.: UCL (University College London), The Rail Freight Group.
- Greene, David L. 2010. “Measuring energy security: Can the United States achieve oil independence?” *Energy Policy* 38(4): 1614–1621.
- IEA. 2012. 690 *Energy Technology Perspectives 2012.* Paris: International Energy Agency.
- 2011a. 56 *Technology Roadmap. Biofuels for Transport.* Paris: International Energy Agency. http://www.iea.org/publications/freepublications/publication/bioenergy.pdf.
- 2009. 418 T*ransport, Energy and CO2: Moving Toward Sustainability.* Paris, France: International Energy Agency.
- 2011b. W*orld Energy Outlook 2011*. Paris: International Energy Agency, OECD/IEA.
- ITF. 2009. “Reducing Transport GHG Emissions: Opportunities and Costs.” http://www.internationaltransportforum.org/Pub/pdf/09GHGsum.pdf.

- Jacoby, H.G., Minten, B. 2009. "On measuring the benefits of lower transport costs." *Journal of Development Economics* 89(1): 28–38.
- JICA. 2005. *The Master Plan for Lima and Callo Metropolitan Area Urban Transportation in the Republic of Peru; Chapter 6, Traffic Control and Management Conditions.* Transport Council of Lima and Callo, Ministry of Transportation and Communications of the Republic of Peru.
- Kahn Ribeiro, S. et al. 2012. "Energy End-Use: Transportation." In T*he Global Energy Assessment: Toward a more Sustainable Future,* IIASA, Laxenburg, Austria and Cambridge University Press, United Kingdom and New York, USA, p. 93.
- Kaufmann, R.K., Dees, S., Karadeloglou, P., Sánchez, M. 2004. "Does OPEC matter? an econometric analysis of oil prices." *Energy Journal* 25(4): 67–90.
- Kunieda, Mika, and Aimée Gauthier. 2007. *50 Gender and Urban Transport: Smart and Affordable — Module 7a. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities.* Eschborn, Germany: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ).
- Lah, O. 2014. "The Barriers to Vehicle Fuel Efficiency and Policies to overcome them." *European Transport Research Review.*
- Leiby, P.N. 2007. "Estimating the Energy Security Benefits of Reduced U. S. Oil Imports." *Estimating the Energy Security Benefits of Reduced US Oil Imports.*
- Lutsey, Nicholas, and Daniel Sperling. 2012. "Regulatory adaptation: Accommodating electric vehicles in a petroleum world." *Energy Policy* 45: 308–316.
- Mazzi, E.A., Dowlatabadi, H. 2007. "Air quality impacts of climate mitigation: UK policy and passenger vehicle choice." *Environmental Science and Technology* 41(2): 387–392.
- Olsson, Jerry, and Johan Woxenius. 2012. "Location of Freight Consolidation Centres Serving the City and Its Surroundings." *Procedia - Social and Behavioral Sciences* 39(0): 293–306.
- Rabl, Ari, and Audrey de Nazelle. 2012. "Benefits of shift from car to active transport." *Transport Policy* 19: 121–131.
- Rojas-Rueda, David et al. 2011. "The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study." *British Medical Journal* 343: 1–8.
- Ruzzenenti, F., and R. Basosi. 2008. "The rebound effect: An evolutionary perspective." *Ecological Economics* 67(4): 526–537.
- Sathaye, J. et al. 2011. "Renewable Energy in the Context of Sustainable Development." In I*PCC Special Report on Renewable Energy Sources and Climate Change Mitigation*, eds. O. Edenhofer et al. Cambridge, UK and New York, NY, USA: Cambridge University Press.
- Schipper, Lee, and Lew Fulton. 2012. "Dazzled by diesel? The impact on carbon dioxide emissions of the shift to diesels in Europe through 2009." *Energy Policy* 54: 3–10.
- Shakya, Shree Raj, and Ram M. Shrestha. 2011. "Transport sector electrification in a hydropower resource rich developing country: Energy security, environmental and climate change co-benefits." *Energy for Sustainable Development* 15(2): 147–159.
- Sietchiping, Remy, Melissa Jane Permezel, and Claude Ngomsi. 2012. "Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements." *Special Section: Urban Planning in Africa* (pp. 155-191) 29(3): 183–189.
- Sims R., R. Schaeffer, F. Creutzig, X. Cruz-Núñez, M. D'Agosto, D. Dimitriu, M.J. Figueroa Meza, L. Fulton, S. Kobayashi, O. Lah, A. McKinnon, P. Newman, M. Ouyang, J.J. Schauer, D. Sperling, and G. Tiwari, 2014: Transport. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.). "Transport." In *Cambridge University Press, Cambridge, United Kingdom and New York*, NY, USA.,.
- Sperling, D., and M. Nichols. 2012. "California's Pioneering Transportation Strategy." http://www.issues.org/28.2/sperling.html.

- Takeshita, T. 2012. "Assessing the co-benefits of CO2 mitigation on air pollutants emissions from road vehicles." *Applied Energy* 97: 225–237.
- Tiwari, G., and D. Jain. 2012. "Accessibility and safety indicators for all road users: Case study Delhi BRT." *Journal of Transport Geography* 22: 87–95.
- Wassmann, Paul. 2011. "Arctic marine ecosystems in an era of rapid climate change." *Progress In Oceanography* 90(1–4): 1–17.
- WHO. 2008. 151 E*conomic valuation of transport related health effects Review of methods and development of practical approaches with a special focus on children.* Copenhagen, DK: World Health Organization Regional Office for Europe. http://www.euro.who.int/__data/assets/pdf_file/0008/53864/E92127.pdf.
- 2011. *Global Status Report on Road Safety.* World Health Organization.
- Woodcock, James et al. 2009. "Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport." *The Lancet* 374(9705): 1930–1943.
- World Bank. 2002. *Cities on the move : a World Bank urban transport strategy review.* Washington, D.C.: The World Bank.

Items from named contributors do not necessarily reflect the views of the company/the editors.

Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

T 06196 79 1997
F 06196 79 80 1997

E transfer@giz.de
I http://transport-namas.org

Author:
Oliver Lah

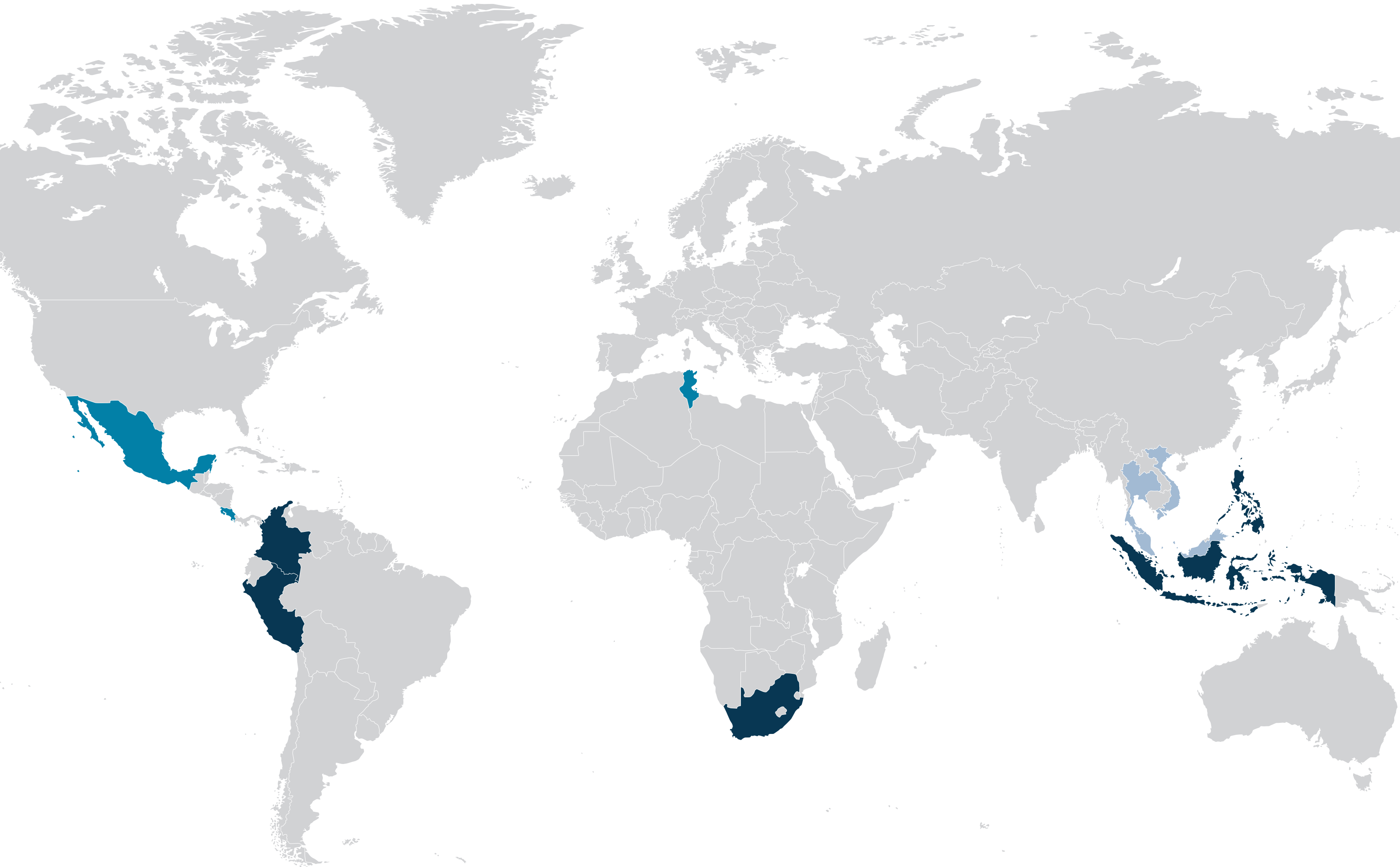
Editors:
Frank Krämer, Carolin Capone

Picture credits / Sources
Text

Design:
Joan-Carolin Paetz

Maps
The geographical maps are for information purposes only and do not constitute recognition under international law of boundaries and territories. GIZ does not guarantee in any way the current status, accuracy or completeness of the maps. All liability for any loss or damage arising directly or indirectly out of their use is excluded.

Printed and distributed by
December 2015
Printed on 100% recycled paper, certified to FSC standards.



Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Sitz der Gesellschaft
Bonn und Eschborn

Friedrich-Ebert-Allee 40
53113 Bonn, Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de
I www.transport-namas.org