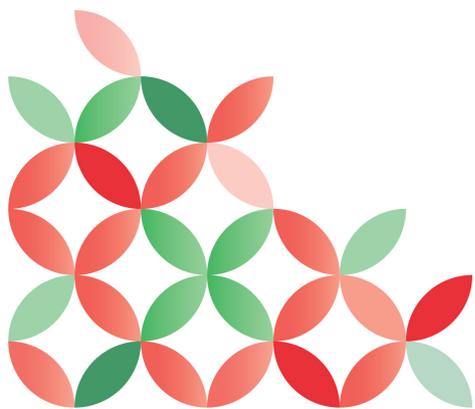




# Decarbonising Morocco's Transport System

Charting the Way Forward



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Cite this work as: ITF (2021), "Decarbonising Morocco's Transport System: Charting the Way Forward", *International Transport Forum Policy Papers*, No. 89, OECD Publishing, Paris.

# Acknowledgements

The main authors of this report are Joshua Alexander Paternina Blanco (ITF) and Eric Jeannière (ITF), who also supervised the project in co-ordination with Francisco Furtado and Elisabeth Windisch, project managers for DTEE at ITF. The part of this report devoted to transport in urban areas was drafted with Frederic Rudolph (WI) and Hamza Diab (WI). The authors would also like to thank Edwina Collins (ITF) for her help in publishing this report.

This document was drafted in the framework of the Decarbonising Transport in Emerging Economies (DTEE) project, based on the data and information provided by representatives from several Moroccan public institutions, most of whom came together at a meeting held in December 2019.

The authors would like to thank the employees of the Moroccan institutions consulted, who provided information and comments that were crucial for drafting this report. The authors would also like to thank the employees at the Ministry of Equipment, Transport, Logistics and Water (METLE), the Ministry of Interior, the Ministry of Energy, Mines and Environment, as well as the many public companies and bodies consulted, including the Moroccan Agency for Energy Efficiency (AMEE), the Directorate General of Civil Aviation (DGAC), the Department of Ports and Maritime Public Domain (DPDPM), the Department of Technical Affairs and Relationships with the Profession (DATPR), the National Railway Office (ONCF), and the Directorate of Road Transport and Logistics (DTTL). In particular, the authors would like to express their warm thanks to Sanaa Lazaar and Adil Bahi from METLE's Department of transport strategy, programmes and coordination, for their invaluable help coordinating this project. This report also benefitted from the help of Yassine Ncir, a local consultant specialised in transport.

The DTEE project is a joint initiative of the International Transport Forum (ITF) and the Wuppertal Institut (WI). It aims to help the governments of four countries, Argentina, Azerbaijan, India and Morocco, to assess which policies to implement to decarbonise transport. This project develops a framework for modelling and assessing the impact of policies related to this goal. Discussions with national governments allow this framework to be adapted to each country, based on its priorities and specificities.

The DTEE project is part of the Decarbonising Transport Initiative (DTi) of the ITF and is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). This project covers the period 2019-2022.

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# Decarbonising transport in Morocco

## Opportunities and challenges for decarbonising the transport sector in Morocco

The transport of goods and passengers is essential for economic development and reducing territorial disparities in Morocco. In this economy, fifth strongest in Africa (The World Bank, 2020b), over 75% of cargo is transported by road. This freight transport contributes to national wealth, first through its contribution to Morocco's industrial production, especially manufacturing (OECD, 2018b), but also from its role in the field of logistics (Robin *et al.*, 2017).

The transport of passengers also contributes to Moroccan economic development, especially in the tourism industry. It also helps increase access to essential opportunities (jobs, education and health services), as well as markets, for both Morocco's rural and urban populations. Whereas close to 70% of the Moroccan population will live in towns by 2040 (HCP, 2020), growing urbanisation indicates a significant increase in transport activities and congestion in the existing urban centres.

This paper looks at opportunities to reduce greenhouse gas (GHG) emissions produced by the Moroccan transport sector. First, it identifies a few global challenges for the decarbonisation of the transport of passengers and freight in Morocco. Then it makes a non-exhaustive assessment of the main characteristics and public policies currently in place to decarbonise the different modes of urban and interurban transport. It then details, where possible, the potential impact in terms of decarbonising these different modes. Finally, it draws up a list of the modelling and planning tools related to transport and GHG emissions that are available to Moroccan public authorities. This first glimpse enables us to suggest potential next steps for the project in Morocco.

This document is an abridged version of a report shared and approved by the Moroccan authorities and other partners. The complete version of this report can be obtained by contacting the ITF team (<https://www.itf-oecd.org/dtee-morocco>).

## Nationally Determined Contributions and the transport sector in Morocco

In 2012, Morocco produced close to 100 million tonnes of CO<sub>2</sub> equivalent (tCO<sub>2</sub>eq), which represented approximately 0.2% of global emissions. That year, the transport sector was responsible for approximately 15% of total CO<sub>2</sub> emissions in the country (UNFCCC, 2020). The emissions produced by the transport sector increased more than 2.5 times between 1994 and 2012, which is the highest growth in the energy sector in Morocco under 20 years (UNFCCC, 2020).

In its Nationally Determined Contribution (NDC), Morocco's government committed unconditionally to reduce the country's GHG emissions by 17% by 2030 compared to a business-as-usual (BAU) scenario (Royaume du Maroc, 2016). Efforts to mitigate emissions in the transport sector will amount to 9.5% of all GHG reductions in the Moroccan NDC by 2030. To achieve that unconditionally, in 2016, authorities committed to improving public transport networks in Casablanca and Rabat and to renew the fleet of inter-municipal taxis, "grand taxis", in the country. These measures could lead to a cumulative reduction of over 12.2 million tCO<sub>2</sub>eq between 2020 and 2030. On condition of receiving foreign financial support, other measures, such as upgrading utility vehicles over 20 years old or initiatives related to the national strategy on logistics development could lead to an additional reduction of close to 40 million tCO<sub>2</sub>eq. The 2020 review of the NDC includes new conditional measures likely to bring about a further decrease of

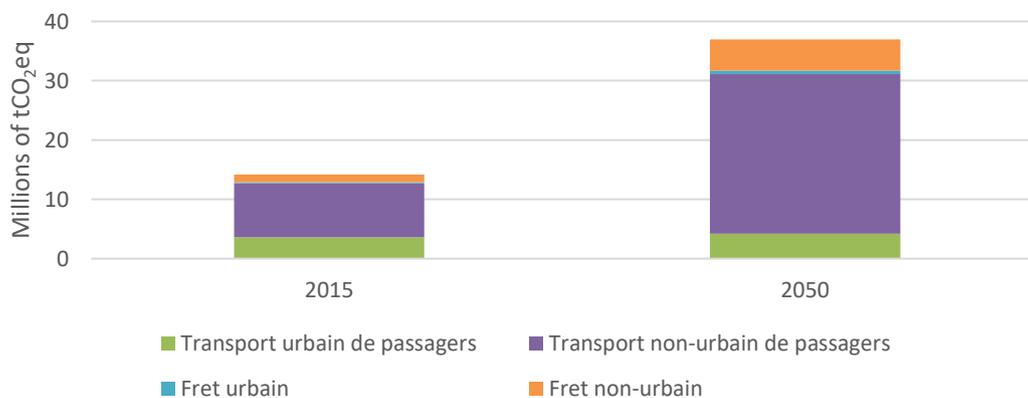
12 million tCO<sub>2</sub>eq. These measures include transitioning to the Euro 6 standard for the environmental performance of vehicles, developing a bonus-malus system for new vehicles, creating a scrapping programme for business vehicles, promoting eco-driving, and converging, in 2030, towards implementing Regulation (EU) 2019/631 concerning CO<sub>2</sub> emission performance standards for new passenger cars and new light commercial vehicles.

Other strategic documents support efforts shown in the NDC, such as the roadmap for sustainable mobility in Morocco (METLE, 2018). This document, drafted with the participation of over 150 of the main public and private stakeholders for decarbonising transport in Morocco, offers a long-term vision. It promotes a cross-disciplinary vision of mobility while considering transport and its decarbonisation in parallel to the developments of urbanisation and of the energy and industrial sectors. The cross-disciplinary nature of the approach provides a complete vision of sustainable mobility, combining environmental, social and economic priorities (METLE, 2018).

### Global challenges for transport decarbonisation strategies in Morocco

The GHG emissions from transport in Morocco could more-than-double between 2015 and 2050 despite measures taken by the government. Increased activity in the sector, especially in terms of interurban transport of freight and passengers, will be the main drivers. A scenario in which the government's 2019 transport decarbonisation goals remained unchanged, would see the volume of passengers and cargo in Morocco quadruple between 2015 and 2050. Emissions from this sector would therefore go from less than 15 million tCO<sub>2</sub>eq in 2015 to over 35 million in 2050 (ITF, 2019) (Figure 1).

Figure 1: Projected trends of GHG emissions related to transport activities in Morocco (2015-50) (in millions of tCO<sub>2</sub>eq)



Source: (ITF, 2019) *ITF Transport Outlook 2019*, <https://doi.org/10.1787/25202367>

The informal nature of the transport sector makes it difficult to establish effective decarbonisation public policies. Over half of freight transportation services in Morocco are thought to be provided by informal carriers, with a fleet of approximately 600 000 vehicles according to government estimates. This hinders the type of data collection that could reorganise activities to improve the efficiency of logistic flows, as well as initiatives for renewing vehicle fleets.

The expansion and sprawl of Moroccan towns creates an additional urban challenge for decarbonising transport. Urban sprawl leads to an increase in private vehicles, especially second-hand vehicles, which makes it difficult to adopt new technologies (KIFAL, 2020). The number of second-hand cars sold in

Morocco went from approximately 400 000 in 2014 to 600 000 in 2019, based on government figures. The absence of any measures aiming to promote sustainable modes of transport in expanding urban peripheries could contribute to the increased use of passenger cars and jeopardise decarbonisation efforts. That is why the government now only permits the import of vehicles under five years old, and those meeting the Euro IV standard. The transition towards the Euro VI standard should take place by 2023. These measures have halved the number of second-hand cars imported between 2010 and 2019.

The Covid-19 crisis creates both problems and new opportunities for decarbonising transport. The economic crisis could prevent acquisition of the funding necessary for implementing decarbonisation policies. The cost of implementing the transport decarbonisation measures of the NDC is estimated at over USD 2.7 billion (Royaume du Maroc, 2016). Additionally, it will cost USD 3 billion to develop urban transport in the country between 2016 and 2026 (Oxford Business Group, 2019). The economic crisis also jeopardises household budgets, which could delay progress in terms of fleet electrification. However, Covid-19 could be an opportunity for decarbonisation due to the modal shift in tourism transport from air travel towards roads and railways. To deal with the reduced flow of foreign passengers, the national authorities signed a 2020-22 contract with private sector stakeholders to revive the tourism sector after the Covid-19 crisis. The state commits, amongst other measures, to make domestic tourism its main focus (Royaume du Maroc, 2020). It could encourage participation in modes of transport that are less energy-intensive than air travel, such as rail transport. Additional efforts, such as increasing the attractiveness of these more sustainable modes, are needed to make this potential modal shift viable.

## **Road transport is the biggest producer of GHG emissions in Morocco within the transport sector**

Road transport of passengers and freight is an essential business in Morocco, but it produces most of the country's GHG emissions. About 75% of national freight transport (excluding phosphates) and 35% of interurban passenger flows are by road (METLE, 2020b). With close to one-third of all GHG emissions attributable to it, road transport is the second-largest producer of emissions in Morocco within the energy sector, behind the production of electricity and heat. The GHG emissions of maritime and rail transport are comparatively much lower: they represent less than 1% in total (4C Maroc, 2018).

The new national road infrastructure scheme (SNIR) for 2040 is an opportunity to make transport decarbonisation a priority in infrastructure development. The Moroccan road network is one of the most developed in Africa thanks to national government investments to promote economic growth and increase access to opportunities in the most remote areas of the country, especially rural areas. Currently, decarbonisation is not an explicit priority in road infrastructure development, which could lead to an increase in high-carbon emitting transport modes. SNIR, the roadmap for developing the country's road system, can be used as a framework to prioritise decarbonisation, in addition to other strategic programmes in the country. SNIR could therefore promote high-potential multi-modal projects and lay out the environmental benefits of these projects. This would complement the suggestions found in the roadmap for sustainable mobility in Morocco, which suggests that a maximum of 60% of freight transported in 2030 be via road (compared to 75% now), favouring other modes of transport, such as rail (METLE, 2018).

The decarbonisation of interurban passenger transport in Morocco will take place through the renewal of the fleet of private vehicles, but above all, through a shift towards public transport. Renewing the private fleet could be slowed by the limited purchasing power of Moroccan households, who increasingly prefer buying second-hand cars at lower costs (Flanders Investment and Trade, 2015). National authorities are

currently studying “bonus-malus” schemes destined to make it easier to buy less carbon-intensive private vehicles. This involves promoting fleet renewal while ensuring a financially-sustainable sales support system for the authorities. These incentives have huge potential: strong government support to renew the fleet and buy new electric vehicles could see over 400 000 electric cars in use by 2030, compared to 11 000 vehicles in the absence of strong support (Fédération de l'Énergie, Groupe Sunergia and Nevolys, 2019). Moreover, simplifying administrative procedures for getting operating licenses could increase the supply of interurban public transport.

The decarbonisation of interurban freight transport is a priority in Morocco, where three-quarters of cargo flows are via the road network. There have been initiatives trying to facilitate renewing the fleet of vehicles, where one-in-five cars is over 20 years old, for years to reduce the sector's GHG emissions (MEFRA, 2013). Scrapping bonuses are not enough to promote the purchase of new vehicles because of the strong presence of informal operators in this sector who have limited financial capacity. Initiatives aiming to increase the efficiency of logistics have also been implemented, for instance, through eco-driving programmes and the establishment of a network of logistic zones in the country. This programme aims to reduce CO<sub>2</sub> emissions of freight transport in Morocco by 30% by 2030 (AMDL, 2020).

In these financially-challenging times brought about by the Covid-19 crisis, climate funding can be an opportunity to decarbonise road transport while improving the network and supporting economic recovery. To benefit from this funding, authorities would be well-advised to include the “Measurement-Reporting-Verification” (MRV) steps when developing infrastructure projects. To achieve that, it would be useful to continue adapting modelling tools, like Trigger, to the Moroccan context. Rigorous and transparent data collection and management are essential.

## **The booming air transport industry could decline in the context of Covid-19**

Passenger air transport has grown significantly in Morocco since the start of the 2000s, driven by a desire to increase the country's touristic appeal. Between 1999 and 2019, the number of passengers registered each year almost quadrupled, going from less than 7 million passengers to over 25 million (Vloeberghs, 2015; ONDA, 2020). Over two-thirds of these flows concerned the airports of Casablanca and Marrakech, which in 2019 respectively welcomed over 10 and over 6 million passengers (ONDA, 2020). In 2019, Europe was the biggest market for the country's international flights: close to eight out of ten flights were originating from or heading to Europe (ONDA, 2020).

National authorities also promoted air freight transport, the volume of which almost doubled between 2010 and 2019 (ONDA, 2020). This growth was primarily driven by international freight, supported by a national strategy to increase the capacity of domestic air terminals. The national civil aviation strategy aims to reach 182 000 tonnes of air freight transported by 2035, compared to 96 000 tonnes in 2019 (METLE, 2017). Under the aegis of the Moroccan Airports Authority (ONDA), the country's airport capacity increased by almost 35% between 2008 and 2012 (UBIFRANCE, 2014). More recently, Royal Air Maroc Cargo and PortNet (a national single window for foreign trade) signed an agreement to simplify and improve digital information sharing between all Moroccan airports (Guichet unique national des procédures du commerce extérieur, 2019). This measure could improve efficiency and reduce logistics costs for the sector.

The Covid-19 crisis creates different scenarios for the decarbonisation of passenger and freight air transport. The crisis could contribute to decarbonising tourist passenger transport thanks to the modal shift from air travel to road and rail transport. The impact of Covid-19 on business growth and the

decarbonisation of the freight transport sector is less clear. The lower oil prices linked to the crisis could, in the short term, increase the relative competitiveness of airfreight compared to other means, such as maritime transport. That could curb decarbonisation efforts.

### Maritime transport: great potential for modal shift

In 2019, Morocco was, behind Egypt, the country in Africa best connected by sea (UNCTADSTAT, 2020). Morocco has 3 500 km of coastline. This includes about 600 km along the Mediterranean Sea and over 2 800 km along the Atlantic Ocean (METLE, 2020a). The Moroccan coast is served by a network of 43 ports, of which 14 are open to international trade. Within this network, the ports of Tanger-Med, Jorf Lasfar and Casablanca manage over 85% of the country's freight traffic (METLE, 2020c). The port of Tanger-Med, the leading port in Morocco both in terms of passengers and freight, handled almost 55% of maritime transport flows of passengers in 2018. To improve the performance of the Moroccan port infrastructure network, the government is planning to develop six maritime hubs for port competitiveness, each focused on a specific field by 2030 (Figure 2).

Figure 2: Map of the six Moroccan hubs for port competitiveness planned in the national port strategy for 2030



Source: (METLE, 2010)

Maritime transport is an essential activity for international freight: 98% of Morocco's external trade is done by sea. International maritime flows primarily concern the transport of raw materials. Nevertheless, container traffic is growing, especially since 2009 with the launch of trans-shipment activities in the country, at Tanger-Med (METLE, 2019). The boom of automotive production within the country also contributes to the diversification of products transported: between 2007 and 2015, the traffic of new vehicles handled by Moroccan ports more than quadrupled (METLE, 2019).

Maritime transport is an important provider of international passenger transport, but it faces fierce competition. Every year, it ferries about 5 million people between Morocco and its neighbours, including France, Spain and Italy (METLE, 2020c). Passengers are primarily Moroccans residing abroad. However,

maritime passenger transport has been stagnating since the Open Skies agreement was concluded with the European Union, which facilitated low-cost air transport of passengers flying to Morocco (METLE, 2015). The situation does seem to be improving thanks to the Tanger-Med port becoming operational, which shortly after it was opened to passenger transport in 2013, became the top passenger port in Morocco (METLE, 2015).

A modal shift from freight transport by road towards cabotage on the one hand, and of passenger transport from air to sea on the other, could help decarbonise the Moroccan transport system. Maritime transport can produce fewer GHG emissions than road haulage and passenger air transport. Increasing cabotage between Moroccan ports nonetheless remains limited by the absence of a national flag, as national regulations only provide for these activities to be carried out by a Moroccan ship or by a vessel chartered by a Moroccan ship-owner (METLE, 2013). The Covid-19 pandemic could help increase the appeal of maritime passenger transport for Moroccans residing abroad.

Clarifying the role of maritime transport in national decarbonisation strategies, as well as making crucial data available, could help reduce GHG emissions in Morocco. The roadmap for sustainable mobility in Morocco briefly mentions the potential for mitigating the GHG emissions of Moroccan transport in the event of a modal shift of interurban freight towards cabotage (METLE, 2018). This reference partially makes up for the lack of direct references to maritime transport in the main strategic documents for mitigating Morocco's GHG emissions (Royaume du Maroc, 2016). Directly quantifying the potential of this transport mode for decarbonising transport would be useful. More data is needed for this.

## **Railway transport: great potential for intermodality**

The Kingdom of Morocco has the second largest railway network in operation in Africa. South Africa has the first. The network is made up of over 3 800 km of track, of which 2 300 km is operational, including about 200 km of high-speed trackage (ONCF, 2019). Almost 800 km of railway lines are double-tracked. Over 60% of the country's rail network is electrified. Most of the rail lines are concentrated in the north of the country, with Marrakech-Oujda being the main line in the network. There are 250 locomotives circulating on this network, of which over half are electric, as well as almost 680 passenger cars and 5 000 freight cars (ONCF, 2019). In 2019, on average, electric locomotives were 27 years old and diesel locomotives were 29 years old (ONCF, 2020b). The National Railway Office (ONCF), a public company, is currently responsible for the infrastructure and is the sole railway operator for the national network. Railway operations are currently opening up to tender competition. With the opening, ONCF will continue managing the network and will enter into competition with other operators, and will from there on be registered as a limited company, (The World Bank, 2017).

Railway transport of passengers keeps rising in Morocco: between 2010 and 2019, it increased by over 9%, going from close to 4.4 billion passenger-kilometres to over 4.8 billion (ITF, 2019). This rise is directly linked to the significant investments made by the national authorities during this period. Public commitments are ongoing thanks to the 2040 Morocco Rail Plan (PRM), a long-term master plan to develop the Moroccan rail network by 2040. PRM plans to invest close to EUR 35 billion (MAD 375 billion) to, amongst other things, extend the 1 100 km of high-speed tracks in the country (ONCF, 2020a).

Rail freight transport is declining in Morocco, contrary to the trend observed with passenger transport. This is partially as a result of the phosphate slurry pipeline stretching from Khouribga to Jorf Lasfar, the longest in the world in 2014. However, between 2012 and 2014, freight transport had already reduced by close to 10% (863 million tonne-kilometres in 2014 (ONCF, 2015)). Over this same period, the share of freight transported excluding phosphates in ONCF's turnover was three times lower than the share of

passengers, and almost four times lower than the share of phosphates transported (ONCF, 2015). There is a genuine potential to increase the freight volume (excluding phosphates) transported via railway in Morocco. Measures were put in place to try to restore the volumes transported excluding phosphate and, in 2019, 938 million tonne-kilometres were transported. This volume is scarcely 2% lower than the volume transported in 2012.

The modal shift towards rail transport represents a genuine opportunity to decarbonise passenger and freight transport in Morocco. The railway sector is responsible for between 2% and 4% of CO<sub>2</sub> emissions in Morocco, whereas 60% of emissions come from road haulage (ONCF, 2015). A passenger train can carry the same number of passengers as 160 cars and uses 93% less diesel per kilometre than a coach. A freight train transports a volume equivalent to that possible by 50 to 60 cargo trucks and uses 78% less diesel per kilometre than a truck (ONCF, 2015). National authorities are seeking to increase railway decarbonisation gains, by ensuring that half the electricity used to fuel railway transport is renewable by the end of 2020 (METLE, 2018). This initiative will contribute towards the objective of reducing railway GHG emissions by 10% by 2030 compared to 2016 (ONCF, 2020c).

Promoting the intermodality of railway transport with road and maritime transport can increase the competitiveness of rail transport, both for passengers and goods. For these two targets, ONCF has developed solutions to ensure a connection between rail and road transport, through its subsidiaries SUPRATOURS and SMTR. To increase intermodality, ONCF is banking on the creation of new logistics platforms connected to the country's main industrial centres (ONCF, 2020a). Moreover, PRM plans to extend the railway network by 2040 to connect stations to twelve ports, compared to just six today (ONCF, 2020a).

## **Improving urban governance for better decarbonisation**

The accelerated urbanisation process in Morocco contributed to a sharp increase in urban mobility as well as pollution and traffic congestion (Plateforme de Mobilité Durable, 2019). This situation was made worse by growing private car ownership, the yearly growth rate of which was estimated to be 5.7% on average between 2006 and 2014 (The World Bank, 2016). There is also a large number of motorbikes in the country, with over 1.4 million motorbikes in circulation in October 2020. These vehicle ownership rates are largely due to the lack of appeal of existing public transport offer, both formal and informal (GIZ, 2012).

On a local scale, authorities in the main urban areas of Morocco implement innovative programmes to improve the mobility of people. These promote the adoption and usage of sustainable transport means, eliminate unnecessary trips and improve the energy efficiency and operational efficiency of transport modes. In Casablanca, the authorities focused on developing an additional public transport network of close to 100 km by 2025, made up of four tram lines and two rapid bus lines (Bus Rapid Transit or BRT) (Casa Transports SA, 2020). The authorities in Rabat have also invested in developing transport infrastructure by creating a 20 km tram network as well as a 39 km network of rail replacement buses between 2011-19 (Enzelberger and Kahramane, 2015). Beyond improving infrastructure, local authorities are also seeking to promote the use of active transport. Marrakech, for instance, has launched the first bike-sharing scheme in an African city, with an initial fleet of 320 bikes (Medina bike, 2016).

On a national scale, several ministries support the initiatives of Moroccan local authorities. The Ministry of Interior, through the Directorate General of Local Governments, contributes to monitoring and supporting local authorities in their implementation of local public services. It also manages the Support Fund for Transport Reform (FART for its French initials), made up in part from local government contributions of value-added tax (CAS-TVA), as well as from the general budget. This fund is a financial incentive to

encourage the efforts of local government to improve their institutional frameworks for transport development planning. Getting this money depends, amongst other things, on creating urban development plans that favour sustainable modes of transport and multi-modality. METLE is responsible for regulating transport services for professionals, including school transport services. It also provides technical support to local authorities who want it. The Ministry of Urban Planning and Territorial Development establishes national regulations for urban planning and land use, which can shape urban mobility policies.

Moroccan authorities face the challenge of fragmented jurisdiction between several institutional stakeholders. Since 2015, government bodies and elected representatives have been sharing, in an unclear way, the jurisdiction for drafting and implementing public policies on regional, departmental and municipal levels (OECD, 2018a). Two other bodies, inter-municipal organisations and local development companies (SDL) can also have authority in terms of mobility. This ambiguity is especially present in terms of structuring policies for public transport, urban planning, parking and land use. For instance, for the metropolitan area of Casablanca, there is no direct link or explicit relationship between the Regional Development Plan for the Casablanca-Settat region, a key document concerning territorial land use, and the Urban Mobility Plan for the Al Beida inter-municipal organisation to which Casablanca belongs (OECD, 2018a). This lack of coherence between land use and mobility strategies – including parking – could harm efforts to promote more sustainable mobility, and as a result harm transport decarbonisation initiatives in Morocco. Updating documents like Urban Mobility Plans could help clarify the link between these various documents.

Moroccan authorities are collaborating with external stakeholders to address these governance challenges. A National Strategy for Urban Mobility was developed in 2008 thanks to the collaboration of several ministries, to help local authorities to promote public transport and active mobility (Ministère de l'Intérieur, 2020). The Ministry of Interior co-ordinated conferences and projects to improve the governance and institutional capacity of local authorities. Similarly, a project developed with the World Bank has been helping local authorities since 2015 to strengthen inter-municipal co-operation to draft sustainable mobility plans (The World Bank, 2020a). Moreover, the MobiliseYourCity partnership provides technical support to teams in the urban areas of Casablanca, Rabat, Kenitra and Oujda to develop plans and programmes for sustainable urban mobility, to integrate the MRV approach in urban mobility planning, and to manage traffic and parking policies (MobiliseYourCity, 2019).

## Quantitative analysis

This project proposes further analysing freight and passenger transport in Morocco. In terms of passengers, it is necessary to make a distinction between urban and interurban transport due to the competition of modes and the specificity of associated data. As for freight, it is difficult to distinguish urban freight as an entirely separate issue, especially because of the lack of available data.

### Urban mobility modelling

Three approaches can be considered for modelling passenger transport in urban areas:

- A detailed approach based on four-step models and origin-destination (OD) trip matrices
- A simplified macroeconomic approach
- Life cycle assessment (LCA) by transport modes and vehicles.

Regardless of the option chosen, data relating to fleets of vehicles and their GHG emissions (ideally by type, engine power, power source, age, size, annual mileage and energy consumption) are essential for assessing the impact of decarbonisation policies, such as fuel taxes or bonus-malus systems for buying vehicles.

#### The detailed approach based on four-step model and origin-destination trip matrices

The traditional four-step traffic model (or sometimes with fewer steps) is generally used to evaluate transport projects. The scope studied is divided into geographical zones, and trips are modelled with the help of origin-destination (OD) matrices, a table including the number of trips for each area of origin towards each area of destination. The first step of the generation estimates the number of trips emitted and attracted by each zone, according to population size and the number of jobs (if these are known). The mobility rate per inhabitant (number of trips per day and person) is the main generation parameter, obtained through household travel surveys (HTS). The second step distributes generated trips by area between all possible OD based on cost and/or travel time for each OD (by a gravity model). The third step, the modal choice, estimates the probability of use for each of these modes of transport by OD. It depends on the generalised cost of each mode (known as disutility) taking into account time, cost and other aspects, such as the frequency of public transport. The last step is the assignment of each OD to the network, selecting one or several itineraries.

Extensive data are necessary to calibrate these four-step models, starting with HTSs (Figure 3). HTSs must allow for the whole population to be represented statistically, with a sample rate usually around 1%. Other data is also necessary, such as traffic counts (on road and public transport), OD surveys or cordons. This data allows for the model to be validated and to supplement trips that are not included in the HTSs, such as transit trips undertaken by external visitors or tourists.

When this type of model already exists (like in Casablanca, for instance), it could be made available to feed into this study in a very precise way, in the form of a simplified Excel version (for the first three steps). However, when this type of model does not yet exist, it is not possible to develop one in the framework of this project, given the time and cost required for developing such a model.

Figure 3. Data needs for the traditional four-step model

<b>Data categories</b>	<b>Socio-economic and urban space</b> > GDP, population > Land use (e.g. residential vs. commercial use) > ...	<b>Transport supply</b> > Transport infrastructure (road and public transport network) > Service levels (e.g. PT frequency, travel times) > Public transport costs for users > Vehicle fleet & emission factors...	<b>Transport demand</b> > Vehicle load factors > Trip distances > Trip patterns > Mode share for base year > ...
<b>Potential sources</b>	City or national statistics – existing network model (?)	Existing network model, Data collection exercises	Household travel surveys

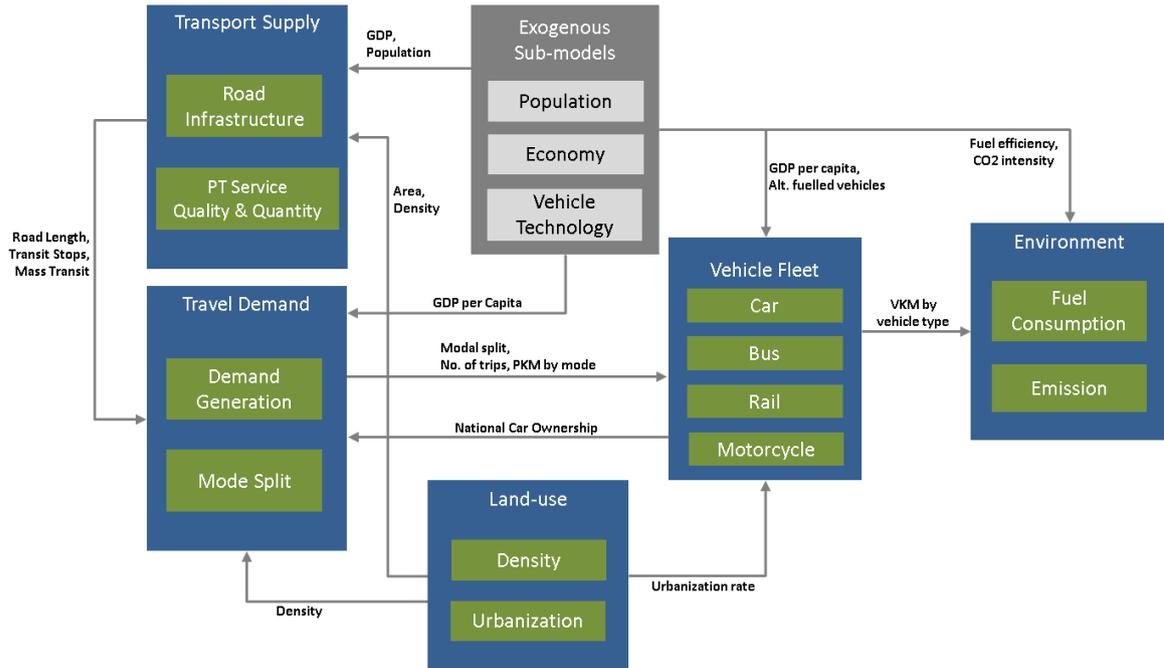
### The simplified macroeconomic approach

The International Transport Forum (ITF) uses the simplified macroeconomic approach for its international urban mobility model (ITF, 2019). Each urban area of over 50 000 inhabitants represents a line in a database, also indicating the total volume of trips and the average distance travelled for each mode (based on several classes of distance). There is no explicit representation of networks (or highly aggregated) nor of trips by origin-destination. Therefore, infrastructure projects for specific forms of transport cannot be assessed, only macro analyses can be carried out on the impact of global policies on a few big mobility indicators (such as average cost and travel time, as well as GHG emissions associated with kilometres travelled according to the transport modes).

Data from HTSs can be used to adapt this type of model to a local context, but the amount of data required is much lower than for the detailed approach. The simplified approach primarily requires validation data, such as total distance travelled by mode, and the associated energy consumption.

It is possible to extract a simplified version from the ITF model, the basic diagram of which is presented in Figure 4, which can be used with Excel. The main input parameters and variables that can be adjusted to test transport policies are the following: population, gross domestic product (GDP), average income, urban sprawl, average distance, mobility rate, road infrastructure, cost and tax on fuel, tolls, parking costs, household car ownership rate, number of stops on public transport, the existence of a solid public transport system (subway or tramway), ticket cost, energy intensity and GHG emission factor. This approach can also include a vehicle stock module to estimate the fleet energy and fuel consumption and related emissions.

Figure 4. Structure of the International Transport Forum model for passenger urban mobility



### Life cycle assessment of vehicles according to mode of transport

Life cycle assessment (LCA) is a methodology for estimating the energy consumption and environmental impact of a product or service throughout its life cycle. This can include from manufacturing, to use, to disposal, design, manufacture (including the materials, energy and transport necessary to the production site), function, upkeep, maintenance and repairs, and end-of-life processing (reuse, recycle or waste processing). This analysis can be applied to transport vehicles, including all the elements necessary for the transport system to work.

LCAs are used to develop important transport policies in Europe, North America, Brazil and the People’s Republic of China, such as:

- Regulations on exhaust emissions and/or energy consumption (gCO<sub>2</sub>/km for cars, vans and trucks in Europe, *Corporate Average Fuel Economy (CAFE)* in the United States, incentives to buy zero-emission vehicles [ZEV] in California, Europe and China).
- The carbon intensity of fuels and the energy required for their production (standards for low-carbon fuels in North America and Brazil, the European directive on fuel quality and renewable energy, emissions trading scheme and renewable energy policies in Europe, California, China, Korea).
- The carbon intensity for manufacturing vehicles and vehicle components (revision of the European directives on batteries and end-of-life of vehicles).

LCA is also very important for international policy, especially for the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO). European and North American institutions have carried out important work on LCAs to clarify their policy-drafting process. Additional examples include the GREET model in the United States and the JEC analysis in Europe.

The ITF recently published an analysis based on international averages (ITF, 2020), which could be adapted to Morocco. This type of approach could complement the macroeconomic model, by focusing on energy requirements and the associated GHG emissions, for the whole system. LCA provides information about the implications of changing vehicles and fuels, for each mode of transport independently by applying more holistic CO<sub>2</sub> emission factors per vehicle-kilometre. This approach, however, is less suitable for interurban trips, because the availability and nature of transport modes are more heterogeneous geographically.

## **Interurban freight and passenger mobility**

The four-step model can be used for interurban trips. It was developed for METLE in 2015 by the association of CID – JLR – Roland Berger, as part of the National Mobility Master Plan. It brings together two models developed under TransCAD, both for freight and passenger transport. A simplified version, without the assignment step, could be developed in Excel so that it can be used by more people.

As for urban mobility, a module for estimating the fleet of vehicles could complete this tool suite, to take into account the impact of energy policies on transport, and taxes and subsidies for vehicles and fuels.

For international passenger transport, there are two main types: by air or by sea. In terms of international air passengers, the main policies influencing GHG emissions are defined on an international level and are therefore outside the scope of this study. Data permitting, the few trade flows with neighbouring countries could be integrated into the national model, because the modal alternatives and behaviours are similar.

## Next steps: Supporting policy exchange and modelling developments

The DTEE project has planned initiatives in Morocco between 2020 and 2022 to support the transport decarbonisation efforts implemented by Moroccan authorities. Other public policy priorities, such as economic recovery and promoting access to opportunities in the country's least developed areas will also be considered. Initiatives will include workshops and technical work to support the Moroccan authorities' data collection and modelling efforts. They will also be an opportunity to promote public policy dialogue between Moroccan authorities at every level, including amongst relevant partners.

The forthcoming programme for the DTEE project includes the following joint initiatives with the ITF, the Wuppertal Institute (WI) and their partners:

- **Early 2021: a survey to confirm the availability of data and strategic documents in the urban areas of the country.** This survey will be carried out with Moroccan public authorities on a regional and local level. It will complement the data collection work and public policy plans and strategies initiated by the teams of the ITF and WI at the end of 2019.
- **May 2021: promoting public policy dialogue on decarbonising transport among emerging economies.** A session will be organised for the DTEE project within the framework of the ITF transport summit in May 2021. Public policy makers from the four main countries of the project (Argentina, Azerbaijan, India and Morocco) will then be able to discuss the difficulties and opportunities encountered in decarbonising transport in their national experience. Representatives from development banks will explain how their institutions could continue to support their efforts to reduce their GHG emissions.
- **By July 2021: developing the assessment framework and modelling work in Morocco.** The quantitative analysis of decarbonisation measures in Morocco is a priority in this project. To this end, the teams of the ITF and WI will develop modelling and visualisation tools in addition to the methodologies and resources available to public authorities.
- **By December 2022: training and skills-building workshops for Moroccan authorities.** The ITF and WI teams will organise in-person and/or virtual workshops to increase the skills of Moroccan teams in terms of using the new modelling and visualisation tools developed. Training could also cover other topics, based on the requests and requirements raised by the Moroccan authorities.
- **Between 2020 and 2022: supporting the activities of other organisations working to promote transport decarbonisation in the country.** The ITF and WI teams will also support the efforts of the Sustainable Mobility Platform to facilitate multi-partner collaboration and encourage dialogue between public bodies to decarbonise transport in the country.

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## Decarbonising Morocco's Transport System

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This paper reviews opportunities and challenges for mitigating greenhouse gas emissions from Morocco's transport sector. It provides an overview of the transport system and reviews the country's existing policies and future plans for reducing CO2 emissions from transport. The paper also provides an overview of the data on transport activity and emissions available for Morocco, and the tools used by government agencies for assessing them. Finally, it proposes options for further action in the context of ITF's "Decarbonising Transport in Emerging Economies" (DTEE) project.

This is the initial scoping paper for Morocco within the ITF "Decarbonising Transport in Emerging Economies" project, funded by Germany's Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

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