MRV of cycling

Measuring the carbon impact of bicycle policy and infrastructure

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Content

Summary

Transport is one of the most significant contributors to greenhouse gas emissions and air pollution in cities, and therefore mitigation actions in urban transport are important. Data from cities in the Netherlands and Denmark, countries that combine a high car ownership with a substantial share of cycling, show that cycling can significantly reduce transport-related greenhouse gas emissions. Although cycling is becoming an integral part of non-motorised transport policies, also in some developing countries, a lot of the potential growth of cycling in urban areas remains untapped.

Since cycling is a means of reducing emissions, projects promoting cycling should be able to access climate finance. So far, transport has been largely neglected by the established emission trading mechanisms. For example, while transport is the source of 22% of global emissions, it accounts for only 0.4% of reductions under the Clean Development Mechanism (CDM).[1] The number of CDM projects that specifically target cycling is zero.

One of the reasons for this imbalance is the difficulty in forecasting and monitoring the impact of transport projects. This paper concludes that quantifying emission reductions in transportation as a result of cycling is possible and there are a number of suitable tools and approaches available.

The monitoring, reporting and verifying (MRV) of emission reductions from cycling projects requires quantifying the number of kilometres cycled and identifying the alternative mode. The alternative mode is the form of transport that would have been used by cyclists had the cycling project not been implemented. Three different approaches to the MRV of cycling can be distinguished:

1. Forecast of a baseline from historical data
2. Use of a transportation mode choice model to determine modal split for both the project scenario and baseline scenario
3. A travel diary survey of bicycle users, gathering trip length information and asking respondents to state the alternative mode that they would have otherwise used

The forecast and mode choice approaches are appropriate for larger scale policy projects in cities where some transport data is already being collected. The survey of bicycle users approach works well for small specific projects, or where limited transportation data is available.

Traditional data collection methods, like surveys, are gradually being replaced with new technological solutions. GPS and mobile phone technology offer potential for seamless and more accurate data collection and processing. However, this technology is still under development, and may not be effective in cities where smartphone usage is not yet common in the target group.

Translating transportation data into emissions is a relatively straightforward last step for calculating the emission reductions from cycling projects. Methodologies from the Verified Carbon Standard (VCS) and the CDM provide clear steps for the translation into emissions of the motorised transportation use in the alternative mode. TEEMP models are based on Excel sheets that can be downloaded free of charge. With both a "sketch" model, and a "full" model, this tool allows for either a quick estimate of emissions of a cycle project, or a full calculation based on the forecast approach.

This paper acknowledges that climate change is seldom the primary driver for supporting cycling in cities in developing countries. Reducing air pollution and congestion, solving parking problems, promoting active lifestyles and associated health benefits, or socio-economic reasons often rank higher on the list of arguments in favour of cycling. The benefits of cycling and the barriers to cycling are identified, aimed at supporting policy-makers at city level with their ambition to advance cycling.

[1] UNEP Risø pipeline, May 2013.

1. Introduction

As cycling gains increasing recognition as a sustainable urban transportation solution and new mechanisms for international climate change financing are developed, an opportunity exists for cities to mobilise climate finance to finance cycling projects. In order to take advantage of this source of finance, cities need to put in place a system for the MRV of emission reductions. Determining the climate impact of cycling requires data and modelling tools. Various modelling tools have become available over the last few years and also the technology to gather transport data is advancing quickly.

In 2010 the transport sector was responsible for 22% of global CO_2 emissions worldwide.[2] Transport related CO_2 emissions are expected to increase by 57% in the time frame 2005 to 2030, making it the fastest growing source of greenhouse gas emissions.[3] More than 80% of estimated growth in transport emissions is expected to come from road transport in emerging economies.[4]

There are various negative externalities that come with the rapid motorisation of transport in emerging economies: traffic congestion, increased greenhouse gas emissions and air pollution to a level that harms not only public health, but also tarnishes a city's reputation and its ability to attract domestic and foreign investments. Moreover, betting on motorised transport has a tendency to marginalise the poor and fails to ensure personal mobility across all income groups. Particularly in developing countries, the poor are hampered in their mobility and typically spend high proportions of their disposable income on transport. Finally, fossil fuel imports or subsidies place a heavy burden on the economies or government budgets of many developing countries.

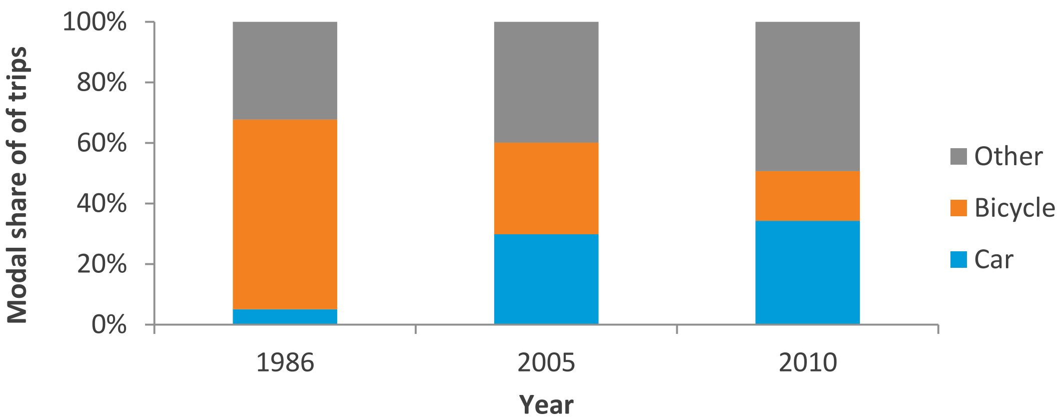

Figure 1: Modal share of cars and bicycles in Beijing 1986-2010.[5]

The negative effects of an increase in car ownership have already been seen in China. While the bicycle has long been an important cultural icon and transportation mode, the world's most populous country only saw a switch from bicycle to car at the end of the last century. In Beijing, the mode share of cycling decreased by more than half from its peak at 63 % in 1986 to 16% in 2010 (Figure 1). At the same time, the car share increased from 5% to 34%.[6] However, faced with heavy traffic congestion and air pollution, in part created by increased car usage, Chinese cities are now turning back to the bicycle as a solution to these problems.[7,8]

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[2] IEA "CO_2 Emissions from Fuel Combustion - 2012 Edition" (2012) Paris: International Energy Agency
[3] UITP "Public Transport and CO_2 Emissions" www.uitp.org/news/pics/pdf/MB_CO23.pdf
[4] IEA "Transport, Energy and CO_2: Moving Towards Sustainability" (2009) Paris: International Energy Agency
[5] Mingying, A., Grabowski, T., Bongardt, D. (2012) Transport Demand Management in Beijing: Work in Progress.
[6] Mingying, A., Grabowski, T., Bongardt, D. (2012) Transport Demand Management in Beijing: Work in Progress.
[7] Earth Policy Institute (2008) www.earth-policy.org/index.php?/indicators/C48/
[8] Mingying, A., Grabowski, T., Bongardt, D. (2012) Transport Demand Management in Beijing: Work in Progress.

Continuing urbanisation, particularly in the developing world, means that crucial urban policy and planning decisions will need to be made in the near future. This will provide cities in developing countries with an opportunity to develop the potential of cycling as a convincing mitigation action, by avoiding the negative externalities of the rapid increase of car use that many other cities have experienced in the past.

Investing in cycling makes economic, transport, health and environmental sense. An IEA study confirmed that there is a strong correlation between government spending on cycling and the mode share, the share of kilometres travelled with a certain type of transport, of cycling in a certain region.

Table 1: Correlation between cycling infrastructure funding and cycling overall mode share.[9]

	Annual funding (USD per resident)	Cycling mode share
USA	1.5	1%
Portland, USA	3.5	4%
Berlin, Germany	6	10%
Copenhagen, Denmark	13	20%
Amsterdam, Netherlands	39	35%

1.1. A role for climate finance

In its broadest sense, climate finance refers to financial flows that target low-carbon development, including the reduction of greenhouse gas emissions, the removal of and sequestration of CO_2, as well as climate-resilient development (the adaptation to the impacts of climate change). This includes financing from the compliance and voluntary carbon markets. Under the Copenhagen Accord, developed countries also committed to deliver climate finance, which includes two components:

- A "fast start" investment of USD 30 billion for the years 2010-2012; and
- A commitment of USD 100 billion per year by 2020.

The findings of a recent WRI[10] report have disclosed that between 2010 and 2012, USD 35 billion of fast start finance was mobilized, exceeding the original commitment.

Climate finance typically takes the form of results-based-payment, where donors seek a degree of upfront clarity on the climate benefits that a project can deliver, and an ex-post verification of the actual climate benefits delivered. Climate finance comes from both public and private sources. Public sources include direct finance from governments and ministries, as well as intermediary finance from development institutions and banks. In 2012, USD 337 billion out of a total of USD 359 billion in climate finance was invested in mitigation. With the lion´s share going to renewables, the transport sector still received around USD 19 billion for sustainable transportation, notably for modal shift.[11]

The design of consistent cycling policies in developing countries can draw on the experience of other countries, both developing and developed countries alike. The design of climate finance mechanisms, such as Nationally Appropriate Mitigation Actions (NAMAs), is geared towards government cooperation, capacity-building technology transfer and finance.

[9] IEA, Transport Energy and CO_2, 2009.
[10] ODI, WRI, IGES, OCN, Mobilising International Climate Finance: Lessons from the Fast-Start Finance Period (2013).
[11] Buchner et al. (2013). The Global Landscape of Climate Finance 2013. Climate Policy Initiative Report. www.climatepolicyinitiative.org.

Table 2: Sources of climate finance.[12]

Sources and intermediaries		Mitigation (USD billion)	Adaptation (USD billion)	Total (USD billion)
Private flows	Project developers	102	n/a	102
	Corporate actors	66	n/a	66
	Households	33	n/a	33
	Commercial financial institutions	0.4	n/a	0.4
		21	n/a	21
	Venture Capital; Private Equity and infrastructure funds	1.2	n/a	1.2
Public flows	Government budgets	9	3	12
	National development banks	61	8	69
	Multilateral development banks	31	7	38
	Bilateral finance institutions	12	3	15
	Climate funds	1.0	0.6	1.6
Total		337	22	359

1.2. The need for MRV

Access to climate finance typically requires a sound MRV approach. The MRV for transport projects is complex, but this should not prevent transport projects from accessing climate finance. In addition, MRV provides an insight into the transport dynamics in a city, which can be used to develop more effective transport policies.

This report presents an assessment of the different MRV solutions for transport. It starts with an introduction on current cycling trends followed by a discussion of the co-benefits of cycling, and an introduction on cycling as part of broader transportation policies. Finally, the report presents an overview of different MRV options, including the different approaches, data collection methods and tools used to translate transportation data into emission reductions.

[12] Buchner et al. (2013). The Global Landscape of Climate Finance 2013. Climate Policy Initiative Report. www.climatepolicyinitiative.org

2. Cycling: a global trend

2.1. Policy and infrastructure

Governments are putting greater emphasis on initiatives to promote cycling through urban policy and infrastructure investments. Paris launched the Vélib' bicycle sharing system in 2007 and has since built one of the largest bicycle share networks in the world. New York City has put significant emphasis on cycling in its sustainable city master plan "PlaNYC." Its Citi Bike bicycle share network was launched in 2013 with over 4,000 bikes. Since 2009, the city has also doubled the size of its bicycle network by building 320 extra kilometres of bicycle lanes.[13] But these developments are not limited to Europe and the United States. With a major initiative led by progressive mayor Enrique Peñalosa, Bogotá spent USD 180 million on bicycle infrastructure between 1990 and 2002 and currently has more than 300 km of dedicated bicycle paths. This initiative has helped in increasing the modal share of bicycle trips from 0.58% to 4.4% between 1996 and 2003.[14]

Smaller cities are also developing cycling programmes. The world map of bike-sharing schemes from the European Cycling Federation shows that bike sharing is developing in small and medium-sized cities as well. [15] The EU is targeting smaller cities with its PRESTo programme, which focuses on promoting cycling in five smaller European cities (Bremen, Grenoble, Tczew, Venice and Zagreb).[16]

2.2. Community action and grassroots support

However, sound cycling policies and infrastructure alone are insufficient. Community support is needed to encourage people to actually change their transport behaviour. Grassroots initiatives for cycling are also increasing. Critical Mass, for example, is a worldwide movement engaged in getting groups of cyclists to ride together through the city and assert their strength in large numbers. In Cuenca, Ecuador, 4,200 cyclists turned up for the "Pedealeando" event in 2012, and this number doubled in 2013. In Mexico City, an activist group used crowd-sourced funds to paint its own "cycle priority" lanes leading to the capital. More than 80 organisations have come together to petition the Mexican government to commit 5% of the transportation budget to bicycle and pedestrian projects.[17]

With the highest rate of cycling in Europe,[18] the Netherlands and Denmark are often cited as examples where sound cycling policies coincide with high modal shares of cycling. Even so, success in these countries has required a combination of government policy and community support. Cycling has been an important part of national transportation planning and policies since the 1970s.[19] Nevertheless, this would not have been the case had it not been for the mass protests against the increasing dangers of cycling due to car-oriented policies in the 1960s and 1970s.

In addition to bicycle advocacy groups, bike shops - sometimes organised as cooperatives - are taking up the role as a hub for the local bicycle community. Their missions vary from providing affordable bicycles,

[13] NYC Department of Transportation
[14] Cervero, R., Sarmiento, O., Jacoby, E., Gomez, L., and Neiman, A. (2009) Influences of Built Environments on Walking and Cycling: Lessons from Bogotá. International Journal of Sustainable Transportation 3:203-226.
[15] For further information, see: www.bikesharingworld.com
[16] For further information, see: www.presto-cycling.eu
[17] IADB (2013). Biciudades 2013 Regional study on the use of the bicycle as a mode of transportation in Latin America. Inter American Development Bank.
[18] ECF cycling barometer, available at: www.ecf.com/news/the-first-eu-wide-ecf-cycling-barometer-launched/
[19] John Pucher, Ralph Buehler . Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. Transport Reviews. Vol. 28, Iss. 4, 2008

parts, and repair services, to offering bicycle repair and maintenance education, and increasing awareness for bicycling and advocacy.[20]

The list of global bicycle initiatives extends across a wide range of localized initiatives to national and supra-national advocacy organisations. Maya Pedal, in San Andrés Itzapa, Guatemala uses bicycle technology to build "Bicimaquinas" (pedal powered machines) that are designed to save time, human energy and electrical energy.[21] The Velo-Almaty initiative group[22] aims to "provide an environment and culture where cycling is a safe, viable and preferred mode of transportation in the Almaty city." Partners for Active Living in Spartanburg, SC, USA seeks to promote cycling as part of a larger strategy to improve health through daily activity.[23] Finally, on a continental scale, the European Cyclists Federation is an advocacy organisation dedicated to promoting cycling in Europe.[24] Its activities include lobbying, networking and cycling research projects.

2.3. Barriers

Despite the level of attention cycling receives at the political level and from communities, there exists significant barriers to giving cycling a prominent place in urban transport. A number of barriers at the individual level are perceived to be deterring travellers or commuters from adopting cycling as their main mode of transport. Other barriers arise at the institutional level, affecting city authority to implement policies and develop suitable and safe infrastructure.

Barriers influencing the choice for cycling include, among others, safety, cultural perception, costs, environmental factors and physical ability. Cycling, especially when roads are shared with cars, is perceived as being dangerous. For example, studies have found that 60% of the British population who are able to cycle cited road safety as a deterrent.[25] This barrier concerns both actual and perceived safety. Cultural perception is another barrier. Often, cycling is seen as a "low status" transportation mode, used only by low-income people and avoided by those who want to be associated with higher socio-economic status. Another cultural barrier is that cycling has traditionally been seen as a recreational activity rather than a transportation mode.

The cost of buying and maintaining a bicycle, as well as the knowledge on how to maintain a bicycle, is a barrier among lower income groups. Barriers to cycling include environmental factors, such as extreme hot or cold weather, wind, rain and snow. Finally, a person must be physically able to cycle, which is a combination of physical strength and learning how to ride a bicycle. This barrier can often be overcome with training courses.

Transport policy-makers tend to overlook cycling or give it less attention than it deserves.[26] This is, in turn, reflected in national and regional budgets.

[20] For further information, see: www.bikecollectives.org
[21] For further information, see: www.mayapedal.org
[22] For further information, see: www.veloalmaty.kz
[23] For further information, see: www.active-living.org
[24] For further information, see: www.ecf.com
[25] Thornton, A. et al. (2011) Climate Change and Transport Choices. Department for Transport. London.
[26] European Conf on Metropolitan Transport (ECMT), 2004 National Policies to Promote Cycling in OECD countries

3. Benefits of cycling

Overcoming the barriers to cycling allows people access to the benefits that cycling brings. Cycling is good for public health, the environment and often brings socio-economic benefits. In particular, these co-benefits are often the main driving force for policy-makers to advance cycling in urban areas facing urgent problems with traffic congestion and air pollution.

3.1. Health

The health benefits of cycling significantly contribute to a positive cost-benefit ratio.[27] The positive impact of cycling on health includes health effects related to physical activity, safety and air quality.

Physical inactivity is a major contributor to health costs and is estimated at EUR 150 to EUR 300 annually per citizen in the EU alone. The physical activity that cycling requires has significant health benefits, including decreasing the risk of cardiovascular disease and diabetes, weight control and mental wellbeing.[28, 29]

Research shows that bicycling leads to fewer premature deaths and increased life expectancy when compared to the same distance travelled by car.[30] This is because the health benefits of cycling outweigh the safety risks. Policy-makers recognise these health benefits. An analysis of the health survey conducted by Capital Bikeshare users in Washington, DC supported the recommendation to pursue health-related grants, based on the positive health impacts of cycling. A British study showed that increasing the "walkability" and "cycleability" of the built environment was among the top five policies to reduce obesity.[31]

There is a strong correlation between the amount of cycling in cities or countries and safety. Countries with a higher modal share of cycling (such as the Netherlands and Denmark) tend to have a lower fatality rate than countries with a lower share of cycling (such as the United States and the United Kingdom.[32]

Finally, as an alternative to motorised transport, cycling can contribute to improving air quality, which in turn can have a positive effect on health.

3.2. Environment

Cycling benefits the environment when bicycles are used instead of a motorised transportation mode. A modal shift from car to bicycle leads to a reduction in the negative externalities of individual motorised transportation, including greenhouse gas emissions, congestion, noise and the need for parking space. Greenhouse gas emissions are directly related to the amount of fuel used for transportation. The land use effects include increased temperatures caused by paved surfaces (the heat island effect), watershed

[27] Cavill et al. (2008). Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review. *Transport Policy*, vol. 15(2008):291–304

[28] ECF: www.ecf.com/advocary/health-and-environment/physical-activity/

[29] Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger-Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review. Scandinavian Journal of Medicine & Science in Sports, 21(4), 496-509.

[30] Teschke, K., C.O. Reynolds, F.J. Ries, B. Gouge, and M. Winters (2012). Bicycling: Health Risk or Benefit. University of British Columbia Medical Journal, 3(2), 6-11.

[31] Government Office for Science, 2007 Foresight Tackling Obesities: Future Choices London 2007.

[32] European Cycling Federation. Fact Sheet: Safety in Numbers. www.ecf.com/advocary/road-safety

degradation, loss of green space and contribution to urban sprawl.[33] While cycling infrastructure includes paved roads, much less space is needed to accommodate the same number of travellers.

In very large urban areas in the United States, the estimated cost of congestion in 2011 was between USD 837 and USD 1,128 per auto commuter.[34] Noise from automobile traffic has been estimated to cost USD 0.006 per vehicle kilometre.[35]

Recent data from the new bicycle share systems has shown that promoting bicycle use can indeed lead to a modal shift from car use. Capital Bikeshare in Washington, DC reported that each of their 22,000 users incurred an average reduction of 320 car kilometres per year, equal to a total of 7.1 million kilometres.[36]

3.3. Socio-economic

Providing access to cycling can increase social equality and treats those who cannot afford a car as valued travellers. Bicycle infrastructure is much cheaper to build per kilometre than automobile infrastructure and generally provides a high return on investment.[37] Bicycle parking is cheaper because it uses space more efficiently than automobile parking.

Taking into account factors such as road congestion, traffic patterns and public transportation characteristics, cycling is often a faster option for short urban trips and represents travel time benefits. Data from trip times observed in the Boston bike share program indicate that cycling tends to be faster than public transportation for the same points of origin and destination.[38] Data from the Vélo′v bike share program in Lyon show that the average speed of bike share trips is 10-15 km/h, similar to, if not slightly faster than, average car speeds in inner cities across Europe.[39]

Cycling can also benefit the local business community and has been shown to increase consumer spending in some downtown commercial centres. Although research is not entirely conclusive, there are several studies that support this claim and little evidence to the contrary. While cyclists often spend less per trip, they have a higher monthly trip rate leading to higher monthly spending.[40,41] For example, businesses on 8th and 9th Avenue in New York saw a 50% increase in sales following the implementation of protected bike lanes, and two-thirds of merchants on Valencia street in San Francisco said that bicycles have been good for business.[42]

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[33] Litman, T. (2002). Transportation Cost Analysis: Techniques, Estimates and Implications. Victoria Transport Policy Institute. Victoria, BC, Canada.

[34] Texas Transportation Institute (2012). Urban Mobility Report Powered by INRIX Traffic Data. http://mobility.tamu.edu/ums/national-congestion-tables/

[35] Schreyer, C., C. Schneider, M. Maibach, W. Rothengatter, C. Doll, and D. Schmedding (2004). External Costs of Transport: Update Study. INFRAS (www.infras.ch) and IWW (Institut für Wirtschaftspolitik und Wirtschaftsforschung, or [translated] Institute for Economic Policy and Research).

[36] LDA Consulting (2013). 2013 Capital Bikeshare Member Survey Report.

[37] Cycling Vision Ottawa. The fiscally conservative argument for bicycle infrastructure – Part One. http://www.cycling-vision.ca/resources/research/bicycle-infrastructure-pt1.html

[38] Chiraphadhanakul, V. (2012). A network analysis of hubway. http://hubway.virot.me/

[39] Jensen, P., Rouquier, J. B., Ovtracht, N., & Robardet, C. (2010). Characterizing the speed and paths of shared bicycle use in Lyon. Transportation research part D: transport and environment, 15(8), 522-524.

[40] Clifton, K., Currans, K. M., Muhs, C. D., Ritter, C., Morrissey, S., & Roughton, C. (2012). Consumer Behavior and Travel Choices: A Focus on Cyclists and Pedestrians. In 92nd Annual Meeting of the Transportation Research Board. Accessed (pp. 1-10).

[41] Bent, E. M., & Singa, K. (2009). Modal Choices and Spending Patterns of Travelers to Downtown San Francisco, California. Transportation Research Record: Journal of the Transportation Research Board, 2115(1), 66-74.

[42] Snyder, T (2013). Bicycling means business: how cycling enriches people and cities. http://dc.streetsblog.org/2013/03/08/bicycling-means-business-how-cycling-enriches-people-and-cities/

4. Transport demand management

Cycling projects are often part of a larger transport demand management (TDM) policy. The goal of TDM is to maximize the efficiency of urban transportation by discouraging private vehicle use, while encouraging public and non-motorised transportation modes.[43] There are four fundamental ways to reduce transport emissions (see Figure 2). Emissions can be reduced using each of these strategies or a combination of them:

1. Activity: Avoiding travel, for example by combining trips, telecommuting or moving closer to work, leads to a reduction of kilometres travelled, and a reduction of emissions from motorised transportation.
2. Structure: Creating modal shift, for example from car to bicycle, leads to a reduction in kilometres travelled by motorised modes and a reduction of emissions.
3. Intensity: Improvements to fuel efficiency allows vehicles to cover the same distance with less fuel, leading to a reduction of emissions.
4. Fuel: Improvements to the emissions factor of the fuel results in a reduction of emissions per litre of fuel consumed, leading to less emissions for the same distance travelled

Emission reductions are calculated as the difference between a business as usual (BaU) scenario, which represents what would happen if current policies continued, and a project scenario, which represents what would happen, for example, after the implementation of cycling policies.

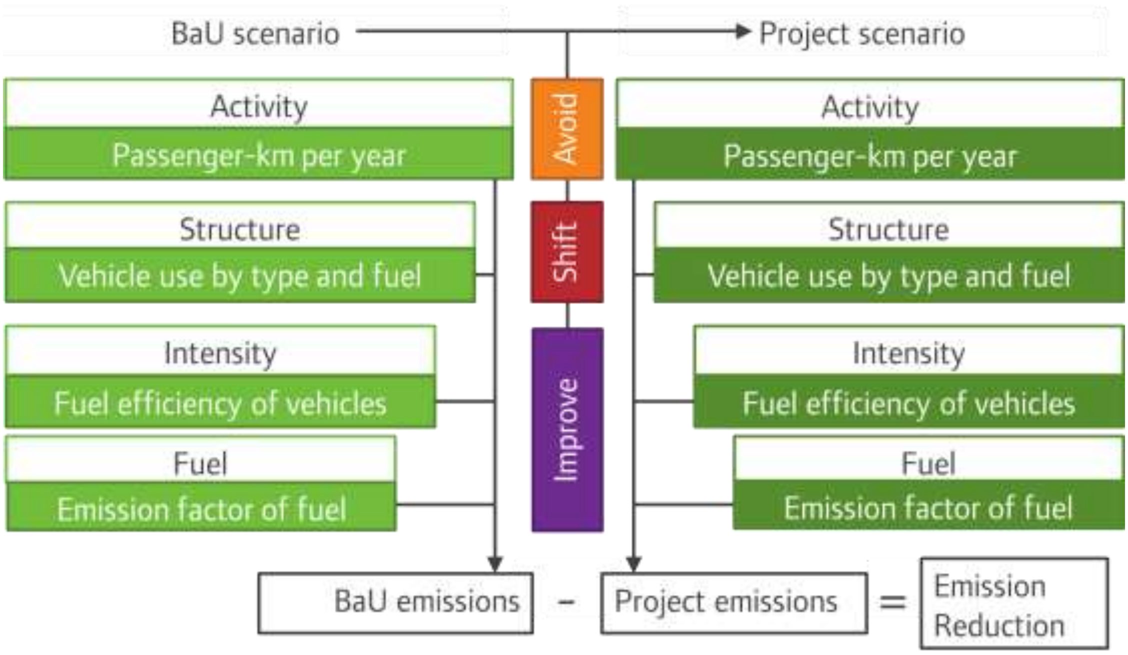

Figure 2: Mitigation options in transportation and estimating their carbon impact.

TDM targets both a change in activity (avoided passenger km per year) and structure (shift in modal share of passenger kilometres).

[43] Broaddus, A., Litman, T., Menon, G. (2009). Transportation Demand Management Training Document. GTZ : Eschborn, Germany.

Transport demand management can include measures that discourage car use, or push people to get out of their cars, as well as measures that encourage the use of public transport or non-motorised transport or pull people towards these more environmentally friendly modes (figure 3).[44]

Push measures are generally implemented through economic policies and programs aimed at reducing car use, which can include road pricing, parking policy and restricted road areas. Pull measures generally focus on improving mobility options. This can include improvement in public transit level of service or bicycle and pedestrian infrastructure. Smart growth and land use policies designed to improve land use accessibility through development density and mixed use zoning are combined push and pull measures.

In order for TDM to be truly effective, push and pull measures should be applied in combination with one another. For example, the London congestion charge was introduced to discourage automobile traffic in central London. However, this was implemented alongside a vast improvement to the city's bus services by almost doubling the fleet and increasing the frequency of services, and improvements in the quality of infrastructure for cyclists and pedestrians.

Figure 3: The push and pull approach towards transportation demand management.[45]

[44] Müller, P., Schleicher-Jester, F., Schmidt, M-P. and Topp, H.H.(1992), "Konzepte flächenhafter Verkehrsberuhigung in 16 Städten", Grüne Reihe des Fachgebiets Verkehrswesen der Universität Kaiserslautern No. 24.

[45] Müller et al. (1992).

5. Monitoring, reporting and verifying

Donors of climate finance typically require an MRV approach to gain insight into the mitigation impact of their funding. In addition, MRV can also aid in effective design of cycling policies, communication with the cycling community and optimisation of co-benefits.

The main data requirements for cycling MRV are distances travelled per mode. This is information that allows for quantification of the emission reductions, but is also generally sufficient to draw conclusions about co-benefits, including health and air quality. Additional indicators are needed to gain insight into the economic benefits, including reduced congestion.

Three steps are needed to calculate the emission reductions from a transport project that targets modal shift. The first step is to select a methodological approach. Several different approaches can be used to estimate changes in motorised vehicle kilometres. Second, the required data must be collected. Often, the required data depends on the chosen approach. In all cases, data can be collected using traditional methods, or by using the newer GPS or smartphone-based technology. Finally, the input data is used to calculate the emission reductions.

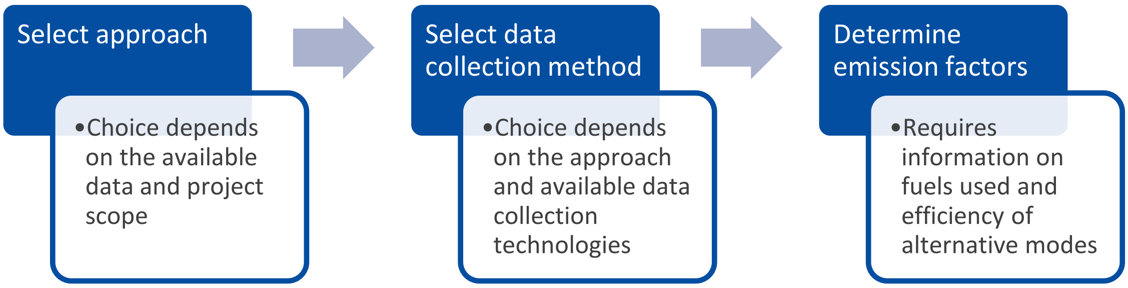

Figure 4: The three steps towards an MRV methodology.

5.1. MRV approach

There are three basic approaches that can be used to estimate the emission reductions from transportation projects, which aim to achieve a modal shift towards cycling. What all three approaches have in common is that emission reductions are a function of cycle kilometres travelled, and the alternative mode that would have been used in the baseline scenario. Each of them also includes assumptions or a model to identify the alternative mode. Each cycle kilometre that can be attributed to the project is assigned to an alternative mode, and emission reductions are calculated based on the emissions associated with this alternative mode.

The alternative transport mode differs strongly per city. Figure 5 shows for different cities the share of bicycle kilometres that would otherwise have been made by car. Avoided emissions that can be attributed to cycling would also vary strongly between these cities.

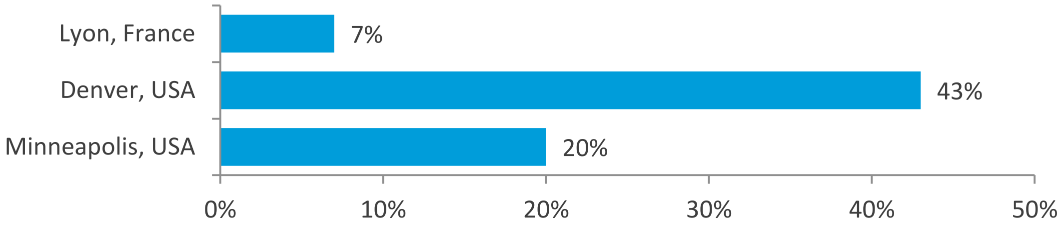

Figure 5: Percentage of bicycle kilometres that would have otherwise been made by car.[46] [47] [48]

The three approaches differ in the way that they estimate the baseline scenario and in the data they require. The forecast from historic data approach involves forecasting a baseline scenario based on past transport and economic data. The transportation mode choice model does not require historic data, but uses a choice model instead to determine the alternative modes in the baseline scenario. A simplified version of this approach (here referred to as the simplified mode choice model) estimates the baseline based on the modal share of non-cycling modes. The survey of bicycle users approach does not require data about non-cycling modes and simply relies on surveying cyclists to identify the transport mode they would have taken if cycling was not available to them. Table 3 provides an overview of the different approaches and their data requirements, where the blue cells indicate the data needed for each approach.

Table 3: Overview of data requirements for different approaches to the MRV of cycling projects.

Data Requirements	Approach 1: Forecast from historic data	Approach 2: Transport mode choice model	Approach 2a: Simplified mode choice model	Approach 3: Survey of bicycle users
Total bicycle km				
Passenger km per mode (after project implementation)				
Passenger km per mode (historical and baseline projection)				
Stated choice of alternative mode in km				
Validated transportation mode choice model				
Mode choice probability distributions by trip length, socio-economic status and/or trip purpose				
Emissions factor per passenger km per mode or Emissions factor per vehicle km per mode and occupancy rate per mode				

[46] Nice Ride Minnesota Survey Results (2010) http://bike-sharing.blogspot.nl/2010/11/nice-ride-minnesota-survey-results.html

[47] Kisner, C (2011). Integrating Bike Share Programs into a Sustainable Transportation System. National League of Cities City Practice Brief.

[48] Buhrmann, Sebastian, Rupprecht Consult Forschung & Beratung GmbH, "New Seamless Mobility Services: Public Bicycles." Niches Consortium; p.5

Approach 1: Forecast from historic data

Approach: Emission reductions are based on the difference between a projected "business-as-usual" baseline scenario and a monitored "project" scenario. The baseline scenario is a forecast based on historic transport data complemented by economic and motorisation trends. Passenger kilometre data for all modes needs to be monitored both before and after project commencement.

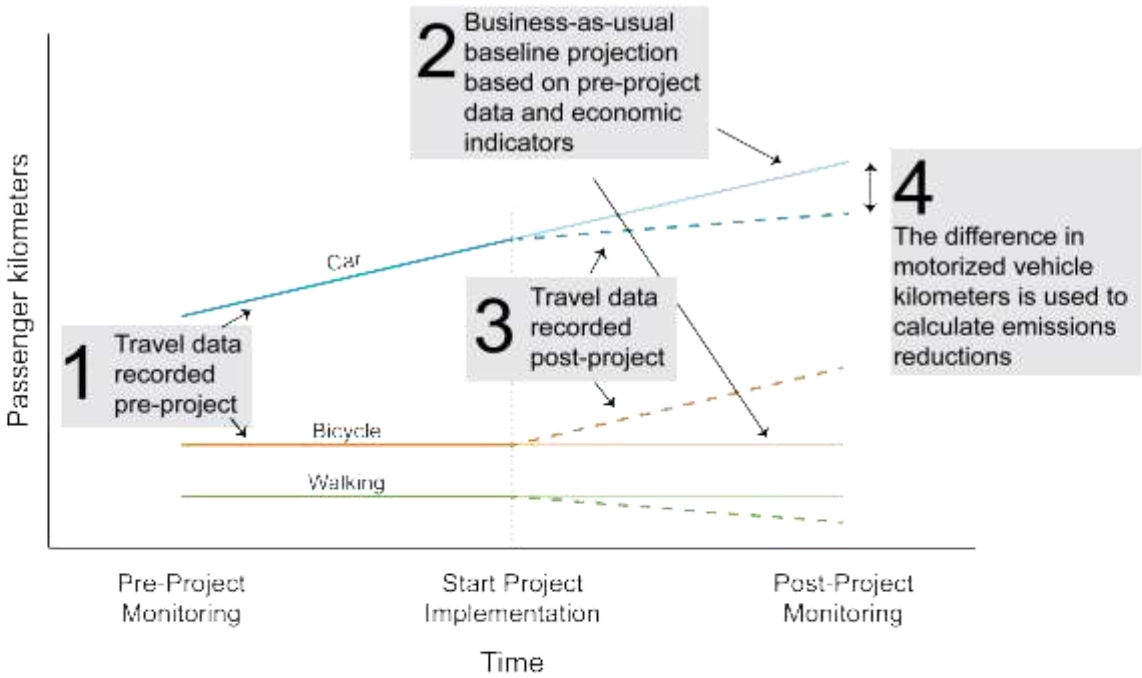

Figure 6: The forecast from historic data approach requires collection of historic transport and socio-economic data.

Tools: The Transport Emissions Evaluation Model Tool (TEEMP[49]) applies both approaches. The TEEMP model is used to calculate emissions based on a business-as-usual and project scenario. It is designed to predict emissions of a future project, but can also be used in conjunction with on-going monitoring. The TEEMP model is Excel-based and can be downloaded free. TEEMP also includes modalities for the calculation of emission reductions and is therefore described in more detail in section 5.3.

Another example is the GEF methodology for transportation projects[50], which also uses historic data to make forecasts.

Pros: This approach monitors the actual change in modal shift both before and after a project is implemented. It is most effective for large-scale projects or policy programmes because it provides insight into the overall performance of a transport system in a city over a longer period of time.

Cons: The quality of the results relies on the quality of the business-as-usual (BaU) forecast. Because this scenario becomes hypothetical the moment the project is implemented, the validity of the BaU scenario cannot be verified. To be able to provide a good BaU forecast the calculations need to be based on several years of high quality data. Since the model only uses and shows data at a higher aggregation level, it is sometimes difficult to attribute results to specific sub- projects.

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[49] Available at: http://cleanairinitiative.org/portal/projects/TEEMP

[50] Institute for Transportation and Development Policy. Manual for calculating greenhouse gas benefits of global environment facility transportation projects. http://www.unep.org/stap/calculatingghgbenefits

Approach 2: Transportation mode choice model

Approach: A transportation mode choice model does not require historic data. Based on transport data collected after the project has been implemented, it runs in two scenarios: with and without the option to cycle. The mode choice model predicts transportation behaviour based on trip characteristics including distance, socio-economic status and trip purpose. When the option to use the bicycle is removed from the model, it predicts the alternative mode choice of cyclists. Mode choice is predicted separately for different categories of trips. For example, long business trips by high-income people will be distributed among each mode with a certain probability. Short trips by low-income people for the purpose of shopping will be distributed among the same modes, but likely with a different probability.

This approach requires a validated mode choice model and the data needed to create probability distributions for mode choice is based on trip length, socio-economic status, and trip purpose. Many cities conduct regular travel surveys to be able to develop such transportation models.

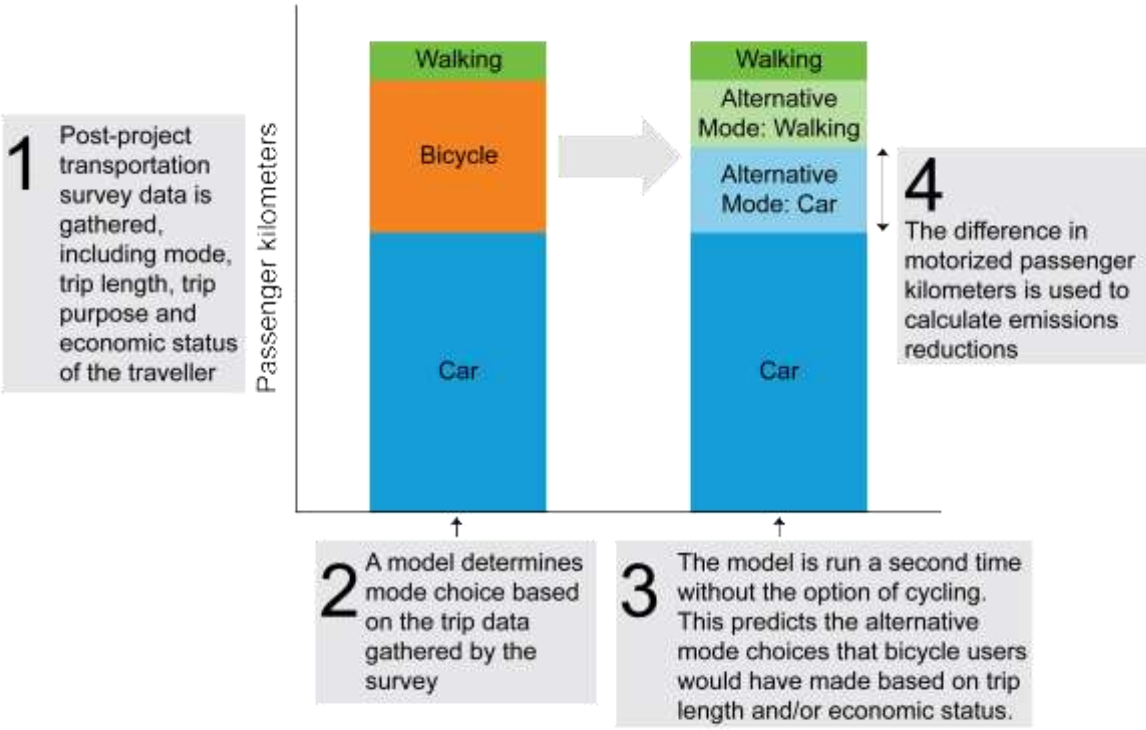

Figure 7: The transportation mode choice model approach approximates the project and baseline scenarios with a transportation model.

Tools: Researchers at Twente University in the Netherlands used this approach to calculate the climate value of cycling in Bogotá and several other cities.[51]

Pros: Emission reductions can be calculated without the need for extensive pre-project data. This makes the transportation mode choice model suitable in situations where there were hardly any cyclists before the cycling project was implemented.

Cons: Results rely on the parameters of the model. It could be used if the pre-project cycling level was not zero, but this would require assumptions or knowledge of pre-project cycling levels and patterns.

[51] Massink, R. (2009). Estimating the climate value of bicycling in Bogotá, Colombia, using a shadow pricing methodology.

Approach 2a: Simplified transportation mode choice model

The transportation mode choice model can be simplified, for example if the required model input data is not available. The amount of bicycle kilometres can be simply divided proportionally, based on the remaining modal split without cycling. If a city's modal split were 33% bike, 33% car and 33% bus, then the alternative modes for the bicycle kilometres would be 50% car and 50% bus. This results in a less accurate portrayal of the alternative mode choice, but provides a basis for a rough estimate of emission reductions related to cycling.

Approach 3: Survey of bicycle users

Approach: Bicycle users are asked through a survey what other mode they would have used for their bicycle trips if bicycling had not been an option. The results of the survey are used to estimate the number of bicycle kilometres that would otherwise have been motorised kilometres.

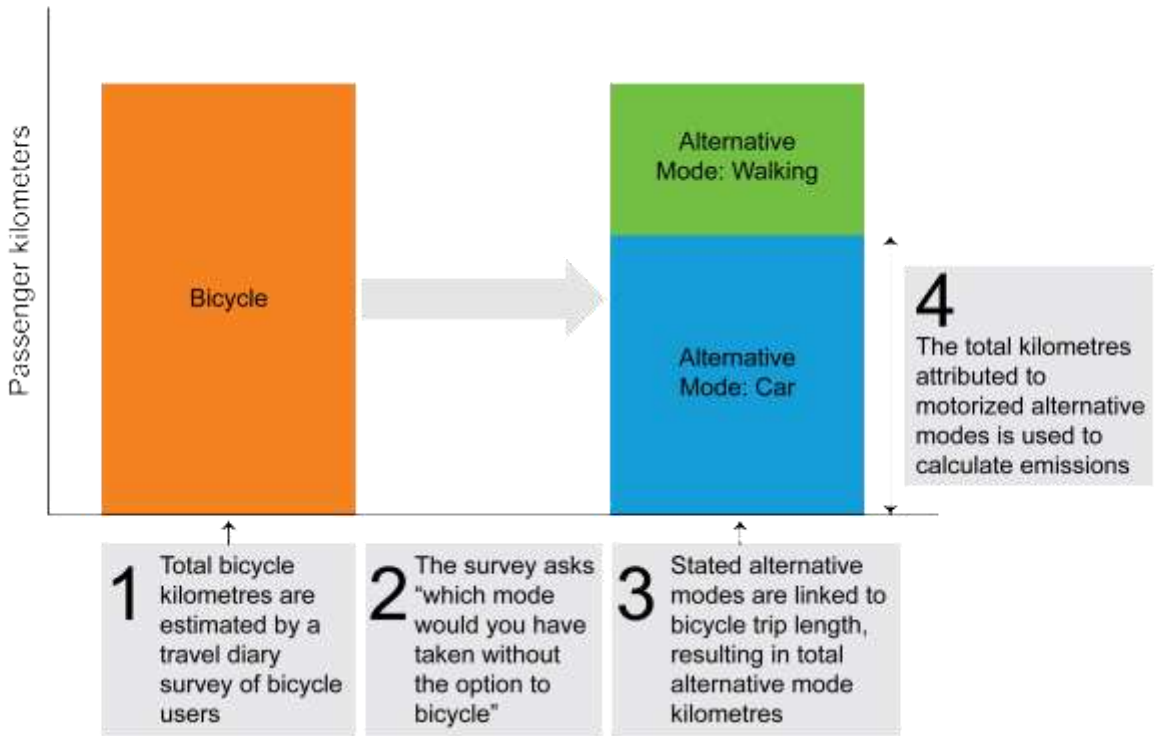

Figure 8: The survey of bicycle users approach does not require data on other transportation modes.

Tools: Several carbon credit methodologies use this approach, including:

- VCS Bike share methodology
- CDM methodology for mass transit projects (AMC0016)
- CDM methodology for Bus Rapid Transit (BRT) (AM0032)

Pros: With this approach, there is no need to source data on actual travel behaviour of modes, other than cycling. This provides a straightforward solution in situations where transportation data is not available. It is also the least costly approach, making it suitable for smaller scale projects, such as a single bike path or a bike share system.

Cons: This approach relies on surveying cyclists on what they would have done in a hypothetical scenario without cycling as an option. This is a relatively difficult question to answer. In addition, this approach provides no insight into actual changes in other transport modalities.

5.2. Data collection methods

Traditionally, transportation surveys have been used to identify origin and destination patterns, travel times, distances and modes. In combination with other models, this information is used by city and regional planners to make important policy and infrastructure decisions. Surveys are traditionally carried out with pen and paper. Even when using computer and phone-assisted travel diaries and recall interviews, this is a time-consuming process and creates room for error, as respondents are expected to make a note of all their trips (including short walking trips) and recall their travel times and distances.

Over recent years, GPS technology relying on the GPS devices in mobile phones, for example, has become an increasingly common way to track trip distances and times, allowing for a lot more accuracy.

GPS

Some city and regional travel surveys, including Cleveland, Jerusalem and the New York metropolitan region, already rely on a GPS device to gather information about origin-destination, distances and travel times. GPS has the advantage of gathering a much more accurate distance and time profile. Furthermore, trip rates per person are found to be higher, suggesting that traditional surveys suffer from underreporting.[52]

In addition to simple travel time and distance information, algorithms have been developed to identify the mode choice[53] from GPS data. There are cases where the travel modality was correctly identified in 92% of the trips.[54] In addition, by combining land-use maps with GPS data, the trip purpose can also be identified.[55] There is a case where the algorithm correctly identified the trip purpose in 93% of the trips, however for 22% of trips follow-up questions were required. An important benefit of these developments is that more travel survey data can be automatically collected. This saves time and effort, potentially making way for monitoring questions, which in the past would have made the survey process too long.

Mobile phone technology

Smartphones combine a GPS with an Internet connection allowing for fast data collection and processing. Several companies are developing applicable products with this technology. For example, the Dutch company Mobidot has developed an application that reports trip length, trip time and transport mode.[56] Users of the application can access a simple platform to correct mistakes. Ring Ring, an application built by Locatienet, tracks bicycle kilometres centred round the IJburg neighbourhood in Amsterdam.[57] Users of the

[52] Wolf, J., Oliveira, M., & Thompson, M. (2003, January). The impact of trip underreporting on VMT and travel time estimates: preliminary findings from the California statewide household travel survey GPS study. In 83rd Annual Meetings of the Transportation Research Board, Washington, DC, January.
[53] Reddy, S., Mun, M., Burke, J., Estrin, D., Hansen, M., & Srivastava, M. (2010). Using mobile phones to determine transportation modes. ACM Transactions on Sensor Networks (TOSN), 6(2), 13.
[54] Brunauer, R., Hufnagl, M., Rehrl, K., & Wagner, A. (2013). Motion pattern analysis enabling accurate travel mode detection from GPS data only. In Proceedings of the 16th international IEEE annual conference on intelligent transportation systems (ITSC 2013). MoC5.4.
[55] Wolf, J., Guensler, R., & Bachman, W. (2001). Elimination of the travel diary: Experiment to derive trip purpose from global positioning system travel data. Transportation Research Record: Journal of the Transportation Research Board, 1768(1), 125-134.
[56] For further information, see: www.mobidot.nl
[57] For further information, see: http://ring-ring.nu

Ring Ring application can benchmark their cycling distances with other cyclists. These kinds of applications potentially allow policy-makers to monitor cycling movements and to communicate directly with a large cycling community, provided that data aggregation secures user privacy.

Smartphone technology has its share of downsides too. The main disadvantage is that the population of smartphone users in many cities remains too small to make a representative sample of a city's population. There are also technological weaknesses and imperfections, such as the impact of GPS usage on battery life and the ability of algorithms to identify the transport mode, but these are likely to be improved in a matter of years.

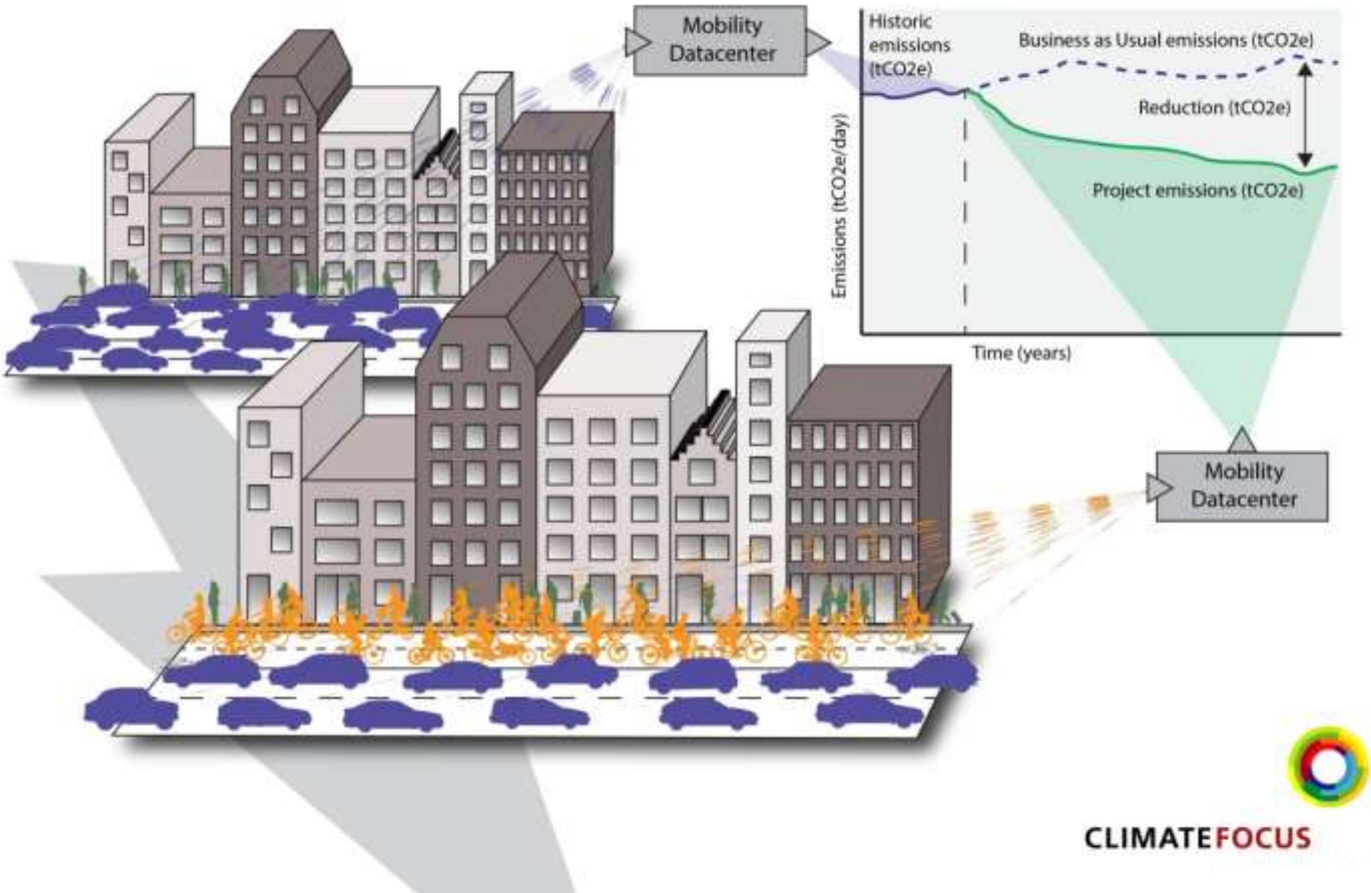

Figure 9: Data collection with smartphones and translation into emission reductions.

Selecting technologies

A city should first select its approach before selecting a data collection method. For large-scale transportation data collection, which is required for the forecasted baseline and mode choice model approaches, the use of mobile phones is not yet recommended. For both of these approaches, the statistical validity of the data requires a representative sample, which the smartphone population in many cities does not provide. Whether to use GPS or not also depends on cost and local familiarity with this technology. A population with relatively low technical skills may face difficulties working with the GPS units, which could lead to data collection problems. A final argument could be the costs involved: more advanced technologies can save significantly on labour when using survey methods.

Mobile phone technology becomes a more viable option for the survey of cyclists approach. Because this approach targets a specific group, there is a greater chance that smartphone users make up a representative sample. In this case, a user-friendly mobile phone application can allow for seamless data collection and save time and effort in data processing. The simplicity of the data needed for this approach can keep the application relatively simple and thereby user-friendly. As smartphone usage continues to rise, their use for data collection is likely to become increasingly attractive in different geographies.

5.3. Translation into emission reductions

The final step is to convert alternative mode kilometres into emission reductions. Passenger kilometres for each mode can be translated into emissions by multiplying them with an emission factor. Emission factors for transport modes consist of three components: occupancy rate of the vehicle, fuel efficiency and the emission factor of the fuel used.

Vehicle occupancy rate. Not all car passenger kilometres are created equal. A car with five passengers generates five times less emissions per passenger kilometre than a car with one passenger. Emissions generated from each vehicle kilometre have to be split among the passengers in the vehicle. The average vehicle occupancy rate is used to translate passenger kilometres in a specific mode into vehicle kilometres.

Fuel efficiency. Vehicle kilometres are not created equal either. A more fuel-efficient car travels the same distance while using less fuel. Generally, the regional or national average fuel efficiency is sufficient to translate vehicle kilometres into the actual amount of fuel used.

Emissions factor of the fuel. Each litre of fuel burned emits a fuel-specific amount of greenhouse gas. Regional differences mostly relate to the split between diesel and petrol, each of which has different emissions factors.

Available tools. The CDM mass rapid transit and BRT methodologies, as well as the VCS bike share methodology, present rigorous methods for these calculations. They include instructions for accessing and choosing all of the relevant emissions factors as well as example surveys.

The TEEMP model is a user-friendly Excel program that performs these calculations based on input data for occupancy rates, fuel types and fuel efficiencies. The TEEMP model also has a sketch mode for cases where little data is available. The sketch mode includes default values for modal shift but would give a much better estimate with local data. Although the TEEMP is designed for forecasting, it includes features that can also be used for monitoring.

Another model, COPERT,[58] is a Windows application that was originally designed to calculate road transport emissions for national inventories. This model could be applied at city level but is not as user-friendly as the TEEMP, and less suitable for the calculation of emission reductions as a result of cycling programmes. COPERT also requires purchasing country specific data, which is available for the EU-27.

[58] Available at: http://www.emisia.com/copert/

6. Recommendations

An increase in cycling can reduce emissions, while at the same time provide health, social and economic benefits but also faces a set of social and political challenges. Emissions are reduced when travellers make the choice to cycle rather than use a motorised form of transport. Successful policies that aim to create a modal shift include push and pull elements - discouraging motorised travel while encouraging bicycle travel.

To gain insight into the climate benefits of cycling, three steps are needed to develop a sound MRV approach for cycling: select an approach; select a data collection method; and determine emission factors.

MRV approach. The choice for an MRV approach depends on the scale of the project, the availability of data, the monitoring and information needs of the municipality, and the information requirements from donors. All three methods offer different benefits and shortcomings.

If a city has already collected consistent transportation data during recent years, forecasts from historic data and transportation mode choice model approaches are appropriate. If the availability of historic data is limited, the survey of bicycle users can be used to gain insights based on data gathered after the project has been implemented.

When the monitored project is a large-scale, citywide policy with multiple elements, the forecast from historic data is the most appropriate approach, provided that historic data is available. The mode choice model is another option, but may be less accurate. For a small single element project, the survey of bicycle users works well without the need for a lot of data. If it is not possible to conduct a survey in this case, a simplified mode choice model can give a rough estimate.

Data collection. For the forecast from historic data and mode choice model approaches, the data collection effort required is larger than that for the other two options. Cities can choose to use GPS technology to increase data quality and quantity, and to make data collection less labour intensive. The start-up costs are generally higher though, as the technology needs to be developed and tailored to the specific situation in the city and the specific data needs for the project.

Applications for smartphones that have an integrated GPS sensor can allow for seamless data collection and processing, without having to hand out dedicated GPS devices. For targeted surveys, as required in the survey bicycle users approach, applications can also reduce the time burden on the sample group. Obviously, the use of applications is only possible if a city has a high level of smartphone usage. In combination with the survey bicycle users approach, smartphone applications can also be an interesting option if the project targets a specific group of people with sufficiently high smartphone usage.

Translation into emission reductions. To translate bicycle kilometres and alternative modes into actual emission reductions, information is needed on the vehicle occupancy rates, fuel efficiency and fuel emission actors of the alternative mode. Various tools are available to support the calculation of emission reductions based on these parameters. Suitable examples are the different CDM and VCS methodologies, such as the VCS Bike share methodology, the CDM methodology for mass transit projects (AMC0016), and the CDM methodology for Bus Rapid Transit (AM0032). Another option is the TEEMP model.