Why the automobile has no future

A global impact analysis

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Imprint

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Foreword

The great growth of our cities and urban areas – and the return to urban living – offers enormous opportunities. More than half of the people on the planet live in urbanised areas, and this is projected to grow to two thirds by 2050. This means we have the potential to develop cities that are sustainable, in environmental, social, economic and cultural terms. But, the transport sector is not travelling in the right direction. Transport is consuming 23 per cent of global energy supplies, growing at nearly 2 per cent per year over the last decade. Transport is producing 23 per cent of global carbon emissions and is the fastest growing emissions source. If we do not change our approaches, and continue with the 'business as usual', these transport emissions will double by 2050. This is why the transport sector is considered the 'make and break' of the global climate agenda.

Around 1.25 million people die each year resulting from road traffic crashes – the leading cause of death amongst people aged 15-29 years. As urbanisation is increasing, an increasing share of the more than 10 billion daily trips are occurring in gridlocked cities that have run out of space to accommodate the massively growing global vehicle fleet. The huge number of cities which have not built an effective public transport system, and walking and cycling networks, are experiencing huge traffic congestion problems, leading to difficulties in providing basic human rights, such as access to employment, housing, education and food.

Achieving sustainable travel behaviours and effective land use is a complex task, involving a large number of actors from the public and private sector, as well as civil society. The private automobile – as this report shows – is the contributor to many adverse impacts and lies at the core of the fundamental challenge to revolutionise and update our cities with low-carbon transport systems.

It is a pleasure to introduce this important analysis, which examines the dominance of automobility, and the early signs that the use of the private car has peaked in some Western contexts. The report provides an argument, which can help us in developing better quality public transport, walking and cycling networks; and to achieve the gigantic task of updating our existing transport systems to support a high quality of life in cities.

The solutions are hugely positive – we can develop cities that offer very attractive urban lifestyles. But, to do this, we need to look beyond the lobbying and vested interests surrounding automobility – and to develop our cities for people.

Dr. Benjamin Stephan
Greenpeace, Hamburg, Germany

Key Messages

The taken-for-granted assumption that cities need to be designed around the automobile is being challenged in many contexts – yet it is in only a limited number of cities that serious investments are being made to develop high quality and extensive public transport, walking and cycling networks. Much greater investments are needed across all cities and contexts, particularly as the scale of urbanisation increases.

There are still very high levels of motorisation in many countries, with the United States reaching 809 vehicles/1000 population and European countries at lower levels, such as Germany (578) and UK (575). In the last few years there has been an emerging, albeit still marginal, trend of reduced vehicle kilometres travelled in European and North American countries – the phenomenon of peak car. It is this trend that can be built upon and developed – with a revolution pursued in transport planning. Designing cities for public transport, walking and cycling needs to be massively scaled up.

More urban areas will be constructed in the next few decades than all of human history – there will be 41 megacities and 63 large cities by 2030. Hence there is much opportunity to develop sustainable city-based strategies. Yet, the expansion of urban areas is twice as fast as urban growth – urban areas are dispersing. This needs to be reversed, with more compact cities developed, so that public transport, walking and cycling can be effectively supported.

Use of the automobile needs to be strongly discouraged – to ensure we can move beyond the age of the automobile. This is due to its adverse impacts and also the potential to support the public transport industry as a key component of urban economies. Automobility has many very serious adverse impacts, meaning that it cannot continue to be supported, including:

- CO2 emissions: though some European countries are reducing national CO2 emissions to a limited degree, the large emitters are dramatically increasing theirs, e.g. China emitted 10.5 GTCO2 in 2014, a growth of over 300 per cent on 1990 levels. The transport sector is the key sector that is failing to contribute to reduced CO2 emissions in almost all contexts – even the progressive cities are only reducing their transport CO2 emissions marginally.
- Traffic casualties: around 1.25 million people die each year resulting from road traffic crashes and road traffic injuries – this approximates to 3,400 deaths per day. In addition, between 20-50 million more people suffer non-fatal injuries, with many incurring ongoing disabilities. This is much too heavy a cost for a means of moving around between activities.
- Non-communicable diseases (NCDs) killed around 38 million people in 2012, representing 68 per cent of 56 million global deaths. These include cardiovascular diseases (mainly heart disease and stroke), cancers, respiratory diseases and diabetes. Many of the risk factors for NCDs are

closely related to diet and physical exercise and, in part, the level of active transport we take.

We can no longer destroy our cities and lives to accommodate the private car. Using 20-30 per cent of the space in the city, and sometimes much more, for highways and parking is a waste of valuable space and incompatible with urban planning objectives.

The recent enthusiasm for automated vehicles is unlikely to solve all of these problems – perhaps energy depletion and CO2 emissions could be reduced if vehicles were clean; and traffic casualties, in theory, could be reduced. But there are many technical issues to be resolved, including how road space priority is allocated in busy pedestrian areas. The lack of physical activity and adverse impacts on the city fabric remain unresolved – and making car usage more attractive is not likely to lead to better cities. There are already too many vehicles in most cities globally. An attractive city in urban design terms always has high levels of walking, cycling and public transport. The motor car city is dull and unremarkable. The priority for all cities should be to continue to invest in state-of-the-art public transport, walking and cycling facilities and to manage private car traffic.

The automobile industry gains great status, but in terms of impact on the economy this is overplayed. The public transport industry employs similar numbers and it is this that should be supported with government subsidy. Around 7-8 million people are directly employed internationally in the public transport industry with additional secondary employment. This can be much increased if public transport usage is doubled, or more, by 2025.

A richer understanding of attitudes to travel and emerging policy measures can form the basis of radical new transport strategies. Policy measures can be targeted at specific discourses amongst population cohorts – and the more enlightened discourses be encouraged and spread to wider contexts. For too long city transport strategies have been weak and ineffective – it is time for much more innovative strategies to be pursued.

Many European cities show good levels of public transport, walking and cycling, e.g. such as Berlin at 70 per cent non-car mode share, Frankfurt at 65 per cent and London at 60 per cent. But much more can be done to achieve greater sustainability in travel in all contexts. Each city strategy will vary, reflecting different problems and opportunities, and different levels of awareness and debate. All cities can work towards two headline targets by 2025:

1. At least 70-80 per cent of trips are by public transport, walking and cycling.
2. The remainder of trips are by low emission vehicles. There are no petrol or diesel vehicles and no private ownership – any private cars are accessed via car clubs.

Public space can be radically redistributed to support public transport, walking and cycling – cities should be designed for people, and not cars.

Transport planning research and practice will also require changed approaches to help achieve greater sustainability in travel – planning beyond the automobile is a major task. But, there are many good examples to follow and we can share knowledge much more effectively to help learn from the best practice available. As William Gibson would say: “The future is already here — it's just not very evenly distributed.” [1]

Acknowledgements

Many thanks for all the help and discussions we had in producing this report. Thanks to Helmut Holzapfel (University of Kassel), Peter Endemann (Regionalverband, FrankfurtRheinMain), Thomas Klinger and Martin Lanzendorf (Goethe University, Frankfurt), Petra Schäfer (Frankfurt University of Applied Sciences), Jeff Kenworthy (Curtin University, Perth), Mikhail Chester (Arizona State University), Michel Arnd (GIZ), Paul Fremer (Radverkehr-Konzept), and the respondents to our surveys on travel discourses in Frankfurt.

AMSTERDAM: The vibrant city is based on high levels of usage of public transport, walking and cycling – and little use of the private car.

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1. Introduction

Chapter summary:

- *There have been many important critiques on the use of the automobile and its impact on city planning. The 'post-car' system seems to be emerging with some initial moves away from car usage.*
- *More people are beginning to understand that the societal disadvantages of mass private car usage far outweigh the perceived individual benefits.*
- *The scale of urbanisation means that transport and city planning need to change significantly to avoid the adverse impacts of motorisation – and to provide the opportunity for attractive city living for all.*
- *The public transport and cycling industries can be supported, instead of the automobile industry, and become increasingly important for national economies.*

1.1. Rethinking automobility

There have been many important critiques on the use of the automobile and its impact on city planning, since at least Lewis Mumford onwards: "the right to access every building in the city by private motor car, in an age where everyone owns such a vehicle, is actually the right to destroy the city." [2, p.23]

Urry [3] began to speculate on the emergence of the 'post-car' system, and perhaps we can see some initial evidence that the end of the automobile era – or at least the start of the end – has begun. But, as yet, there is only a small move away from private car usage, limited to only selected parts of the Western industrialised countries [4-6]. Indeed, in the UK, the reduction in vehicle km travelled is only evident in the large cities, such as London, and mainly associated with young males and former company car owners driving a little less [7]. There is certainly no such trend extending to the newer car markets in Asia, where dramatic increases in vehicle sales figures are being experienced. From the global perspective, these emerging trends are perhaps important signs of things to come – but still very marginal.

Today, many of us still think little of travelling long distances to work each day, to visit family and friends, to ferry around the children, to participate in and watch sports, to go shopping, and to visit the countryside or other countries for holidays – and much of this activity is facilitated by use of the private car.

To help us understand the continuing attraction of the car, and the wide-ranging systemic nature of automobility, we can view the system as comprising six parts [3]:

- the manufactured object
- the item of consumption
- the complex of industries involved

- the quasi-private form of mobility that subordinates other modes
- the dominant culture
- the cause of resource use and many significant adverse impacts

Hence the individual choice to use the private car is complex, more than the utility of driving from A to B; shaped by advertising and a supportive media, with many cultural and societal influences.

Though use of the private car is currently pervasive, it has only existed as a mass form of mobility, in the Western industrialised countries, since the 1950s. It has its origins back to 1885, when the first modern gasoline motor car was built by Carl Benz in Mannheim, Germany. The car was famously driven by his wife, Bertha, on the first long-distance road trip, demonstrating its practicality for travelling long distances – and, from then onwards, the promotion of the use of the private car began.

The central narrative of this report is that the automobile has had its day. An increasing number of people are beginning to understand the adverse impacts of the private car – and that the societal disadvantages of mass private car usage far outweigh the perceived individual benefits. Yet, this message needs to be demonstrated to a much wider audience. The scale of urbanisation we will witness in the next decades is unprecedented, and if this is based on high levels of motorisation, the adverse impacts will be horrendous. Our transport and city planning need to change significantly to encourage the end of the automobile age. Many people now want to live in attractive cities and to use public transport, walking and cycling as their main modes of travel – but the opportunities to do this are relatively limited.

Whilst calling for the end of the automobile age might seem a bold aspiration, it is made on the basis of two points:

- The adverse impacts of mass car usage are very significant even in today's urban areas – including energy depletion, CO_2 emissions, traffic casualties, local air quality, obesity and health impacts of inactivity, the loss of streetspace to the car and inconsistency with city design objectives. The continued public support of the car cannot continue as these adverse impacts become better understood and more widely known and as urbanisation grows.
- The size of the automobility industry is large, and is seen as an important part of many national economies. It is often argued that this sector should be supported by national governments as an important contributor to national gross domestic product. Yet, this needs to be seen in perspective. The automobile industry achieves great status, yet is concentrated in very few countries and is less significant to national economies than is commonly believed, even in countries with a relatively large automotive sectors such as the USA or Germany. The public transport and cycling industries are also very important as an employer in many

countries and should be supported, instead of the automobile industry, in view of their much more beneficial impacts.

Many progressive cities are investing significantly in public transport, walking and cycling. Some cities are leading the way and achieving high non-car mode shares, including Amsterdam, Berlin, Copenhagen, Groningen, London and Freiburg. The quality of life available in these cities is very attractive – and needs to be replicated in many more cities so that the choice of attractive city living can be open to all.

The commentary in the report is global, but also with a focus on cities in Germany. We consider the example of Frankfurt towards the end of this report – and the discourses that are evident – as an example of a relatively progressive city. These different views on travel can be better understood and responded to in strategy making, so that suitable policies and projects are developed.

1.2. **Structure of the report**

This report is written to answer the following five questions:

- Part 2: What levels of motorisation have been reached and are there signs of decline?
- Part 3: What are the impacts of the automobile system?
- Part 4: How might infrastructure needs and costs be reduced by more compact development?
- Part 5: What employment is associated with the automobile, public transport and cycling industries?
- Part 6: What discourses can be found at the city level – and how might they be responded to?

BILBAO: A revolution in transport planning is required – with high quality investment in the public realm, and massive investment in public transport, walking and cycling.

2. The Dominance of Automobility

Chapter summary:

- *The level of motorisation is running at unprecedented levels – there are 1.236 billion motor vehicles globally in 2014.*
- *The private car has been heavily advertised over the last 70 years, shaping public attitudes – in the USA, nearly $15 billion was spent in 2012 on vehicle advertising.*
- *But, there are signs that we are reaching 'peak car' in the Western industrialised countries – where vehicle km have reduced since 2000 and rail passenger km have been rising since 1990.*

2.1. Automobility: the indispensable medium?

For many, the promotion of life built around use of the automobile, as an integral part of the dispersed city, now seems hopelessly outdated. Webber [8] perhaps best encapsulated the Californian modernist dream:

"As the urban freeway extensions that are now under construction are extended farther out and connected to one another, an unprecedented degree of freedom and flexibility will be open to the traveller for moving among widely separated establishments in conducting his affairs. A network of freeways, such as that planned for the Los Angeles area, will make many points highly accessible … and the positive advantages of automobiles over transit systems … make it inconceivable that they will be abandoned […] or that the expansion of the freeway systems on which they depend will taper off. We would do well, then, to accept the private vehicle as an indispensable medium of metropolitan interaction – more, as an important instrument of personal freedom."

Though the advantages of car-based mobility were seen as being attractive in the 1950s and 1960s, and came to be heavily advertised, they were seldom realised – and the adverse impacts have become all too clear. The automobile city became the antithesis of all things appreciated in city life – the dullness of life in the suburbs, the endless car journeys travelling to the dispersed activities, the queuing in congestion, the horrific vehicle-related casualties, the severed neighbourhoods, the noise and intrusion, and the greenhouse gas emissions. Surely this was not the unprecedented convenience, freedom and flexibility that was foreseen?

Many have gone on to question the value of unlimited mobility, perhaps most famously with Adams [9, p.206]:

"The year 2205 is a milestone in so far as it is the year in which Britain becomes a millionaire society. It is the year in which, assuming that the government's growth target is achieved, average incomes will reach one million pounds […] the volume of freight moving about on the roads will have increased one-hundredfold. To accommodate this our descendants would need 60 million lorries […] and this means that the number of lorries would almost exactly equal the population […] since the service sector of the economy will have virtually disappeared, people will spend most of their time driving around in the family juggernaut picking up piles of machine-made stuff from automatic warehouses [...] such is the volume of stuff that will require shifting it is doubtful whether they will have the time to do all the holiday to-ing and fro-ing expected of them by the road and airport planners."

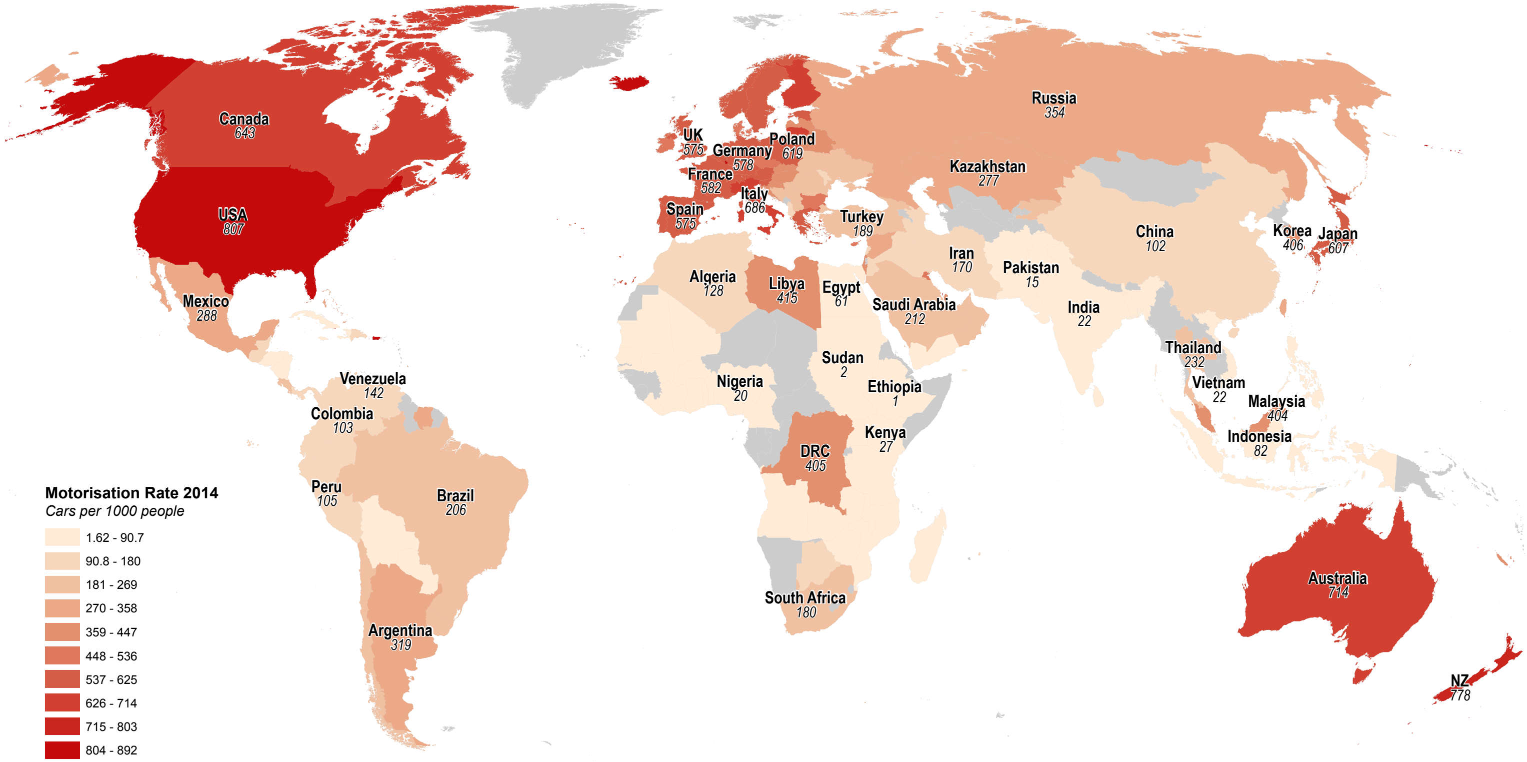
Yet, many of the warnings have remained unheeded. The private car is still heavily advertised and owning a car is a common aspiration internationally. The level of motorisation is running at unprecedented levels – there are 1.236 billion motor vehicles globally in 2014, including 907 million passenger cars and 329 million commercial vehicles. This is an increase in motor vehicles of 4 per cent from 2014-2013 and 38 per cent from 2014-2005 [10].

Figure 1 shows the motorisation rate for different countries in 2014. The global average is 180 vehicles/1000 population, but there is a huge difference between contexts. The United States has the highest levels of motorisation (809), followed by New Zealand (778), Australia (714), Canada (642) and Japan (607). The European countries have mid-range levels, including Germany (578), UK (575), and the Netherlands (550). Asia, South America and Africa have much lower levels of motorisation, but are rapidly increasing, including Central & South America (176), China (102), Africa (44), and India (22) [10].

It is estimated that there are likely to be two billion cars in 2020 [11]. Change in the motorisation rate is shown in Figure 2 for 2005-2014. Almost all countries are experiencing increases in motorisation, with some large increases in Poland (+234 vehicles/1000 population), Russia (+134), Argentina (+132), Mexico (+89), China (+80), Brazil (+80), Canada (+58), and India (+13). European countries are experiencing much reduced increases, with Germany even experiencing a reduced level of motorisation over the same time period (-8).

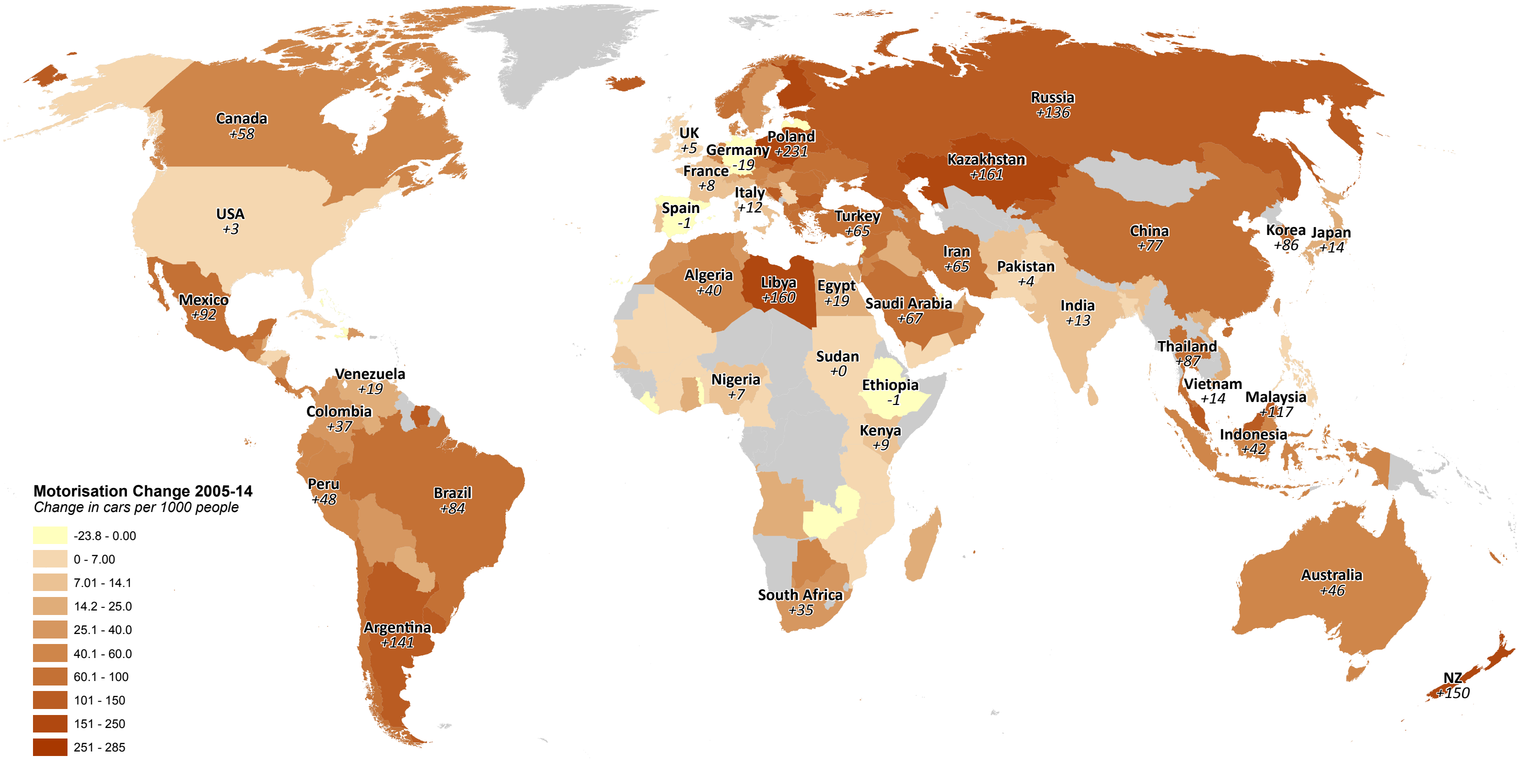
LIVERPOOL: Planning around the private car has ruined many cities – and the use of the car has hugely adverse impacts.

Figure 1: Global motorisation rate



[10]

Figure 2: Change in motorisation rate

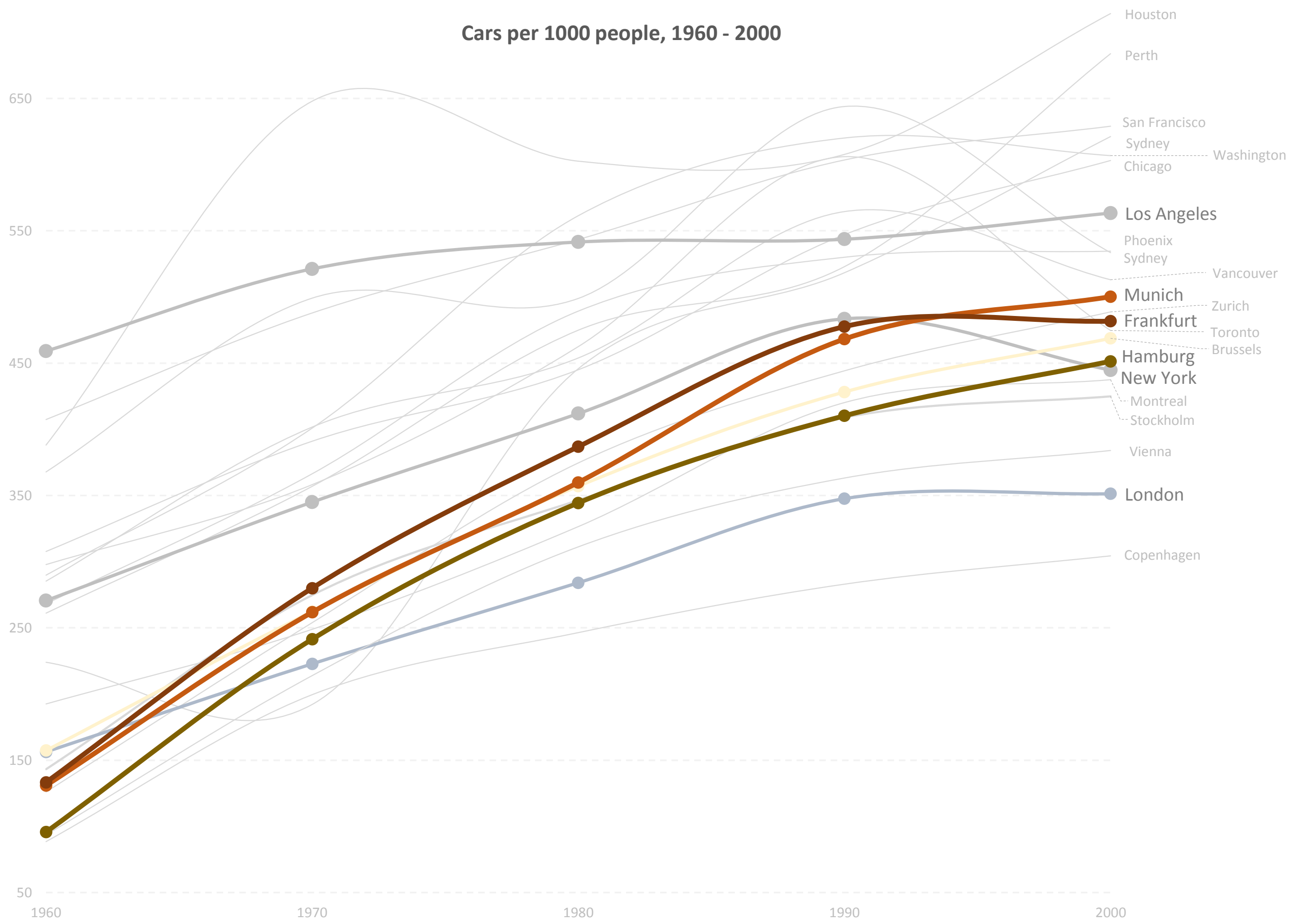


[10]

Some data is also available to consider trends over time at the city level, but only over the time period 1960-2000 [12]. There is no comparative data at the city level, as yet, for more recent years.

Car ownership is peaking or reaching a plateau in many cities, though not all. For example, in Los Angeles, car ownership has risen from 459 cars per 1,000 population in 1960 to 563 cars per 1,000 population in 2000. In comparison, European cities have much lower levels of car ownership – Frankfurt rising rapidly from a low 133 cars per 1,000 population in 1960 to 482 cars per 1,000 population in 2000; and London rising from 156 cars per 1,000 population in 1960 to a still relatively low 351 cars per 1,000 population in 2000 (Figure 3).

Figure 3: Cars per 1000 population



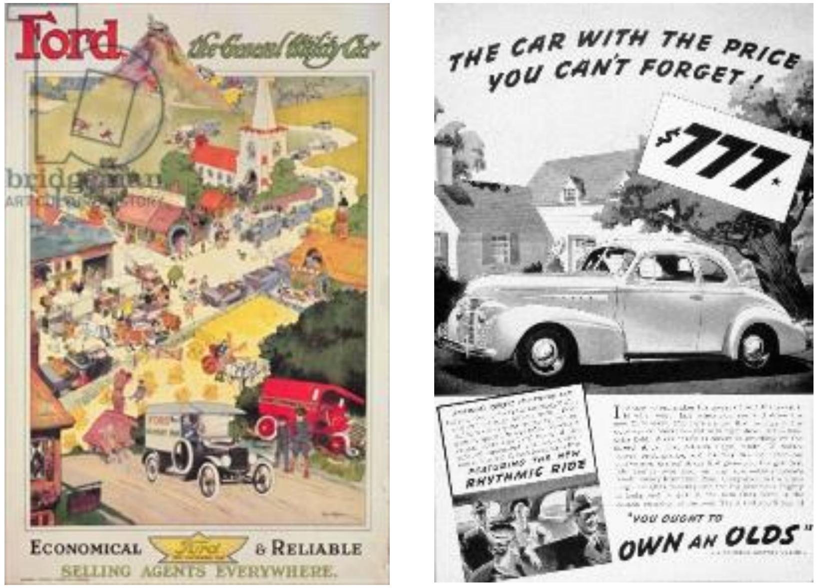
[12]

The Advertising of the Car

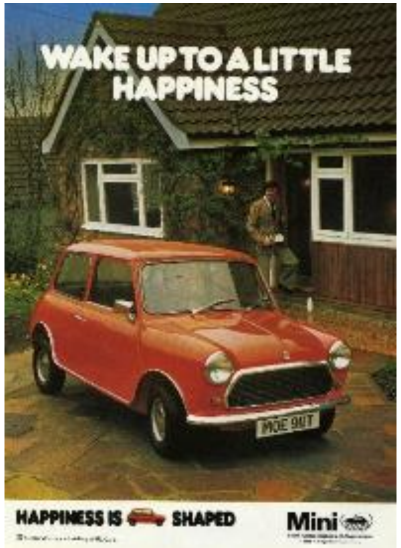
The private car has been heavily advertised over the last 70 years – to encourage the purchase of often the most expensive item beyond the home (Figure 4). There has been an increasing sophistication in the message over time, from selling the basic utility of the private car to the mass population, to the car as full of 'useful' gadgets, and to more subtle messages of the car as an 'environmentally-friendly' purchase – and many incorporating the latest in fashionable styling.

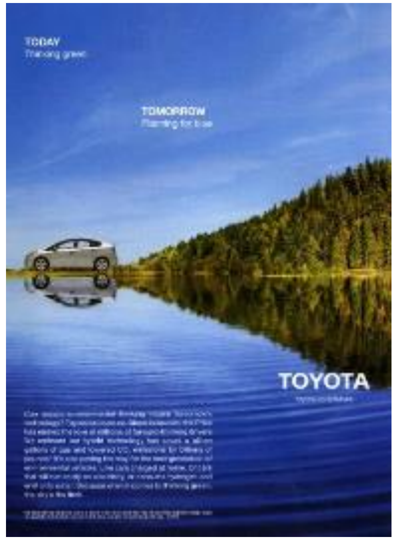
In the USA, vehicle advertising accounted for nearly US$15 billion of expenditure in 2012. Nearly half of the amount was contributed by three companies – General Motors (US$3 billion), Ford (US$2.3 billion) and Toyota (US$2 billion) [13].

Figure 4: The advertising of the car



(The Advertising Archives/The Bridgeman Art Library/Flickr Creative Commons)



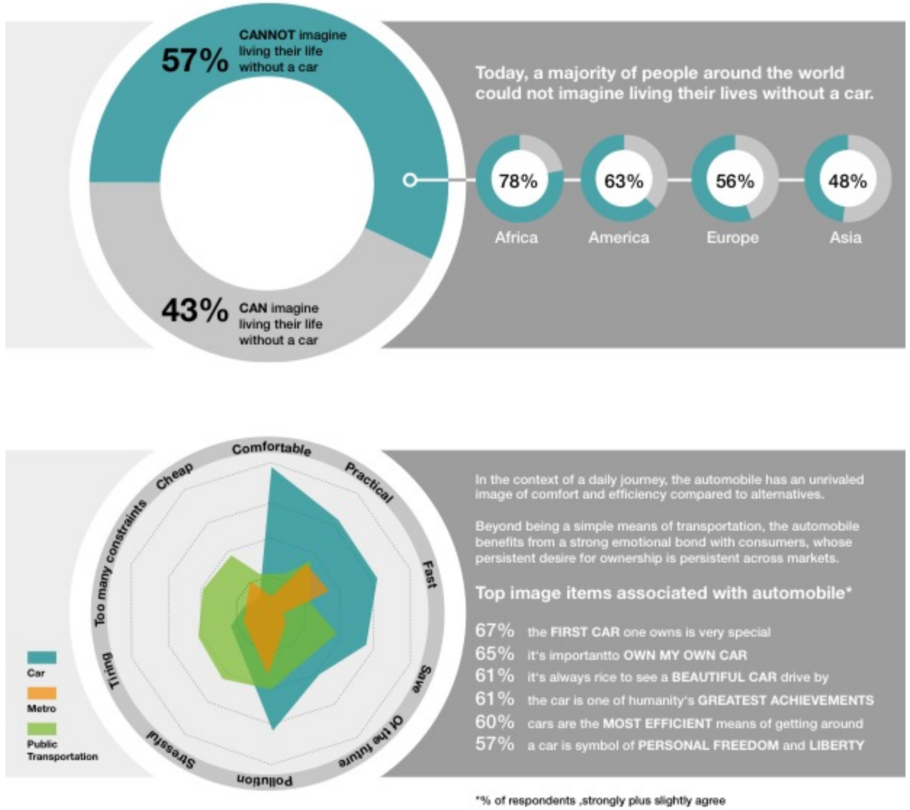


(The Advertising Archives/The Bridgeman Art Library/Flickr Creative Commons)

The International Organization of Motor Vehicle Manufacturers (OICA), founded in Paris in 1919, is one of a number of trade organisations promoting motor vehicle usage on behalf of its membership – the motor manufacturers. Market 'research' [14], commissioned by OICA, outlines the motor manufacturers views on the benefits of the private car. They produce infographics (Figure 5) to illustrate the proportion of people who 'cannot imagine living without a car' – apparently 57 per cent globally, rising to even 78 per cent in Africa. The 'top image items' associated with the car include 'comfort', 'practicality', 'speed' and perhaps uncomfortably 'pollution'. Apparently 65 per cent of respondents believe it is important to 'own my own car', and 61 per cent that 'the car is one of humanity's greatest achievement'.

Without questioning the statistical validity of the survey, we can see that much of this is naked advertising, positioning car ownership and usage in a way that sells the most vehicle units for the motor manufacturers. The results for 'Africa', for example, are derived from 800 interviews in South Africa and Nigeria, the former conveniently where the highest levels of car ownership in Africa are found. The problem is that this type of misinformation is presented in the media and popular press, alongside the billions spent on advertising, and the public's opinions are gradually shaped – so that car ownership becomes the cultural norm and aspiration across many contexts.

Figure 5: The advertised benefits of the car – humanity's greatest achievement?



[From 14]

The disadvantages of automobility receive much less attention, but include the issues below, some of which are explored in greater detail in section 2 of this report. A society focused on too much use of the private car is:

- associated with many adverse impacts, including energy depletion, CO2 emissions, traffic casualties, poor local air quality, obesity and health impacts of inactivity, and a loss of street space to the car
- more dispersed, including more suburban sprawl
- more socially polarized, with a greater disparity between rich and poor
- more anonymous and less convivial, i.e. fewer people will know their neighbours
- less culturally distinctive – a car-based city is very much like any other car-based city
- less democratic – vested interests will influence governments and decision-making and the public will have less influence over the decisions that govern their lives

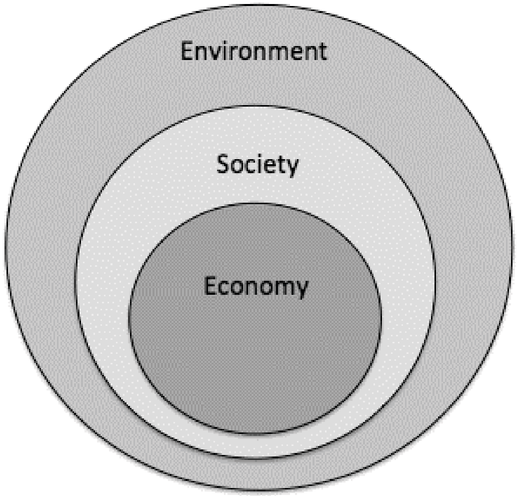
Though car ownership and use is rising globally, there are some contexts where policy makers are encouraging a different way of life – with large investments in walking, cycling and public transport, an urban renaissance, and a return to the city.

2.2. Reinterpreting sustainability in transport

Greater sustainability in travel has been a long held aspiration for policymakers, as the dominant policy consensus, yet has proved difficult to achieve. It has even been problematic to understand what is meant by 'sustainability' in transport planning. Infrastructure planning has been positioned as critical to support economic growth, and even capitalism itself – and this has resulted in economic growth objectives outweighing environmental, social and cultural objectives. We suggest we should move away from this 'three pillars' interpretation of sustainability – and, instead, to apply a nested concept of sustainability [15, 16]. This would incorporate limits and targets for environmental, social, economic and cultural objectives, where thresholds of achievement are used for transport planning. Infrastructure and new neighbourhoods would be designed to meet a range of objectives, and only be implemented if all were met (Figure 6).

Strategies and projects will hence need to achieve positive environmental, social, economic and cultural impacts in order to gain investment. Much higher investment in public transport, walking and cycling networks, alongside compact urban development, would result. In many cities this strategy is not being effectively delivered, with too much focus still being given to highway investment and dispersed development.

Figure 6: Applying a nested concept of sustainability in transport



[15]

Today, we are experiencing unprecedented demand for increased levels of mobility. The global population of 7.3 billion in 2015 is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100 [17]. In 2050, more than two thirds will live in cities, compared to 50 per cent today. More urban areas will be built in the next few decades than all of previous history. The number of megacities, with populations over 10 million, has increased from 10 in 1990, to 28 in 2015, and is projected to reach 41 by 2030 – and most of the emerging cities will be in Asia, South America and Africa [18]. The implications for mobility – and the impacts of billions of people moving around – are huge, with many potential adverse impacts depending on the kilometres travelled and modes taken. But, the opportunities for transport and city planners are also huge – we can use this incredible scale of development to develop cities which support sustainable travel behaviours.

2.3. The end of the automobile era?

In the last few years, there has been much interest in how vehicle kilometres travelled have appeared to flatten, and even reduce, in some contexts, such as in European and North American countries. This phenomenon has become known as 'peak car' [4, 5, 19]. There appear to be a number of contributory factors, including:

- The global financial crisis of 2007-2009 led to economic recession in many countries, with an impact of reduced mobility, including car-based travel.
- Increased fuel prices – as a response to volatile oil prices and also increased taxation on fuel.
- Sustainable transport policy initiatives, including investment in public transport, walking and cycling, and traffic demand management measures (e.g. road space reallocation and more restrictive car parking), are beginning to reduce usage of the car.
- The changing nature of work – there are many jobs that now do not require employees to be present 5 days a week in the office – hence there is a growth in working at home and potential for reduced commuting.
- Online retailing – there is less individual-based travel for shopping, though this is offset by home deliveries.
- Internet-based interaction – perhaps there is less need for face-to-face social interaction, though again the actual substitution effect is unclear.
- Reduced financial incentives for company car ownership – it is much less attractive to have a company car in terms of purchase price and free fuel, many of these incentives are now more heavily taxed, certainly in European countries such as the UK.
- More people are living in urban areas, hence it is easier to be less dependent on the car. There are large spatial differences in car usage – and those living in the larger urban areas and cities are much less likely to drive. There may be a changed attitude in those living in urban areas, with urban residents being less receptive to buying and using cars.
- Young people are delaying acquiring a driving license and are less likely to use the car. A large proportion of this cohort has a significantly different attitude to owning cars than previous generations.
- And, in addition, more people are travelling abroad, hence they have less time for travel domestically.

Hence, there are many factors which act in different directions – and a complex set of relationships. In Europe, levels of mobility, including car-based travel, remain high – and there is much scope for reduced levels of car-based mobility. There are important signs that private car travel distance is reducing and there is a much wider recognition that living in an urban area, with little use of the car, is actually very attractive.

In some contexts, such as the USA, there has been an extremely positive view of the potential for emerging technologies to solve societal problems – that low emission vehicles will become very important for travel in future years, with different options including petrol/electric hybrids, electric and even biofuel or hydrogen vehicles. The viewpoint here is that the dominance of private car mobility and dispersed urban form is perhaps unlikely to change significantly, but travel will become cleaner in fuel terms [11]. Public transport options will become more popular in some cities, but, for much of life in suburban areas and smaller urban centres, it is the low emission vehicle that will still serve the vast majority of trips.

Emerging vehicle technologies gain much governmental support and feature heavily in national strategies for sustainable transport. For example, in the UK, experts from the motor industry have even been involved in preparing governmental publications on low carbon transport, with low emission vehicles heavily featured, e.g. the King Review [20]. Similarly, organisations such as the European Automotive Manufacturers Association (ACEA) are influential in lobbying for EU legislation supportive of the motor manufacturers.

In addition, there is often a very positive view of the potential for automated vehicles, particularly in the USA, including the possibilities for carrying out activities whilst being 'driven' and for a large reduction in casualties. This could be part of a revolution in the provision of mobility as a service (MaaS), where the car is no longer an individually owned product, but mobility is purchased as a service from different, integrated providers, e.g. car sharing services, such as Uber and Lyft, will mean we no longer purchase our own car, but rent or collectively own for when we need to drive [19].

There is much scepticism beyond the motor manufacturers on the suitability of automated vehicles as a sustainable travel option, particularly in urban areas. There is no certainty that the technical problems of automated vehicles mixing with pedestrians and cyclists on busy urban streets can be overcome. Vehicles would travel very slowly if they were programmed to brake near every pedestrian or cyclist, yet this would be required on busy urban streets if casualties were not to occur. There is a further large problem with automated vehicles, which is often ignored: the emerging technologies may lead to easier and more comfortable travel by car – and hence an increase in car travel. There are already too many cars in the vast majority of urban areas – hence further vehicle growth should be discouraged.

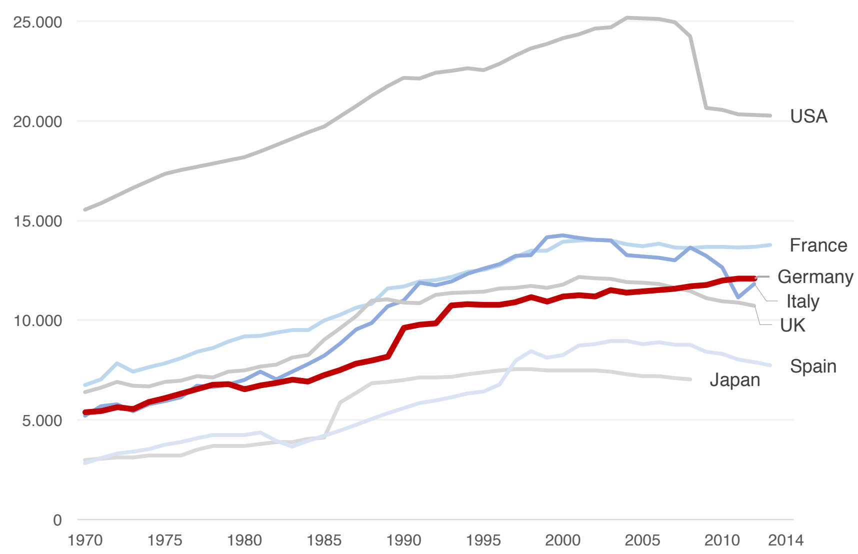
Figure 7 shows how road passenger transport distance per capita has fallen in many industrialised countries since the early 2000s. Data is given for road passenger kilometres per capita for inland transport. For example, the USA has dropped from a peak of 25,200 km per capita in 2004 to just over 20,200 km per capita in 2013; Germany has slowly increased to around 12,100 km per capita in 2013, but has remained fairly flat in road distance travelled over the last 20 years; and the UK has fallen from a peak of 12,200 km per capita in 2002 to 10,700 km per capita in 2013.

In the EU-28 in 2012, total passenger transport activities by all motorised means of transport are estimated at around 6,391 billion passenger km or on average of around 12,652 km per person. This includes intra-EU air and sea transport but not transport activities between the EU and the rest of the world. Passenger cars accounted for 72.2 per cent of this total, powered two-wheelers for 2 per cent, buses and coaches for 8.2 per cent, railways for 6.5 per cent and tram and metro for 1.5 per cent. Intra-EU air and intra-EU maritime transport contributed 9 per cent and 0.6 per cent [21].

In 2012, total goods transport activities in the EU-28 are estimated at around 3,768 billion tonne-kilometres (tkm). This again includes intra-EU air and sea transport but not transport activities between the EU and the rest of the world. Road transport accounted for 44.9 per cent of this total, rail for 10.8 per cent, inland waterways for 4 per cent and oil pipelines for 3 per cent. Intra-EU maritime transport was the second most important mode with a share of 37.2 per cent while intra-EU air transport accounted for 0.1 per cent of the total [21].

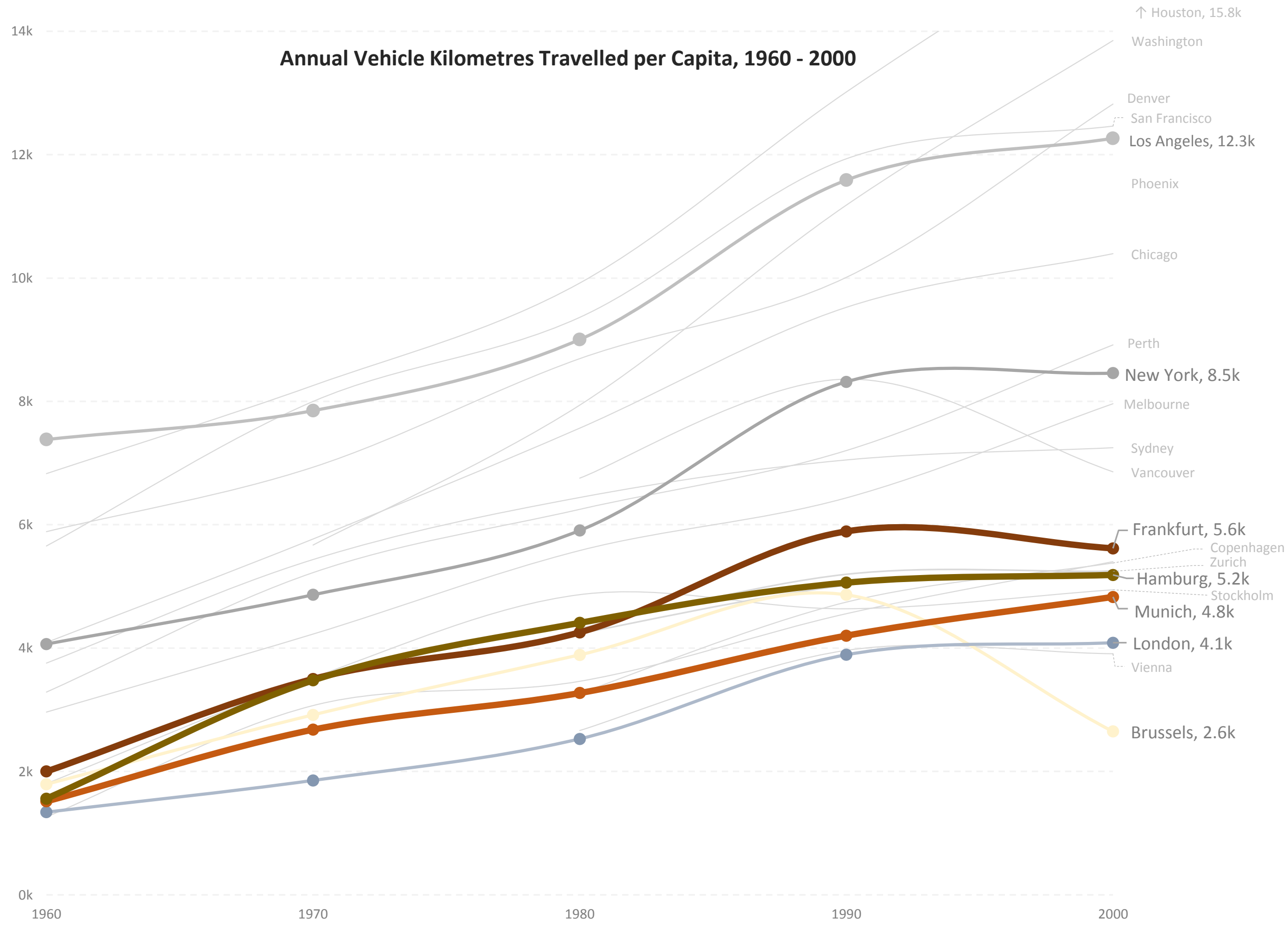
At the city level, annual car vehicle kilometres travelled (VKT) per capita also differs markedly by context (Figure 8). For example, car VKT in Los Angeles has risen from 7,382 km per capita in 1960 to 12,265 km per capita in 2000. European cities have much lower levels of car VKT – Frankfurt rising from a low 2,000 km per capita in 1960 to 5,618 km per capita in 2000; and London rising from 1,341 km per capita in 1960 to a still relatively low 4,088 km per capita in 2000 [12].

Figure 7: National road passenger km per capita



OECD data [22]; USA data [23]

Figure 8: Annual car km travelled per capita

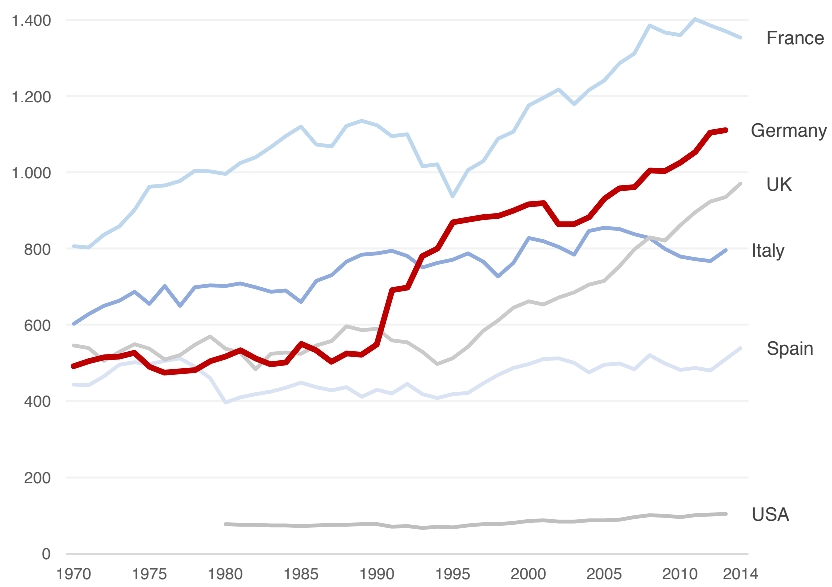


[12]

In parallel, there has been a significant rise in rail passenger distance per capita across many industrialised countries since the 1990s. Figure 9 gives rail passenger kilometres per capita per year. Rail usage in the USA remains very low at a marginal 105 km per capita per year, but in Europe the distances travelled by rail are much higher. Germany has experienced large increases, since the 1980s, from around 520 km per capita per year in 1980 to 1,100 km per capita in 2014. The rapid rise from 1990 was associated with reunification, but there has been a gradual rise alongside this per capita. The UK has risen from similar levels in the 1970s, at a slightly slower rate, from around 500 km per capita in 1970 to 970 km per capita in 2014. France has consistently had higher levels of rail passenger usage, and has reached over 1,350 km per capita per year in 2014.

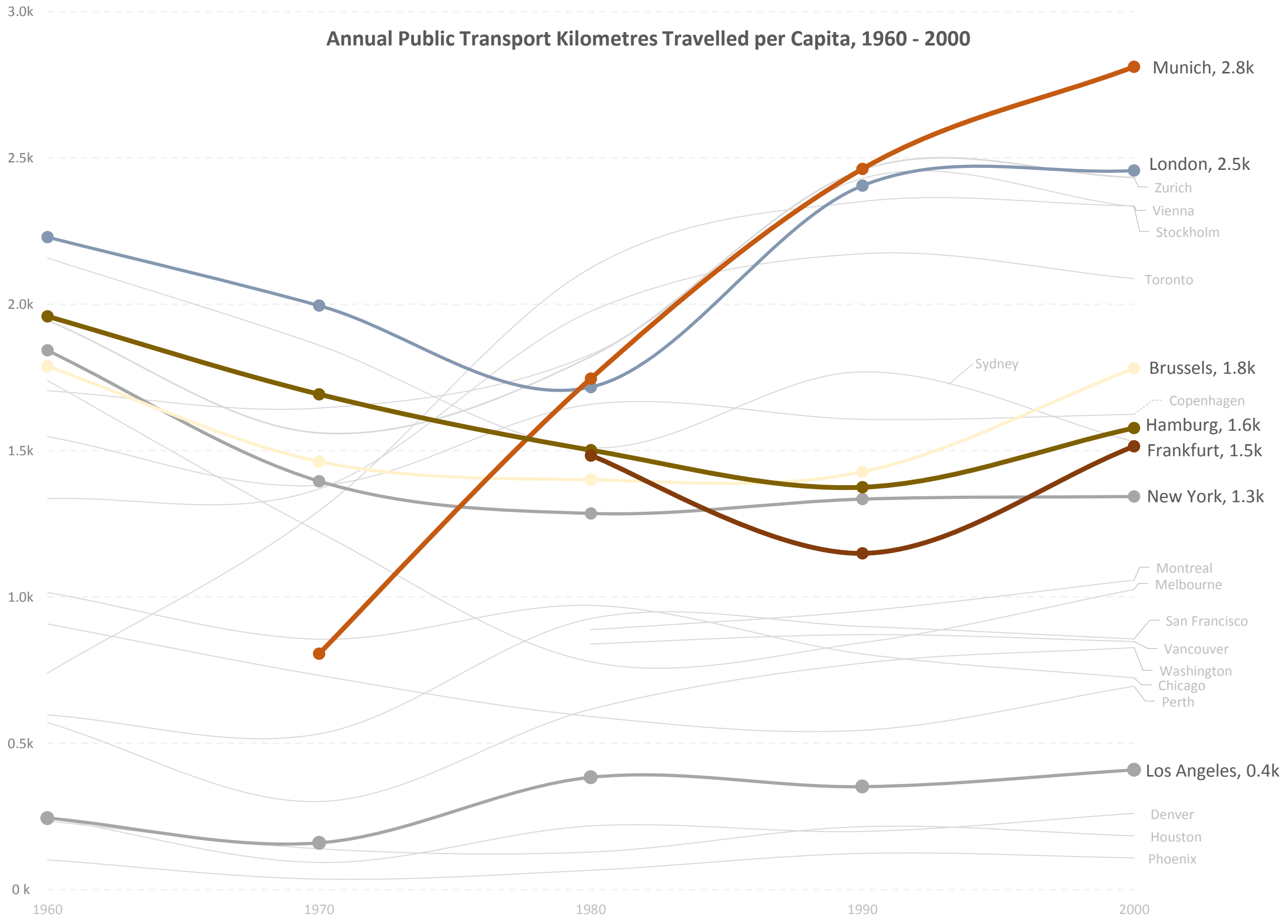
At the city level, annual public transport kilometres travelled (PTKT) per capita also differs markedly by context (Figure 10). Average PTKT in European cities runs at high levels – Munich rising rapidly from 806 km per capita in 1970 to 2,811 km per capita in 2000; Frankfurt rising from 1,484 km per capita in 1980 to 1,515 km per capita in 2000; and London rising from a high 2,229 km per capita in 1960 to 2,459 km per capita in 2000. Some of the North American and Australian cities have very low levels of PTKT – such as Los Angeles at 244 km per capita in 1960 and rising only a little to 409 km per capita in 2000 [12].

Figure 9: National rail passenger km per capita



OECD data [22]; USA data [23]

Figure 10: Annual public transport km travelled per capita



[12]

3. The Impacts of the Automobile System

Chapter summary:

- *Increased levels of mobility are leading to huge demand for energy consumption – in 2015, the transport sector consumed 23 per cent of global energy supplies, and is growing at 2 per cent per year over the last decade.*
- *The transport sector is the key sector that is failing to contribute to reduced CO2 emissions – even the progressive cities are only reducing transport CO2 emissions marginally.*
- *Around 1.25 million people die each year resulting from road traffic crashes and road traffic injuries.*

NEW YORK: The private car-based model has now been discredited – there are too many adverse impacts in environmental, social, economic terms – and on city planning. Many are now improving their public transport systems – but efforts need dramatically strengthening.

MANILA: Where the market is left to provide transport, cities suffer from huge problems – there are many like this in Asia and the emerging countries. Much more investment in public transport is required.

3.1. A range of adverse impacts

The transport sector is facing many challenges over the next decades to 2050, with an increasing population and large projected increases in mobility. There are many adverse impacts associated with the private car dominating our current travel behaviours, and these are likely to get significantly more severe with the projected increase in the use of the car. These include:

- Energy depletion
- Carbon dioxide (CO2) emissions
- Traffic casualties
- Local air quality
- Obesity and health impacts of inactivity
- The loss of street space to the car.

Each of these are considered in turn.

3.2. Energy depletion

Increased levels of mobility are leading to huge demand for energy, largely in the form of petrol and diesel to fuel vehicles. In 2015, the world consumed 13,559 million tons of oil equivalent (mtoe), an increase of 35 per cent on 2000 levels (Table 1). OECD countries[1] have recently been overtaken as the highest energy consumers by non-OECD countries (with 58 per cent of total energy consumption), including China (35 per cent) [24]. OECD countries are generally declining in energy consumption, whereas Eastern Europe, Asia, South America and Africa are experiencing large increases in energy consumption.

The majority of oil production is currently sourced from land and shallow water reserves. As these decline, there will be increased demand to exploit arctic and deep sea environments. This is likely to have very significant impacts on unique and vulnerable marine ecosystems.

In 2015, the transport sector consumed around 2,200 million tons of oil equivalent (mtoe), equating to 23 per cent of global energy supplies, and has grown at nearly 2 per cent per year over the last decade. The vast majority of this comes from oil-based sources (94 per cent) – there has been little change since the early 1970s. The remainder is derived from natural gas, biofuels and electricity [25].

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[1] There are 34 OECD (Organisation for Economic Co-operation and Development) countries, covering mainly the Western industrialised countries, including: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

Table 1: World primary energy demand by region (Mtoe)

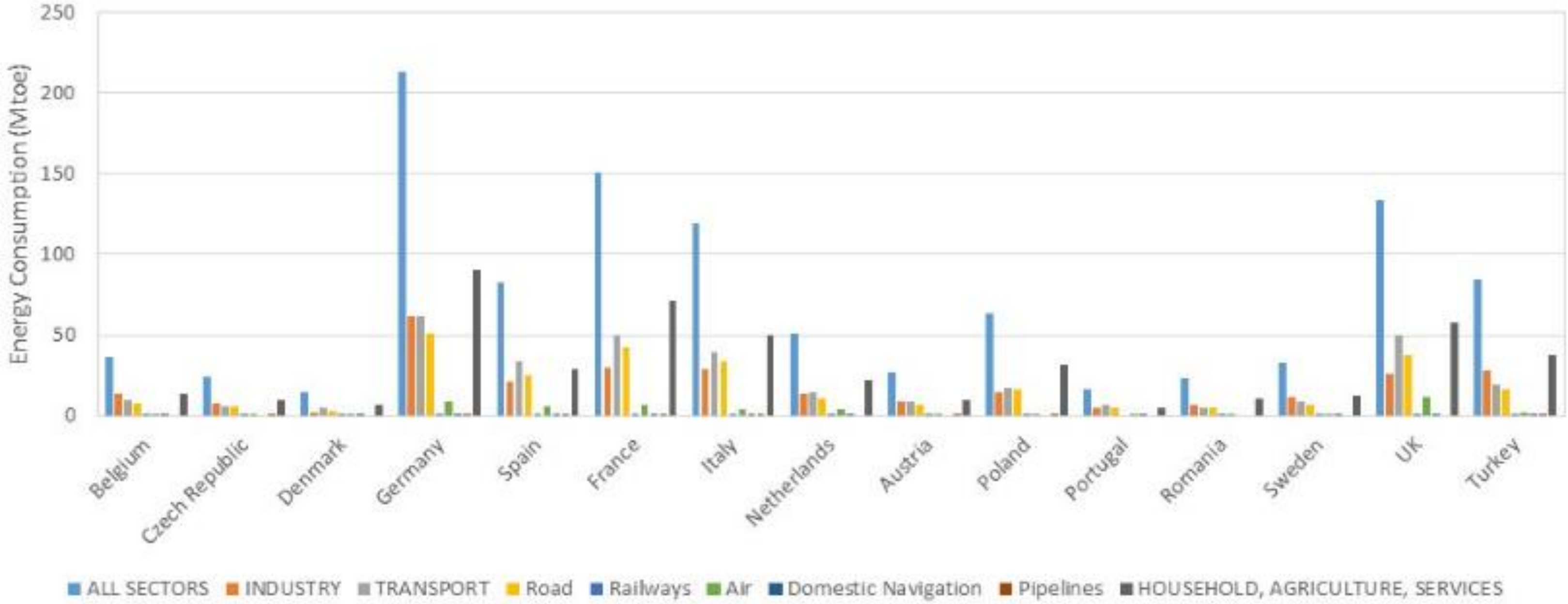
Region	2000	2013	% Change
OECD	5,294	5,324	0.6%
Americas	2,968	2,694	-9.2%
United States	2,270	2,185	-3.7%
Europe	1,764	1,760	-0.2%
Asia Oceania	832	870	4.6%
Japan	519	455	-12.3%
Non-OECD	4,497	7,884	75.3%
Eastern Europe/Eurasia	1,004	1,139	13.4%
Russia	620	715	15.3%
Asia	2,215	4,693	111.9%
China	1,174	3,037	158.7%
India	441	775	75.7%
South East Asia	386	594	53.9%
Middle East	356	689	93.5%
Africa	497	744	49.7%
South Africa	111	139	25.2%
South America	424	618	45.8%
Brazil	184	291	58.2%
World	10,063	13,559	34.7%

[24]

For the EU-28, transport accounts for 32 per cent of aggregate energy consumption, with road accounting for 82 per cent and air 14 per cent of the transport share. Germany is the highest transport energy consumer in the EU, followed by France, UK and Italy (Figure 11). The proportion of energy consumption in transport relative to all sectors varies across countries, ranging from Portugal (40 per cent), Spain (40 per cent) and the UK (37 per cent); to Germany (29 per cent), Netherlands (29 per cent) and Romania (23 per cent). Similarly, the energy consumption of road traffic relative to all transport also varies markedly, ranging from Poland (93 per cent), Germany (82 per cent); to Denmark (74 per cent) and Netherlands (74 per cent) [21]. There are many factors contributing to these figures, including the levels of car usage, and also income and other socio-demographic factors.

THE ARCTIC: Arctic and deep sea environments are very vulnerable to extreme oil sourcing – with unique and vulnerable marine ecosystems likely to be affected.

Figure 11: Energy consumption by sector, EU countries (Mtoe)



[21]

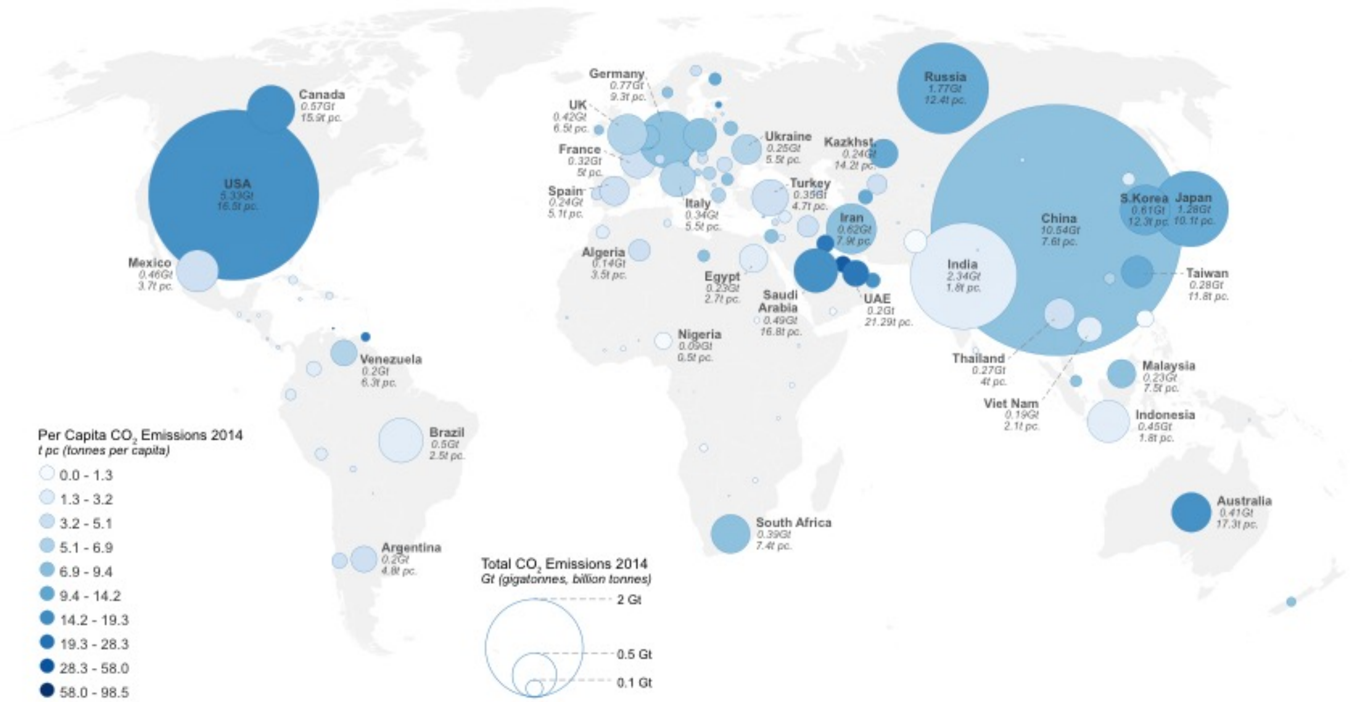
3.3. CO2 emissions

The transport sector is the key sector that is failing to contribute to reduced CO2 emissions – even the progressive cities are only reducing transport CO2 emissions marginally [26]. This is a huge problem for transport planning if it is to contribute to climate change and wider environmental objectives – and means that much more radical transport strategies need to be developed and implemented.

Globally, there is a large difference in national and per capita CO2 emissions (Figure 12). The Emission Database for Global Atmospheric Research (EDGAR) gives the latest data for aggregate emissions, covering the industrial, residential and transport sectors [27]. China has grown rapidly in recent years to be the largest emitter in aggregate terms at over 10.5 GTCO2 emissions in 2014 (7.6 tons CO2 per capita), which is a growth of over 300 per cent on 1990 emissions, and accounts for 29.6 per cent of global emissions. The United States is the next largest aggregate emitter at 5.3 GTCO2 (16.5 tons CO2 per capita), a growth of 7 per cent on 1990 levels, and accounting for 15 per cent of global emissions. The European countries are mostly all reducing CO2 emissions. Germany, for example, emits 0.8 GTCO2 (9.3 tons CO2 per capita), a reduction of 24 per cent on 1990 levels.

Any efforts to reduce the impacts of climate change have to include the large emitters, including China, the United States and India. However, the European countries can demonstrate how it is possible to reduce emissions from previous high levels – and, of course, they are responsible for much of the historical emissions in the atmosphere. Most European countries have begun to reduce CO2 emissions, but not to the degree required. There are important allocation issues within these figures – such as China producing many of the goods consumed in the West, and the CO2 emissions being allocated to China. This reduces the scale of emissions associated with lifestyles in the Western countries, and accounts for most of the perceived reductions in Europe.

Figure 12: National Aggregate CO2 emissions



EDGARv4.3, European Commission, Joint Research Centre (JRC)/PBL Netherlands Environmental Assessment Agency. Emission Database for Global Atmospheric Research (EDGAR) [27]

Figure 13 gives transport CO2 emissions (kt) and percentage of transport relative to total fuel combustion by country. Transport CO2 emissions accounts for over 20 per cent of total emissions in most countries, with the exception of those with large industrial emissions such as China and India. Even in Europe, where there are relatively high non-car mode shares, transport accounts for a significant proportion of CO2 emissions. This proportion also tends to be rising over time as domestic and industrial emissions are reduced. Transport is the sector that is reducing CO2 emissions least. For example, transport CO2 emissions are rising in Germany from 12 per cent (1980) to 20 percent (2010) and in the UK from 16 per cent (1980) to 25 percent (2010), relative to all emissions [28].

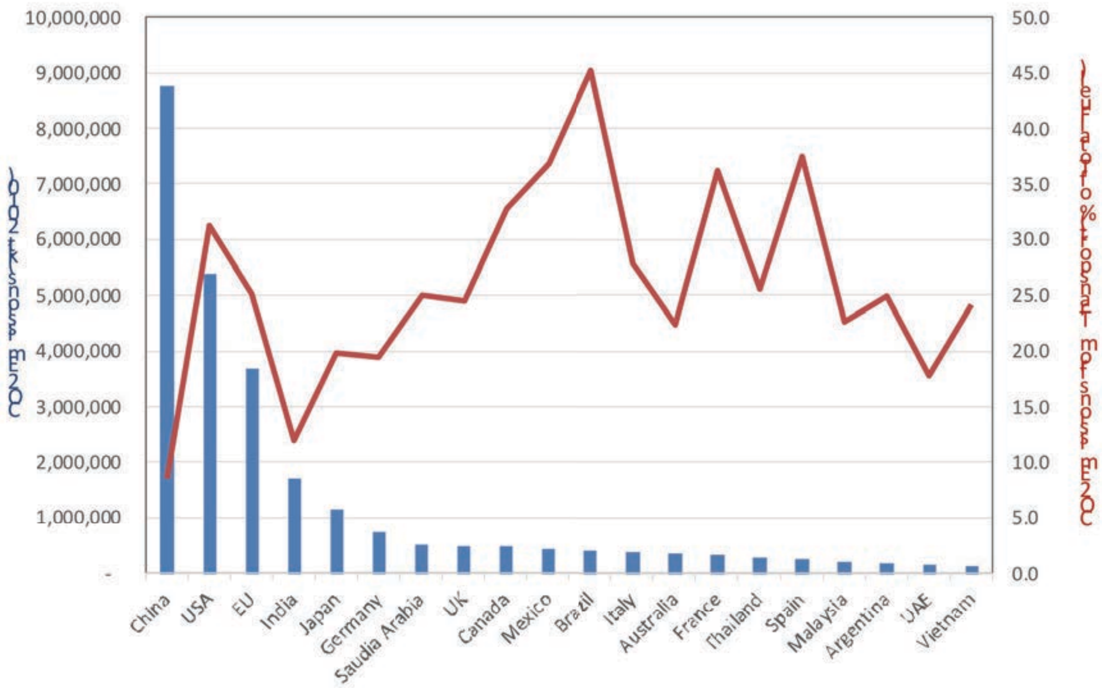


Figure 13: National transport CO2 emissions

[28]

There are very large concerns over the concentrations of CO_2 in the atmosphere. The current global annual mean concentration of CO_2 in the atmosphere is at 407 ppm (parts per million) in 2016 [29], meaning that over 0.04 per cent of the atmosphere is made up of CO_2. The daily average concentration of atmospheric CO_2, measured at Mauna Loa, Hawaii, first exceeded 400 ppm in May 2013, and is rising at 2-3 ppm each year. The projections are that the 450 ppm level will be reached before 2040. This is an increase of more than 40 per cent since the start of the Industrial Revolution, rising from 280 ppm in the mid-18th century. The present concentration is the highest in the past 20 million years. The increase has been caused by anthropogenic (human induced) sources, particularly the burning of fossil fuels and deforestation. Again, the transport sector is a major contributor here – and a rising contributor. The petrol and diesel-fuelled motor car are the most important source of these transport CO_2 emissions. This needs to change, and less CO_2 emitting means of travel be used, such as public transport, walking and cycling, if transport CO_2 emissions are to reduce significantly.

Stern [30] argues that a doubling of pre-industrial levels of CO_2 concentration is very likely to commit the Earth to a rise of 2-5 degrees Celsius (°C) in global mean temperature, a level that will be reached between 2030 and 2060. Table 2 gives CO_2 concentration levels and likely temperature increases, linking the two measures, presented in terms of probabilities. Holding global concentrations of CO_2 to around 500ppm gives a 96 per cent probability of a temperature rise of 2°C; a 44 per cent probability of over 2°C and 11 per cent probability of over 4°C

Table 2: CO2 concentration levels and likely temperature increases

Stabilisation level (ppm CO2e)	Likelihood of exceeding					
	2°C	3°C	4°C	5°C	6°C	7°C
450	78%	18%	3%	1%	0%	0%
500	96%	44%	11%	3%	1%	0%
550	99%	69%	24%	7%	2%	1%
650	100%	94%	58%	24%	9%	4%
750	100%	99%	82%	47%	22%	9%

Note: given the uncertainties, climate sensitivity is described in terms of probabilities against a range of stabilisation levels and temperature increases at equilibrium relative to 1850 – representing average global surface temperatures across the surface of the planet, ocean and land. Within this there will be much variation by area.

[30]

There are advocates for different stabilisation levels, including down to 350 ppm from some environmental groups. Yet the business as usual trajectory is estimated at around 750 ppm. Huge climatic problems are likely with any of the medium or higher stabilisation levels, with very large adverse impacts on populations, including those located at sea level and close to the major rivers or estuaries. Unfortunately, this includes the majority of the world's major cities.

Table 3 shows the Intended Nationally Determined Contributions (INDCs), including a GHG reduction of at least 40 per cent by 2030 on 2005 levels for the EU, a GHG reduction of 26-28 per cent by 2025 for the USA, and a peaking of GHG emissions by 2030 and a carbon intensity reduction target for China. It has been estimated that the INDCs collectively equate to limiting global warming to 2.7 °C by 2100. Even this relatively weak response to climate change requires major changes to travel behaviour, with much less use of the petrol and diesel car.

Table 3: UNFCCC party intended nationally determined contribution (INDC)

China	Peak GHG emissions by 2030 or earlier and reduce carbon intensity of GDP by 60-65% below their 2005 levels by 2030.
United States	Reduce net GHG emissions by 26-28% below 2005 levels by 2025.
European Union	Reduce EU domestic GHG emissions by at least 40% below 1990 levels by 2030.
India	Reduce the emissions intensity of GDP by 33-35% below 2005 levels by 2030.
Russia	Reduce anthropogenic GHG emissions by 25-30% below 1990 levels by 2030 subject to the maximum possible account of absorptive capacity of forests.

Japan	Reduce energy-related CO_2 emissions by 25%, reduce non-energy CO_2 emissions by 6.7%, CH_4 by 12.3%, N_2O by 6.1%, and fluorinated gases by 25.1% compared with 2013 levels by 2030.
Korea	Reduce GHG emissions by 37% by 2030 compared with a business-as-usual scenario.
Canada	Reduce GHG emissions by 30% below 2005 levels by 2030.
Brazil	Reduce GHG emissions by 37% compared with 2005 levels by 2025.
Mexico	Reduce GHG and short-lived climate pollutant emissions unconditionally by 25% by 2030 with respect to a business-as-usual scenario.

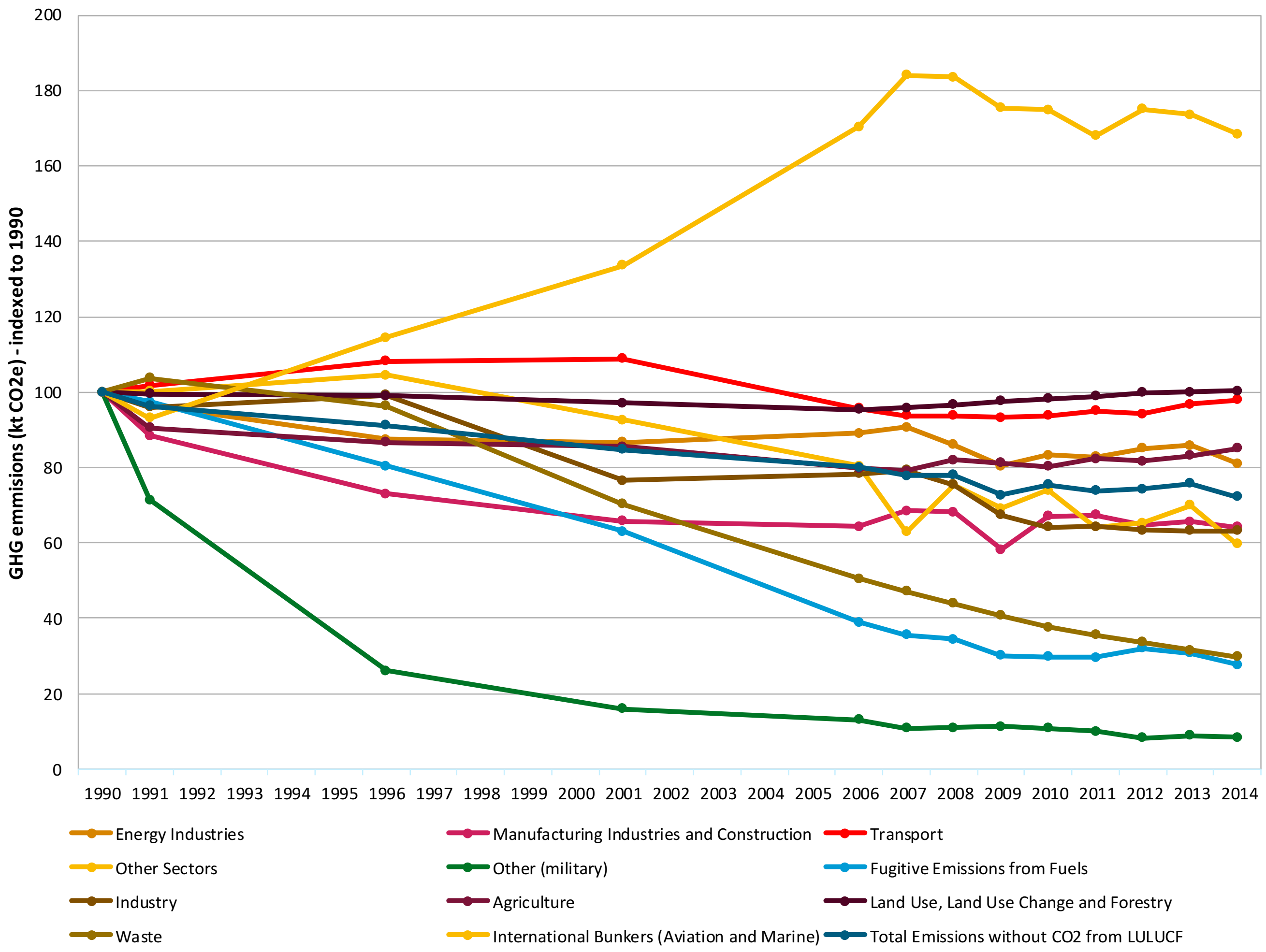
[24]

Some countries, and more usually cities, are being much more ambitious in developing their own targets. Cities, in particular, have the potential to lead the progressive response to climate change. Some national strategies are well developed – for example, since 2007, Germany has aimed to cut greenhouse gas emissions by 40 per cent by 2020 and up to 95 per cent by 2050. The current progress is a 27 per cent reduction in CO_2 emissions by 2015 on 1990 levels. Hence, although there is progress, the 2020 target is unlikely to be reached. Cities such as Berlin have an 85 per cent CO_2 reduction target by 2050 [31]. Alongside, the share of renewables in final energy consumption is to rise to 60 per cent (from 12.6 percent in 2015) by 2050.

This demonstrates good progress – but much more is required. Though the city-based targets are ambitious, they will be difficult to achieve. Transport CO_2 emissions are rising in many cities beyond the progressive examples most often mentioned.

In Germany, between 1990 and 2014, most major emission sectors achieved significant reductions (Figure 14). When indexed to 1990 levels, the energy sector fell by 19 per cent and manufacturing industry and construction by 36 per cent. The transport sector, in comparison, is making much less progress, with emissions only reducing by 2 per cent. International bunkers (aviation and maritime) have increased by 68 per cent. With such marginal emission reduction in transport, the sector is gradually taking up more and more of the total national emissions – up to 17 per cent in 2013 relative to 13 per cent in 1990 [32]. Much more progress is required in transport; with much higher investment in extensive public transport, cycling and walking networks, alongside making the private car (and flying) more expensive. Because of the lack of progress in reducing CO_2 emissions in transport, this sector has become the make and break for all of the national and city-based targets.

Figure 14: GHG emission trends in Germany by sector – indexed to 1990



[32]

3.4. Traffic casualties

One of the most pervasive and unacceptable consequences of automobility is the level of traffic-related casualties [33, 34]. Around 1.25 million people die each year resulting from road traffic crashes and road traffic injuries – this approximates to 3,400 deaths per day. Traffic casualties are the leading cause of death among young people aged 15–29 years. Nearly 50 per cent of deaths are 'vulnerable road users', i.e. pedestrians, cyclists and motorcyclists. In addition, between 20-50 million more people suffer non-fatal injuries, with many incurring ongoing disabilities [34].

These figures can be compared to the numbers killed by malaria – which accounted for 429,000 deaths in 2015 [35]. The scale of traffic-related casualties is off the scale and is clearly an unacceptable casualty rate for a means of travelling between activities, where there are also many other options available.

Figure 15 gives road traffic death rates (per 100,000 population) by country in 2013. The United States has a high rate (10.6 deaths per 1000 population); Australia (5.4); Germany (4.3), the UK (2.9) and other European countries relatively low; but the very high rates are in China (18.8), India (16.6), Brazil (23.4); and other Asian and African countries, where traffic safety is poor and death rates exceed 30 deaths per 1000 population [34].

Figure 16 shows how road traffic death rates vary markedly by road user type by country, again for 2013 [34]. In the United States, four-wheeled vehicle drivers and passengers account for 64 per cent of deaths, pedestrians for 14 per cent and cyclists for 2 per cent; in Germany four-wheeled vehicle drivers and passengers account for 48 per cent of deaths, pedestrians for 17 per cent and cyclists for 11 per cent; in China four-wheeled vehicle drivers and passengers account for 19 per cent of deaths, two-wheeled vehicles 26 per cent and pedestrians for 26 per cent; whilst in Kenya four-wheeled vehicle drivers and passengers account for 34 per cent of deaths and pedestrians for 46 per cent. Hence the distribution of traffic-related deaths relates to the mode shares experienced in each country and also the safety of the facilities provided. Two-wheeler deaths are particularly prevalent in Asia and parts of South America. The road user type that is responsible for the road traffic deaths is almost always the same – the private car or other road vehicle.

In the EU-28, 28,126 persons were killed in road accidents in 2012 (fatalities within 30 days), this is 8.3 per cent fewer than in 2011 (when 30,686 people were killed). In comparison with 2001, the number of road fatalities was lower by more than 40 per cent. Hence, in principle, there seems to be some progress being made. In terms of rail accidents, 36 passengers[2] lost their lives in 2012 [21]. The most important contributory factor to the road traffic casualty rate is vehicle speed. An increase in average speed is directly related to the likelihood of a crash occurring and to the severity of the crash. An adult pedestrian's risk of dying is less than 20 per cent if struck

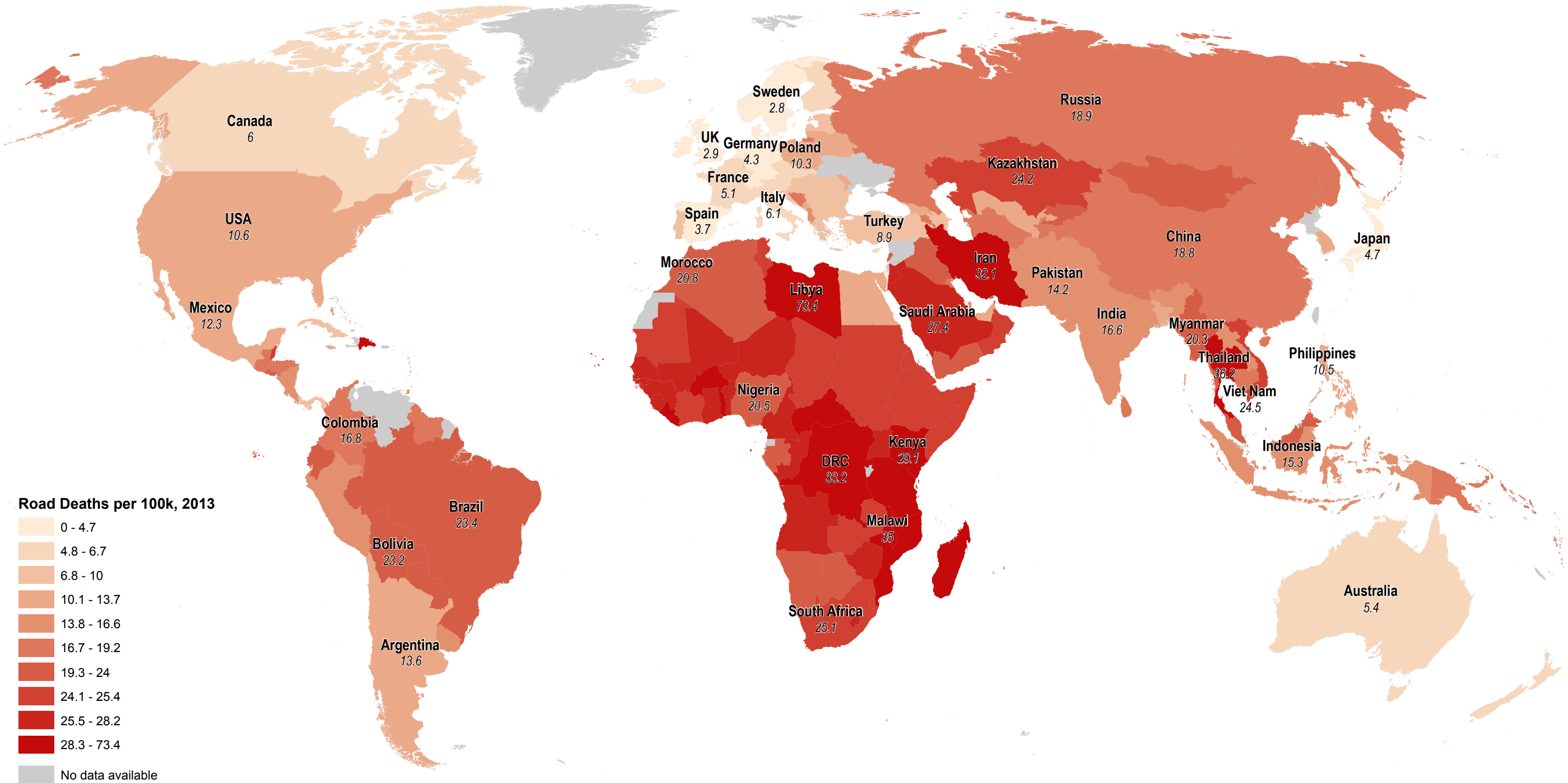
[2] This figure does not include casualties among railway employees or other people run over by trains.

by a car at 50 kmph and almost 60 per cent if hit at 80 kmph [34]. 30 kmph low speed zones can greatly reduce the risk of crashes. They are very suitable for urban centres and residential and school neighbourhoods.

Looking beyond the headline figures, there are many ways that the data is made to look more acceptable in some contexts. Traffic ‘accidents’ is used as the terminology to describe crashes, yet the majority of these are very predictable and preventable [33], resulting from high traffic volumes and the incompatibility of vehicles with other road users. Perceived reductions in traffic casualties are often the result of users withdrawing from use of the street, particularly the young and other vulnerable road users. For example, in the UK, 80 per cent of seven and eight-year-old children were allowed to go to school without adult supervision in 1970; but this figure had fallen to 9 per cent in 1990 – hence a major part of the reduced casualty figures are due to people withdrawing from use of the street.

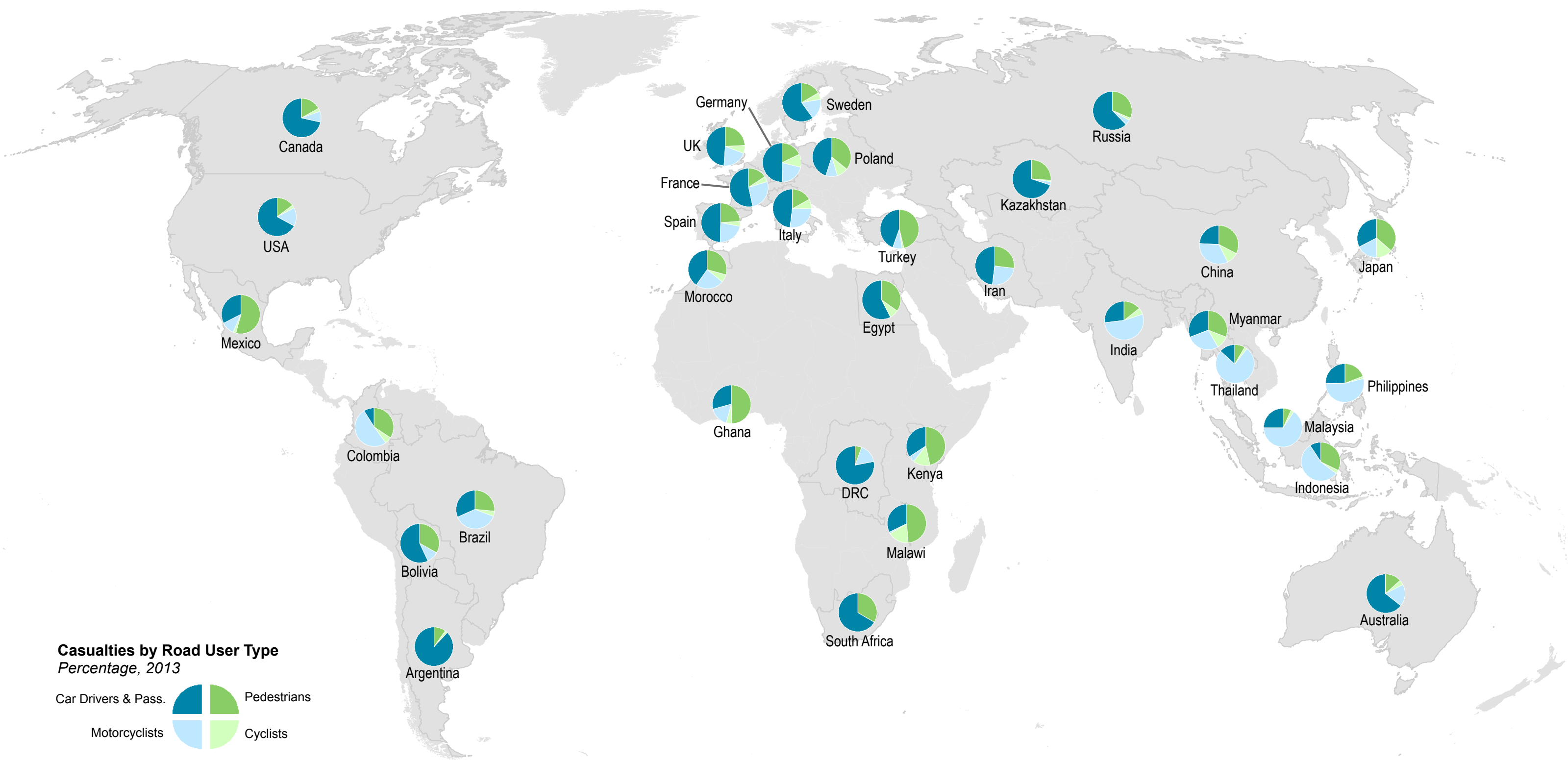
These figures and behaviours are replicated across many contexts. Road accidents involving children have declined not because the roads have become safer but because children are longer exposed to the dangers they pose [36]. The casualty reduction topic is considered in terms of ‘engineering out’ the perceived problematic casualty sites, and often appraised in cost-benefit terms; whereas many would argue that these approaches are flawed, that human life should not be quantified in such a way, and that significantly reducing traffic volumes and speeds, and increasing the numbers of people using public transport, and walking and cycling, are the only way to effectively reduce casualties.

Figure 15: Global road traffic death rates (per 100,000 population)



[37]

Figure 16: Global road traffic death rates by road user type (per 100,000 population)



[37]

3.5. Local air quality

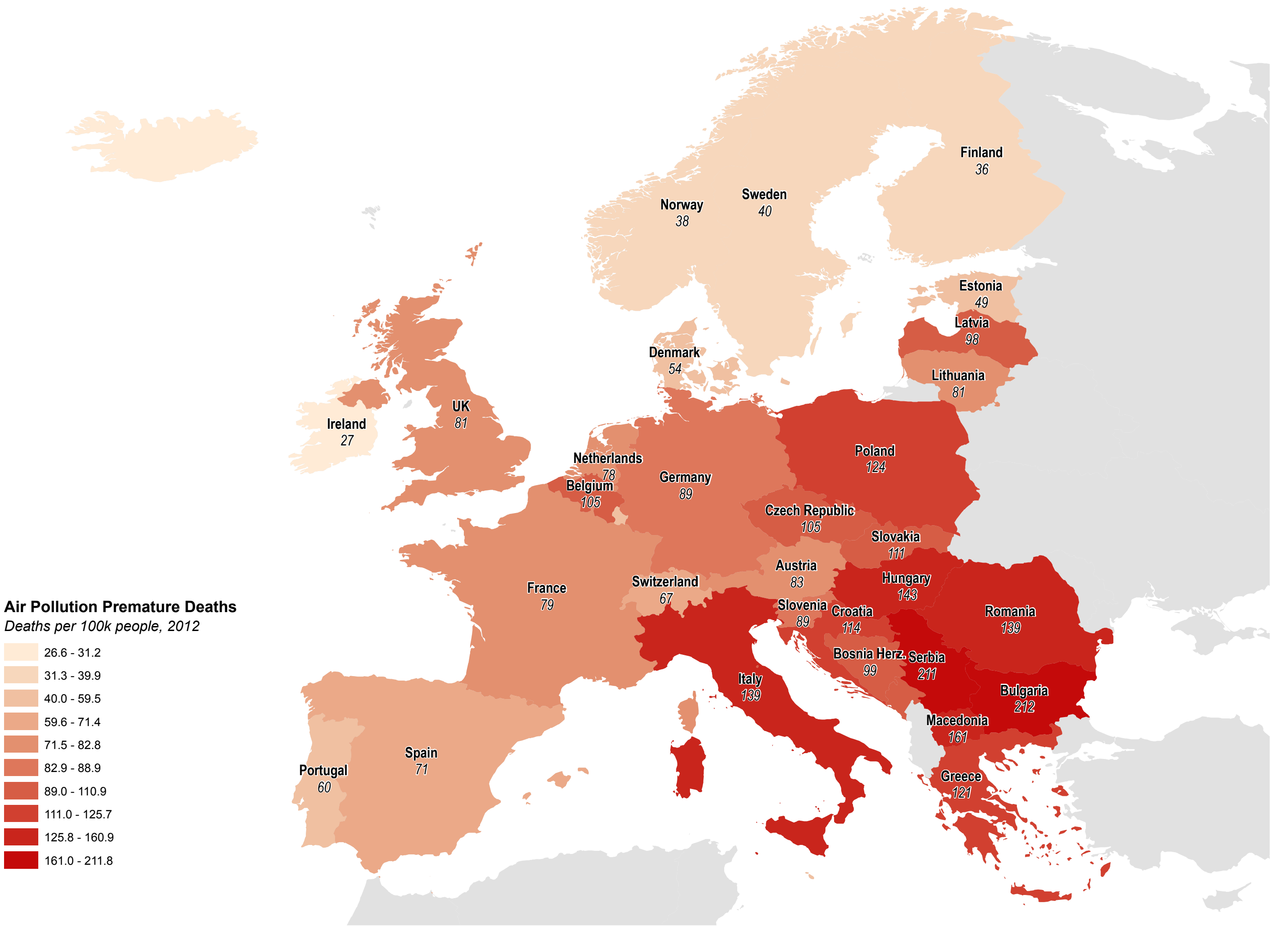
Air pollution represents the single largest environmental health risk in Europe today [38], with pollutants emitted from anthropogenic (human induced) and natural sources. In 2012, an estimated 6.5 million deaths (11.6 per cent of all global deaths) were associated with indoor and outdoor air pollution – with 3 million of these deaths linked to exposure to outdoor air pollution. Nearly 90 per cent of air pollution related deaths occur in low- and middle-income countries, and most from Asia [39]. There are, however, severe air pollution problems in many European countries, particularly from cities in Italy, Greece and Eastern Europe.

Transport is to a high extent responsible for local air quality and associated health effects; alongside industrial, commercial, domestic, agriculture and waste emissions. Air pollution comprises particles and gases, including particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NO_x), nitrogen dioxide (NO_2), ozone (O_3), benzopyrene (BaP), sulphur dioxide (SO_2), carbon monoxide (CO), toxic metals and benzene (C_6H_6). Daily limits are often exceeded for large cohorts of the population. For example, in 2013, around 17 per cent of the EU‑28 urban population was exposed to PM_{10} above the EU daily limit value (50µg/m3, not to be exceeded on more than 35 days a calendar year, for short‑term exposure). Transport accounts for 13 per cent of PM_{10}, 15 per cent of $PM_{2.5}$ emissions, and 46 per cent of NO_x emissions, across the EU‑28 in 2013 [38]. NO_2, in particular, is the pollutant which is dominated by transport emissions, especially in countries with a high share of diesel cars, such as in Europe.

The health effects are related to short-term and long-term exposure to air pollutants. Short-term (exposure over a few hours or days) is linked with acute health effects, whereas long-term exposure (over months or years) is linked with chronic health effects. The disease burden is substantial, including many non-communicable diseases (NCDs), such as heart disease, stroke, cancers and respiratory diseases.

Figure 17 shows the estimated number of premature deaths due to poor air quality in the EU-28 countries in 2012. The numbers are very high – 403,000 premature deaths are attributed to $PM_{2.5}$ exposure, 72,000 to NO_2 exposure, and 16,000 to O_3 exposure. This equates to a total of 491,000 premature deaths. In Germany alone this amounts to 72,000 premature deaths in 2012, or 89 deaths per 100,000 population. Italy (139 deaths per 100,000 population) and Eastern Europe have much higher levels [38], reflecting poor levels of air quality. Again, this is an incredible toll to accept for travelling between activities.

Figure 17: EU-28 premature deaths attributable to PM2.5, O3 and NO2 exposure



[38]

3.6. Obesity and health impacts of inactivity

A profound shift has occurred in the balance of the major causes of death and disease with the rise of NCDs. Also known as chronic diseases, these are not passed from one person to another, but develop within each individual. NCDs killed around 38 million people in 2012, representing 68 per cent of 56 million global deaths. There are strong correlations with mode shares and the built environment – with a high levels of car usage being associated with inactive and unhealthy individuals. The four main types of NCDs and numbers of deaths are given below:

- Cardiovascular diseases (mainly heart disease and stroke): 17.5 million deaths.
- Cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney and colon): 8.2 million deaths.
- Respiratory diseases: 4 million deaths.
- Diabetes: 1.5 million deaths.

[40]

Almost three quarters of NCD deaths (28 million) occur in low and middle-income countries and 16 million NCD deaths occur before the age of 70 – known as 'premature deaths'.

Though NCDs are not directly caused by motorisation, poor urban planning, dispersed built environments, and a lack of infrastructure for walking and cycling, contribute to the problems by making it difficult to choose active means of travel [41]. The most important risks leading to NCDs are: high blood pressure, inadequate intake of fruit and vegetables, being overweight or obese (also linked to type 2 diabetes), physical inactivity and tobacco use. Hence, five out of these six risk factors are closely related to diet and physical activity.

The Body Mass Index (BMI) is used to measure levels of obesity. Adult obesity is defined as BMI > 30 kg/m^2, with moderate obesity at BMI of 30-35 kg/m^2, and morbid obesity at BMI of 40-50 kg/m^2. An adult is viewed as overweight with BMI of 25-30 kg/m^2 and underweight with BMI of < 18.5 kg/m^2. Hence most adults should have BMI of 18.5-25 kg/m^2. Use of the BMI has some limitations, for example it doesn't distinguish between excess fat, muscle or bone; or age, gender or ethnicity. But it is a useful initial measurement of levels of obesity.

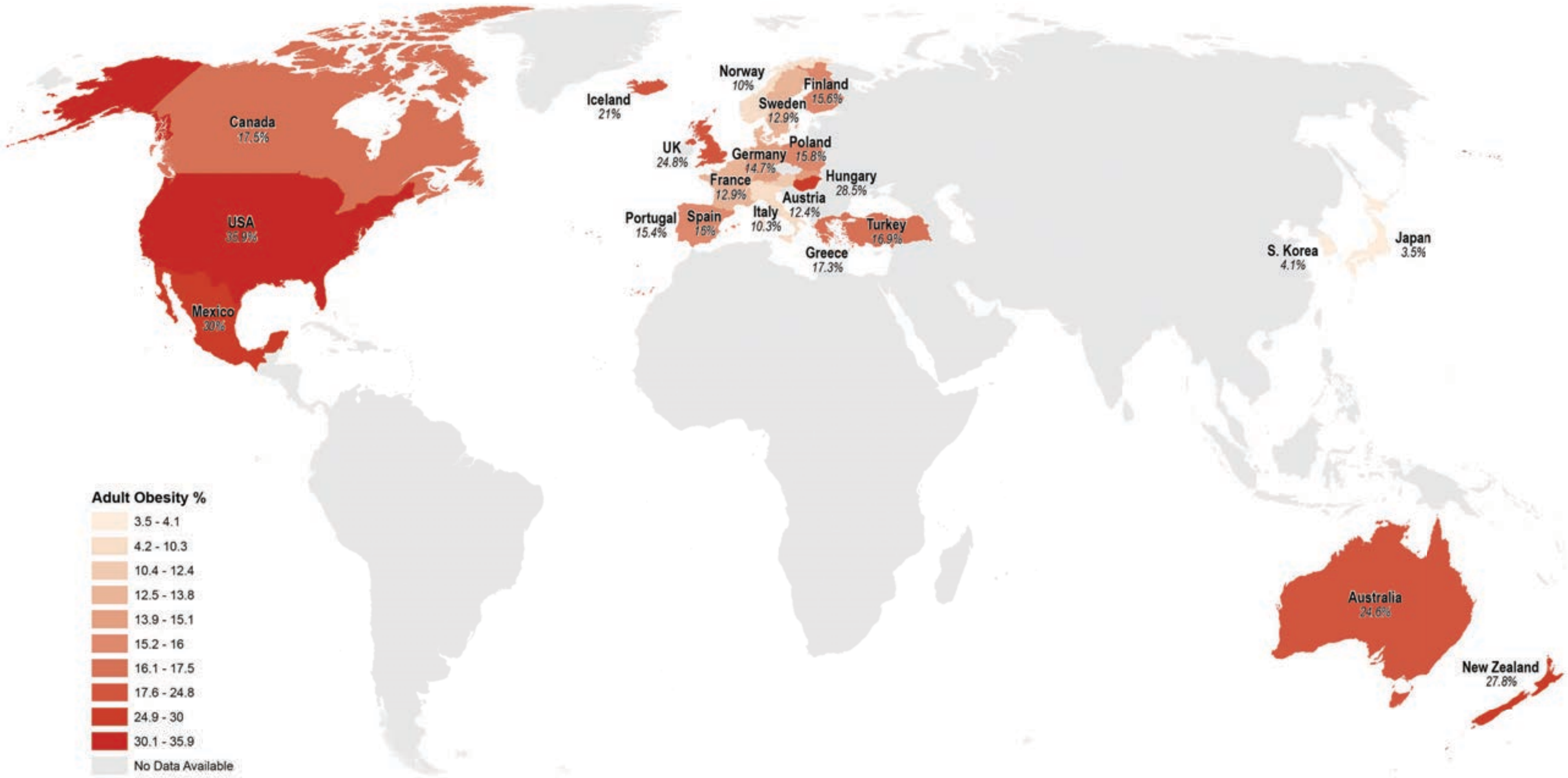
Obesity is a risk factor for NCDs and also contributes to musculoskeletal disorders, especially osteoarthritis – a highly disabling degenerative disease of the joints [40]. Global obesity has more than doubled since 1980 and now represents a very significant health problem. In 2014, more than 1.9 billion adults (18 years and older) were overweight; of these, over 600 million were obese. 39 per cent of adults were overweight in 2014, and 13 per cent were obese. The increased consumption of energy-dense, nutrient-poor foods that are high in fat, sugar and salt; reduced levels of physical activity at home, at school, at work and for recreation and travel; and use of tobacco; all contribute to the NCD problem. Physical activity is a key determinant of energy usage by individuals, and therefore important to weight control. Physical activity reduces the risk of NCDs and has substantial benefits for many conditions, not only those associated with obesity.

The beneficial effects of physical activity extend beyond controlling excess body weight. For example, physical activity reduces blood pressure, improves the level of high density lipoprotein cholesterol, improves the control of blood glucose in overweight people, even without significant weight loss, and reduces the risk for colon cancer and breast cancer among women [42]. The WHO recommend that individuals engage in adequate levels of exercise throughout their lives – at least 30 minutes of regular, moderate-intensity physical activity are required on most days. More activity is usually required for weight control.

Figure 18 shows the prevalence of adult obesity (BMI >30 kg/m^2) by selected countries, with a large variation between contexts. Japan has a very low prevalence of obesity at 3.5 per cent and Korea at 4.1 per cent; most European countries are at slightly higher levels, with Italy at 10.1 per cent, the Netherlands at 11.4 per cent and Germany at 14.7 per cent. Some countries have very high levels – such as Australia at 24.6 per cent, England at 24.8 per cent, Mexico at 30 per cent and the United States at 35.9 per cent. The data shown is broadly comparable – some countries publish obesity prevalence based on measured height and weight, whereas other countries use self-reported data. It is likely that obesity prevalence estimates based on self-reported measures are lower than those based on actual measurements, hence many of the figures may be worse than shown. Moderate obesity (BMI of 30-35 kg/m^2) is found to reduce life expectancy by an average of three years, while morbid obesity (BMI of 40-50 kg/m^2) reduces life expectancy by 8-10 years. Around 8 per cent of annual deaths in Europe (around one in 13) are attributed to levels of obesity [43].

The correlation of obesity with motorisation is given in Figure 19. The highly motorised countries usually have the highest obesity ratios, such as the USA, New Zealand, Australia and the UK. There are however some outliers, such as Mexico, with a lower motorisation rate and high obesity; or Japan, with a high motorisation rate, but low obesity – illustrating that obesity is only partly related to travel inactivity and that other contributory factors are also important [10, 43].

Figure 18: Prevalence of adult obesity

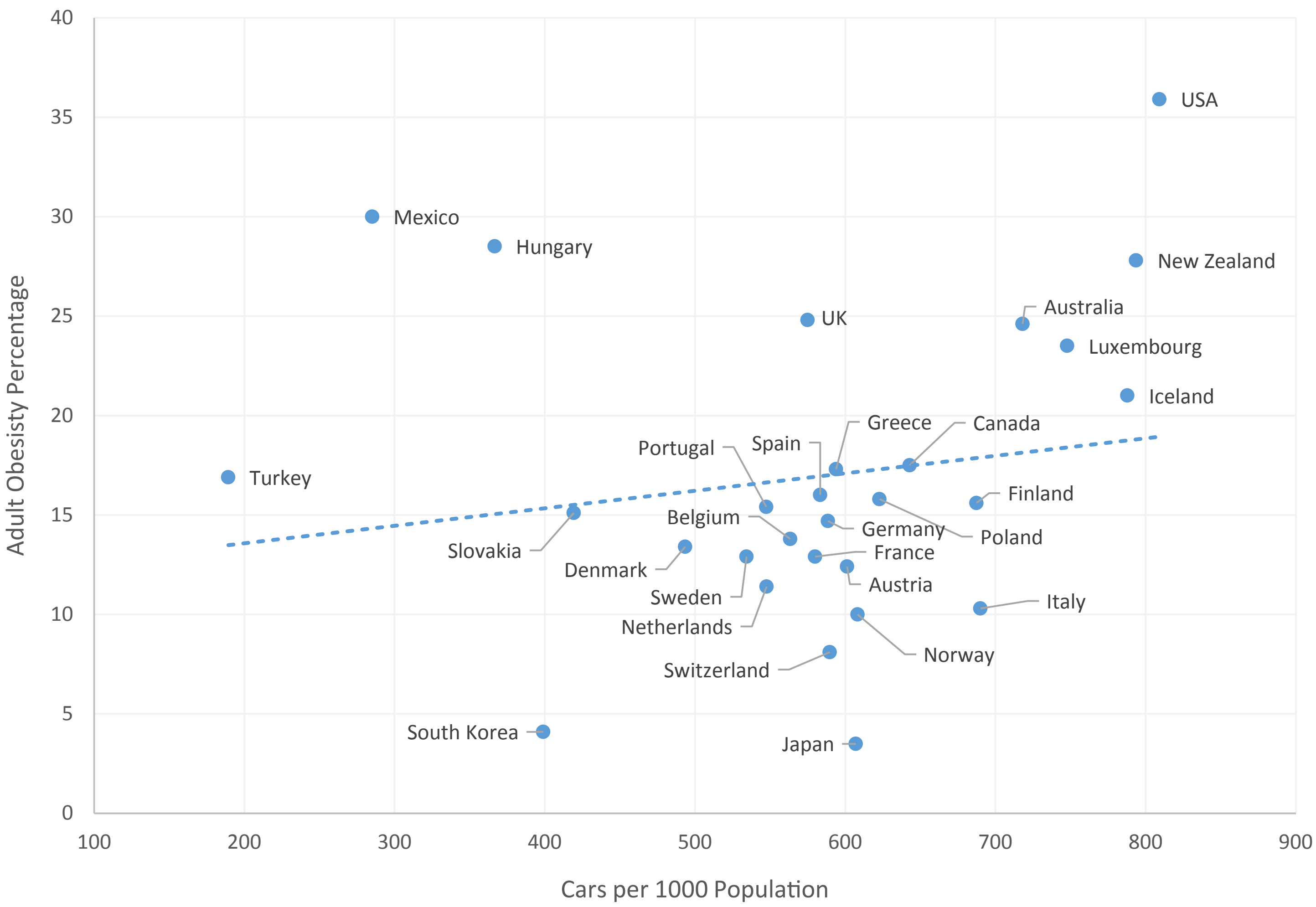


[43]

BMI >30 kg/m^2

Data from OECD, 2013; Health Survey for England, 2011; Welsh Health Survey, 2011; Scottish Health Survey, 2011; Survey of Lifestyle, Attitudes and Nutrition, Republic of Ireland, 2007; and Health Survey Northern Ireland, 2011/12.

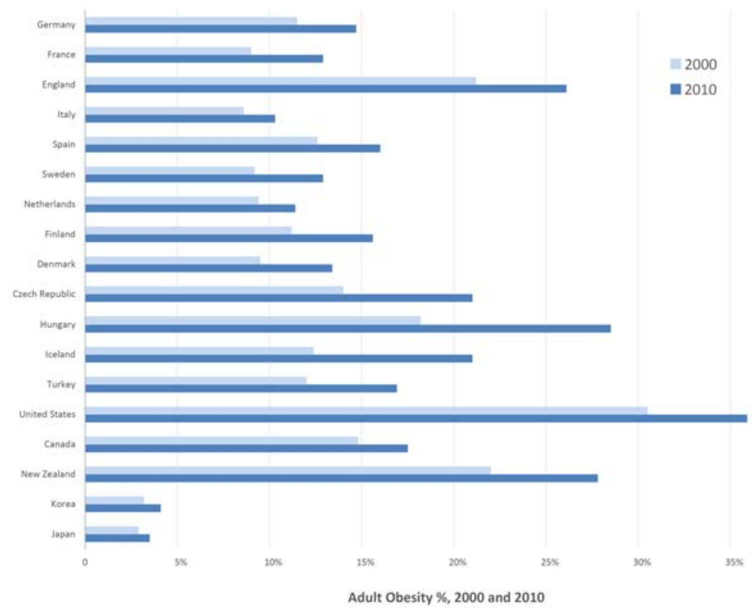
Figure 19: Adult obesity and motorisation rate



Adult obesity and motorisation rate, 2014 [10, 43]

Figure 20 shows the changes over time, and we can see the disastrous trends experienced in many countries, even over the 10 year period. All countries are associated with rises in prevalence of adult obesity, on low and high baselines. For example, Japan has experienced a 34.6 per cent increase in adult obesity (from 1995-2010), the Netherlands 65.2 per cent (1995-2010), Germany 27.8 per cent (1999-2009), England 51.2 per cent (1995-2011) and the United States 85.1 per cent (1997-2010). The USA is at such high levels it surely cannot go much higher – yet, of course, we may have said that 10 years ago.

Figure 20: Changes in adult obesity



[43]

BMI >30 kg/m^2

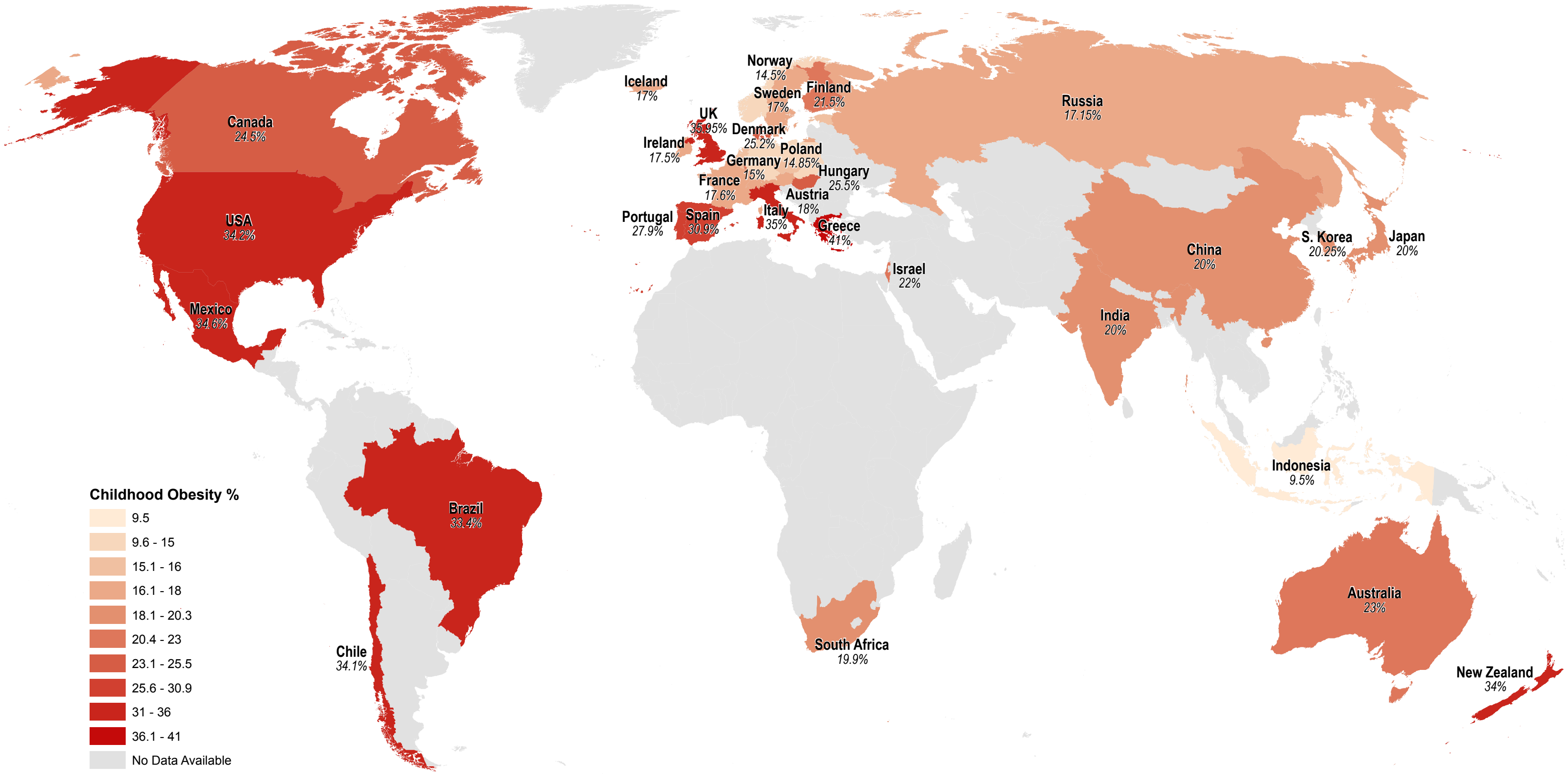
Data from OECD, 2013; Health Survey for England, 2011; Welsh Health Survey, 2011; Scottish Health Survey, 2011; Survey of Lifestyle, Attitudes and Nutrition, Republic of Ireland, 2007; and Health Survey Northern Ireland, 2011/12.

Children who are overweight or obese are a serious concern, with a greater risk of poor health in adolescence as well as in adulthood. Orthopedic and psychosocial problems, such as low self-image, depression and impaired quality of life can result from being overweight, and lead to an increased risk of cardiovascular disease, diabetes and other diseases in later life.

Figure 21 gives measured (rather than self-reported) overweight and obesity levels for 11-15 year olds in different countries. BMI is used, again with 25-30 defined as overweight and >30 as obese. Overweight levels are different to the total population. Japan has more concerning levels of children overweight and obese, with boys at 23 per cent and girls at 17 per cent; similar to levels in most European countries, such as the Netherlands, with boys at 17 per cent and girls at 15 per cent; and Germany, with boys and girls at 15 per cent. Much higher levels are seen in the UK, with boys at 35 per cent and girls at 36 per cent; higher even than the USA, with boys at 33 per cent and girls at 35 per cent [44].

The levels of those overweight and obese tend to be highest in population cohorts with lower educational attainment and socio-economic status; but has affected all population groups, regardless of sex, age, race, income and education level. Childhood is an important period for forming lifelong healthy behaviours, hence the importance of encouraging much better levels of health in children.

Figure 21: Children measured overweight



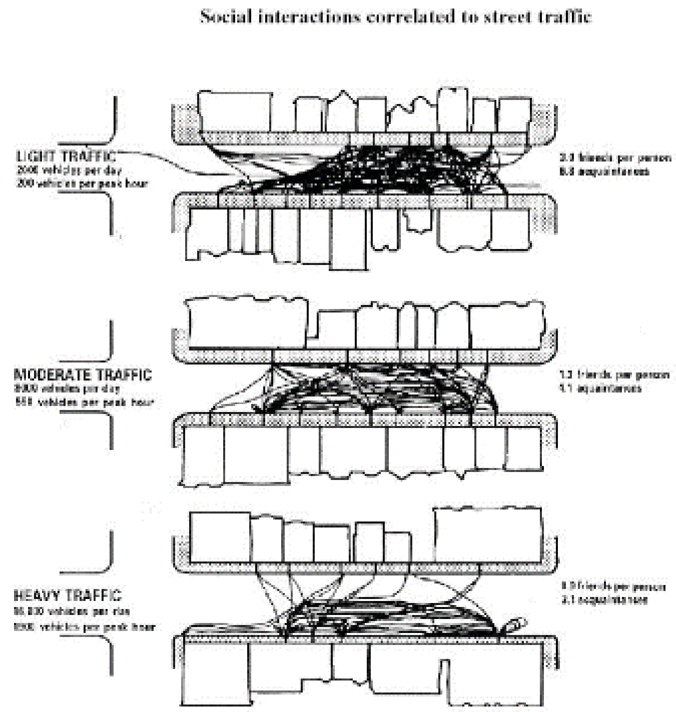
[44] BMI >25 kg/m^2

3.7. Loss of street space to the car

Perhaps less evident, but also of critical importance to the design of attractive cities, is the loss of street space to the car. Over time, the street has gradually been appropriated by the car [45]. In some contexts, the space given over to the car is very extensive. The early reports from downtown Los Angeles suggested that 28 per cent of the land area was used for the street, freeway and serviceway and 38 per cent for off-street vehicle parking and loading – hence 64 per cent is used for automobile-related purposes [46]. There is much dispute over the figures [47], including concerning the difficulty of accurately analysing which part of the street is used for the car and other modes. However, it seems that in most cities, 20-30 per cent of land is given over to highways and parking, and in some cities much more. This seems an extraordinary waste of space and an excessive use of land for vehicle movement. It explains why there is such incompatibility between highway planning and city planning objectives. A city built to facilitate car usage is never an attractive city in urban planning terms. In many cities there are housing and office space affordability problems and a lack of open space – perhaps a return of car parking space can provide a significant supply of land for these types of uses.

At the streetscape scale, Appleyard [48] famously examined traffic volume and social interaction on the street (Figure 22), demonstrating how a higher traffic volume on the street leads to less interaction with friends and acquaintances and a reduced view of 'home territory', with the reverse associated with a lower traffic volume. This problem is often linked to the prioritisation of long distance travel over short, and highway traffic over walking, cycling and public transport [45].

Figure 22: Street traffic and social interaction



Appleyard [48]

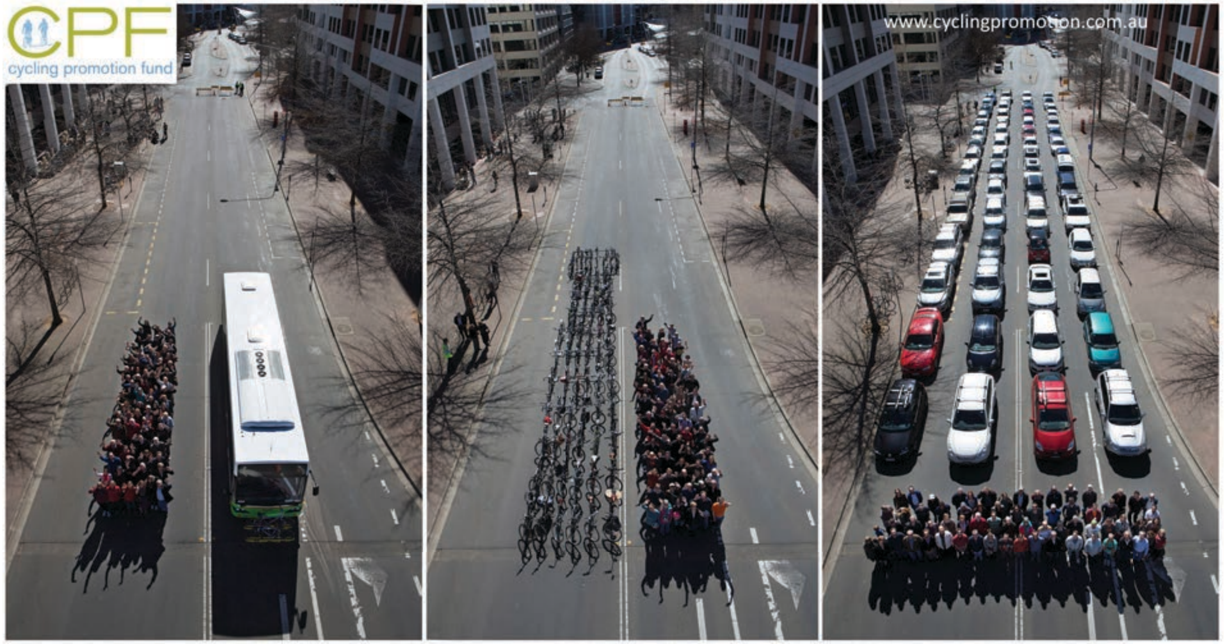


Figure 23: The private car and inefficient use of space

The famous image from Münster's Planning Office, 1979, used to illustrate the amount of space taken up for carrying 60 people by different modes has been updated many times – this time by the Cycling Promotion Fund in Canberra, Australia [50].

The core message remains: it is obvious that a modern, dense city cannot be served by the car – there is not enough space as the car takes a disproportionate amount of space to deliver people to the central activities. The bus and bicycle (and wider public transport and walking) are much more efficient in space terms, and these modes should be prioritised in city planning.

[49, 50]

4. Transport Infrastructure and Cities

Chapter summary:

- *Urban areas are expanding at an unprecedented rate in history presenting a huge window of opportunity for low carbon urban development: In 2030, there are expected to be 41 megacities, 63 large cities and 558 medium-sized cities – and the global population will have risen from the present 7.3 billion to 8.5 billion.*
- *Cities develop their unique trajectories in terms of urban development and transport system pathways – many of these pathways have strong path dependencies. Much of the growth is happening in medium-sized and small cities and is happening in low density, dispersed urban forms.*
- *The infrastructure build-up associated with this rapid urban expansion, much of it likely to be dispersed and car dependent sprawl, means the 2°C, let alone 1.5°C, atmospheric warming thresholds will not be met – approx. 470 GtCO2 will be added to the atmosphere under this business as usual scenario.*
- *Designing cities to have a compact and polycentric urban form, with extensive public transport, walking and cycling networks is critical to lower CO2 emissions, including infrastructure build-up and transport CO2 emissions.*
- *Compact cities also provide huge efficiencies and cost savings as they reduce transport infrastructure needs and costs and greatly reduce negative external costs associated with rapid urbanisation.*

GRENOBLE: A compact urban form is critical to help support public transport, walking and cycling – and much of the current growth in cities is much too dispersed.

4.1. Global urbanisation

Today, we are experiencing the greatest urban expansion in history – with a consequential and unprecedented demand for increased levels of mobility. The global population of 7.3 billion in 2015 is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100 [17].

Since 2007, over 50 per cent of the global population has lived in urban areas, reflecting a huge shift from rural to urban societies. In 2014, the urban population has risen to 54 per cent, compared to just 13 per cent in 1900 [51]. Today, there are nearly 1,000 urban areas with populations of over 500,000, three quarters of which are in the Global South. Each week the global urban population increases by 1.3 million. By 2050, the global urban population will have increased by 2.5-3 billion and more than two thirds will live in cities [51].

More urban areas will be built in the next few decades than all of previous history, and most of the emerging cities will be in the Global South – in Asia, South America and Africa [18]. The number of large urban areas, including megacities with populations over 10 million, is rapidly increasing (Figure 24):

- In 1800, when the global population was around one billion, only 3 per cent of the population lived in urban areas, and only one city (Beijing) had a population greater than one million.
- In 1990, there were 10 megacities, home to 153 million people, accounting for less than 7 per cent of the global urban population; 21 large cities and 239 medium-sized cities[3].
- In 2014, there were 28 megacities, with 453 million residents, and 12 per cent of the global population; 43 large cities and 417 medium-sized cities
- In 2030, there are expected to be 41 megacities; 63 large cities and 558 medium-sized cities.

Tokyo is currently the world's largest megacity with 38 million inhabitants in 2014, but is projected to lose population to around 37 million inhabitants by 2030. All of the other megacities are expected to significantly rise in population by 2030 – Delhi has 25 million inhabitants (projected to rise to 36 million), Shanghai has 23 million (to rise to 31 million) and Mumbai has 21 million (to rise to 28 million).

In 2014, the 43 large cities, with 5-10 million inhabitants, include urban areas such as Santiago (Chile), London (UK) and Singapore, and account for around 300 million people. The number of large cities is expected to grow to 63 by 2030, accounting for 9 per cent of the global population and 400 million people. The fastest growing urban areas are, however, medium-sized cities (1-5 million

[3] A megacity has 10 million population or more; large city, 5-10 million; and medium-sized city, 1-5 million.

inhabitants) and small cities (500,000-1 million inhabitants) – accounting for 26 of the 43 fastest growing urban areas.

The implications of this urban growth for mobility are huge, with many potential adverse impacts depending on the urban form, kilometres travelled and modes taken. Current and future urbanisation trends are significantly different from the past – the majority of urban development is likely to take place in the medium-sized and small cities and at lower densities if current development trends continue. The expansion of urban areas is twice as fast as urban population growth – hence urban areas are dispersing. Urban development from 2000-2030 is expected to cover an area greater than all of the previous urban development pre-2000 [51].

But, these trends also provide great opportunities to actively design the future cities for human habitat. We can use this scale of future urban development to develop cities which support environmentally and socially sustainable travel behaviours. There is a window of opportunity – but it requires compact urban development, and massive investment in public transport, walking and cycling networks.

Figure 24: Global population growth in urban areas

[18]

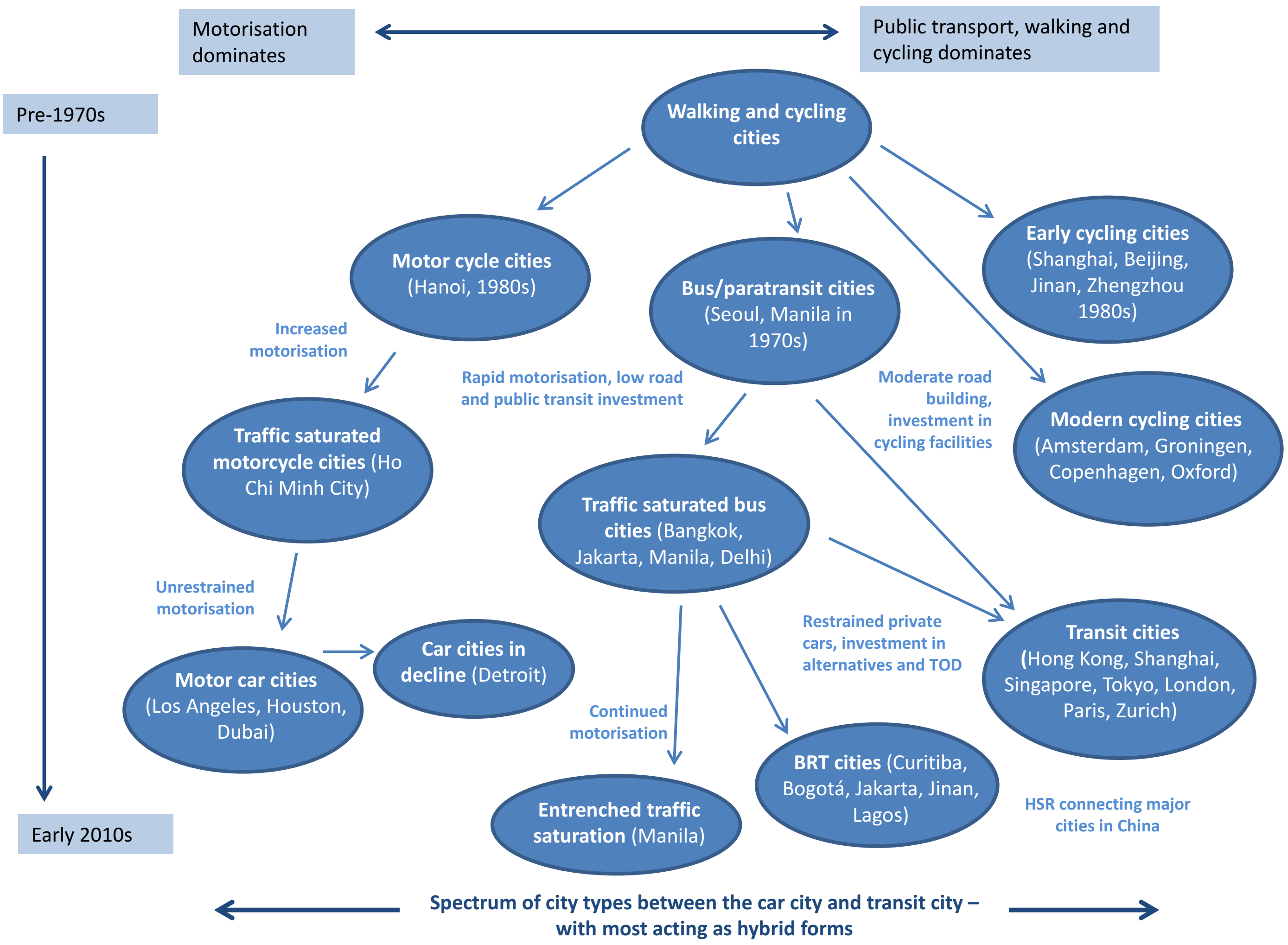
4.2. Transport development pathways

The importance of designing new urban development and transport systems, in a manner that is consistent with sustainability objectives, can be illustrated by considering previous city development pathways.

Each city has developed its own historical trajectory – and urban development form and transport systems are inextricably linked. This historical development has been called the transport development pathway or urban accessibility pathway [52-54], reflecting that there are strong path dependencies evident once a particular development form and transport system has been implemented. Figure 25 gives examples of the car-dependent cities (such as Los Angeles and Houston), the entrenched traffic cities (Manila) and even the car cities in decline (Detroit). This tends to be the development pathway followed if the governance structure is weak and there is little attempt to coordinate urban planning and invest in high quality public transport – this is what the private market approach provides. There are many of these types of cities in North America, Australasia and the Middle East. Once this pathway has been taken, it can be very difficult and expensive to retrofit the city structure – and the public become very reliant on the private car for almost all journeys.

There are alternative pathways – and most cities are now attempting to build more effective public transport systems. The BRT cities (Curitiba, Bogotá), transit cities (Singapore and London) and cycling cities (Amsterdam and Groningen) offer a different way forward – where the non-car modes gain much more investment and the urban form is much more compact to help support the use of these modes. Most cities are, of course, hybrids of these simple typologies – even Los Angeles and Manila are being retrofitted nowadays with a public transport system, albeit with limited networks as yet.

Figure 25: Transport development pathways



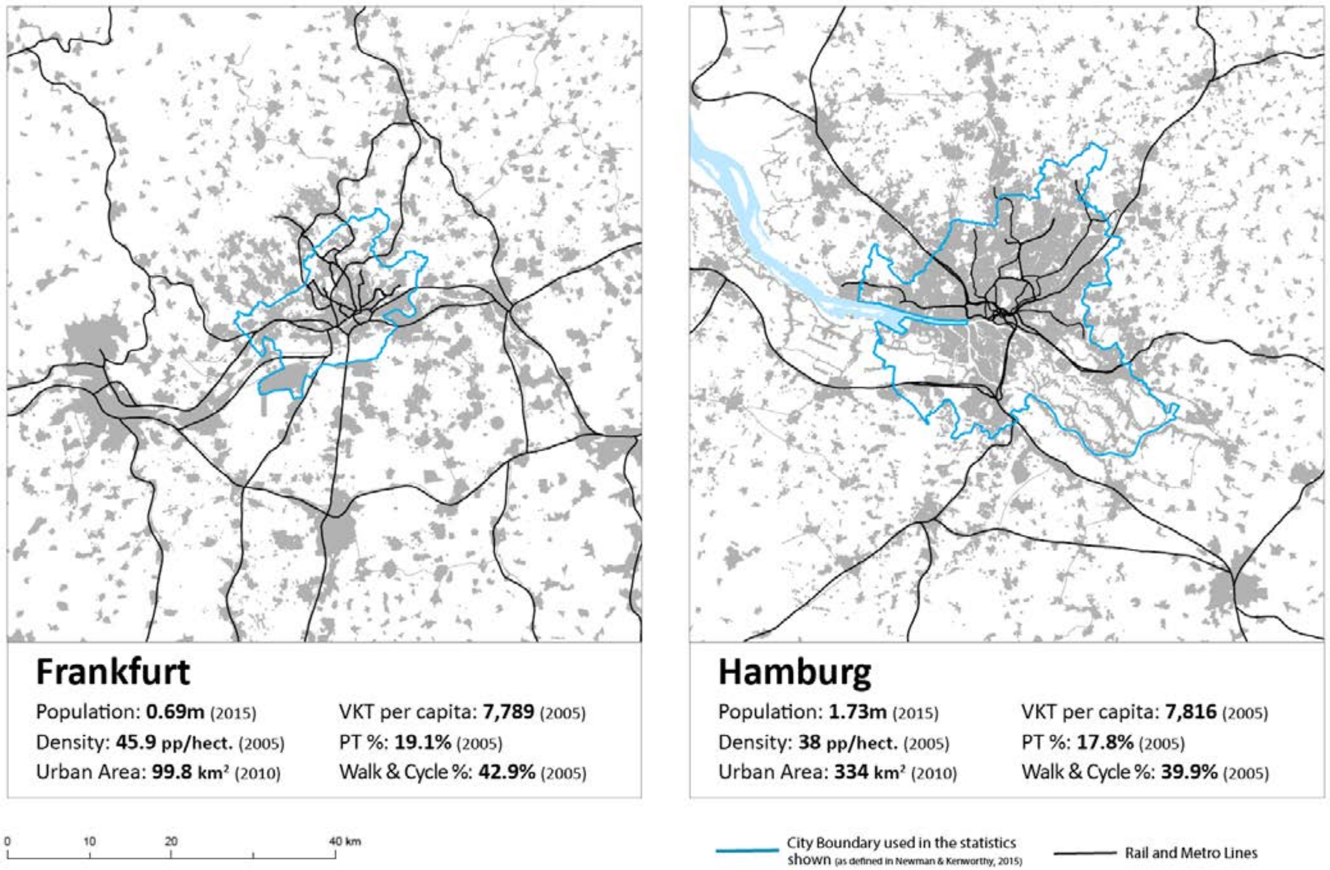
[52, 53]

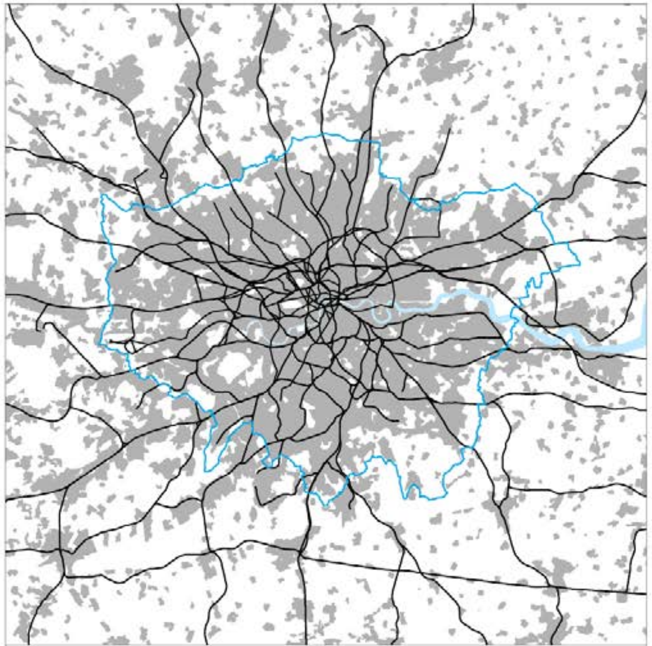
4.3. Urban form and transport

Figure 26 illustrates the differences in urban footprint relative to population and transport CO2 emissions – and it can be seen how important urban form can be to travel. The smaller compact cities, such as Frankfurt, Hamburg; or the larger compact cities, such as London and Hong Kong; have relatively high urban densities, at least 40-75 persons per hectare, and much higher in Hong Kong (164 persons per hectare) – meaning that the urban area is relatively small. Often a growth boundary and planning regulations are used to keep the development from sprawling over greater distances. Alongside, there are extensive public transport networks, resulting in high public transport, walking and cycling mode shares (60 per cent and higher non-car mode share) and little VKT per capita (5,000-8,000 VKT per capita or less).

In the dispersed cities, such as Los Angeles and Houston, journeys between homes, workplaces and other activities usually involve large distances which can only be reached by private car – the urban areas are huge and densities very low (10-28 persons per hectare). Public transport networks are very sparse – public transport needs a much higher population and employment density to give effective patronage levels. The resulting public transport, walking and cycling mode shares are virtually non-existent (3-15 per cent non-car mode share) and VKT per capita is huge (17,000 VKT and higher per capita).

Figure 26: Urban footprints, population density and modal shares





London

Population: **8.67m** (2015)
Density: **73.6 pp/hect.** (2011)
Urban Area: **416 km²** (2015)

VKT per capita: **5,607** (2005)
PT %: **33.3%** (2005)
Walk & Cycle %: **25.2%** (2005)

Hong Kong

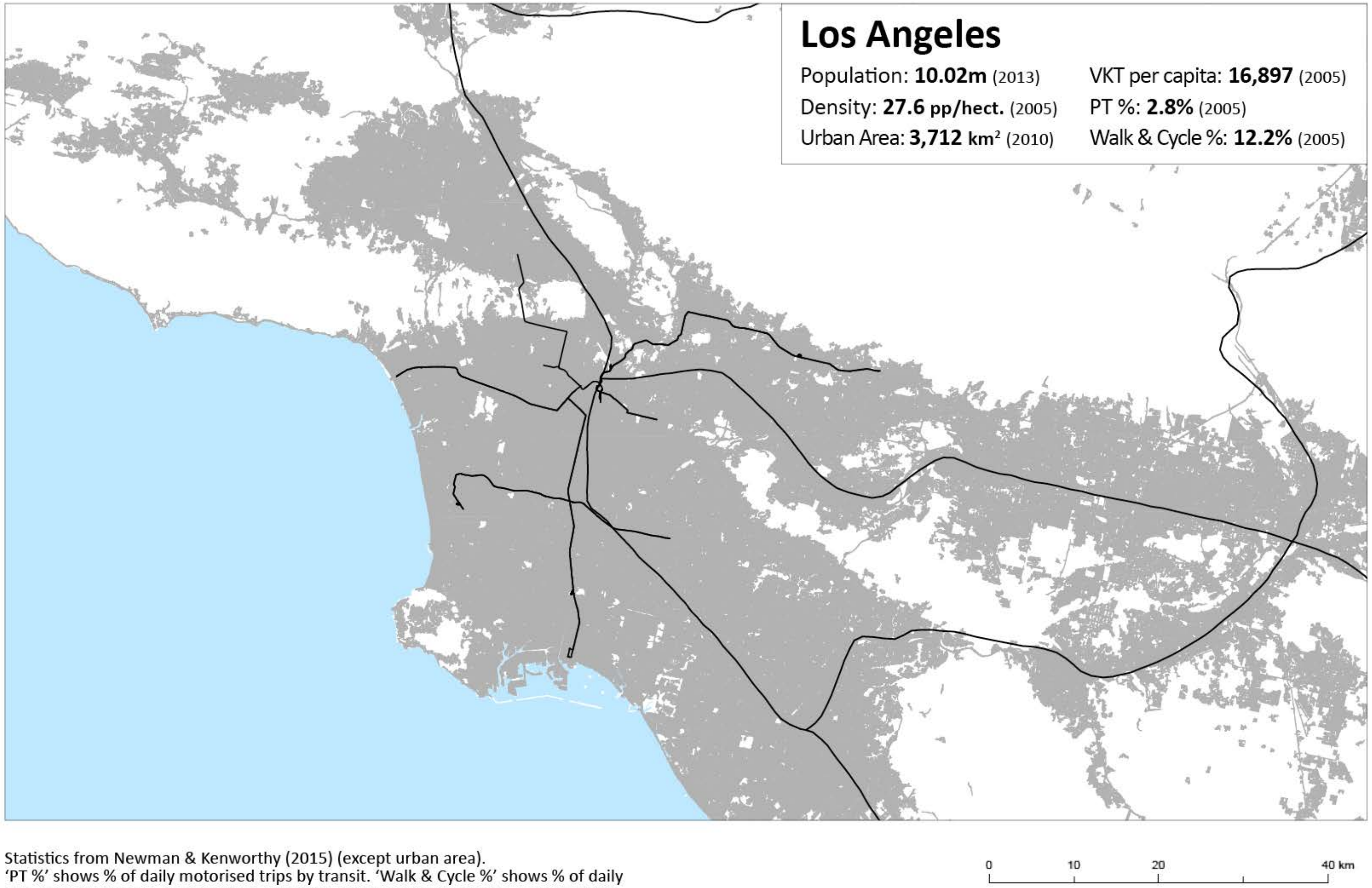
Population: **7.19m** (2013)
Density: **164 pp/hect.** (2005)
Urban Area: **341 km²** (2010)

VKT per capita: **910** (2005)
PT %: **83.8%** (2005)
Walk & Cycle %: **36%** (2005)

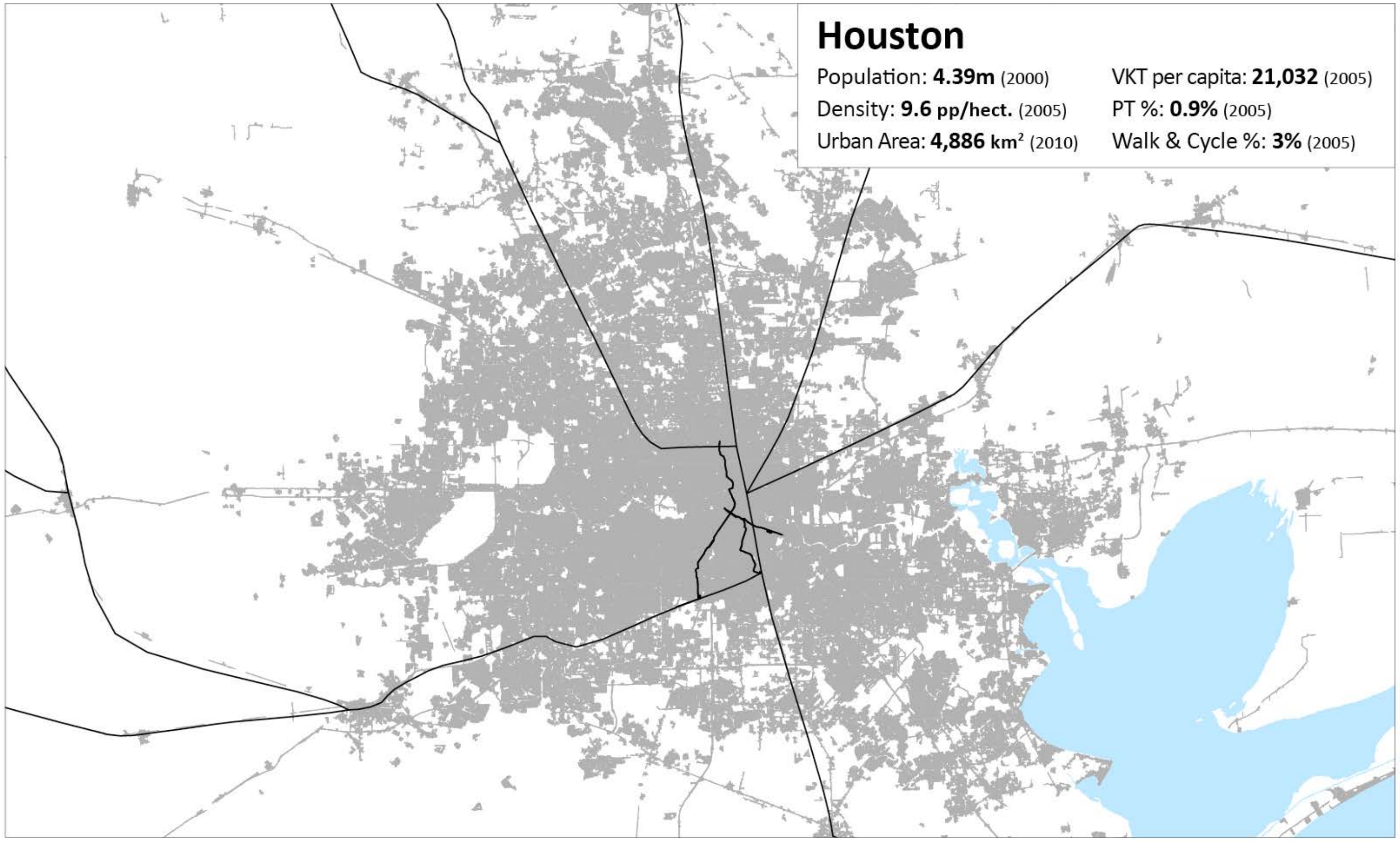
0 10 20 40 km

City Boundary used in the statistics shown (as defined in Newman & Kenworthy, 2015)

Rail and Metro Lines



Statistics from Newman & Kenworthy (2015) (except urban area).
'PT %' shows % of daily motorised trips by transit. 'Walk & Cycle %' shows % of daily non-motorised trips. Geographical data from European Environment Agency Urban Atlas, US Census Bureau, USGS NLCD, Ordnance Survey, HK City Authority.



Statistics from Newman & Kenworthy (2015) (except urban area).
'PT %' shows % of daily motorised trips by transit. 'Walk & Cycle %' shows % of daily non-motorised trips. Geographical data from European Environment Agency Urban Atlas, US Census Bureau, USGS NLCD, Ordnance Survey, HK City Authority.

0 10 20 40 km

The relationships between urban form, travel, energy consumption, and more recently CO2 emissions, has been subject to a large amount of research over the last 30-40 years. The early research developed from examining the effective integration of land use and transport in cities and appropriate density thresholds in supporting the design of public transport systems [55, 56]. Newman and Kenworthy published their well-known analysis on the relationship between density and energy consumption in transport [57, 58], arguing that higher densities were associated with reduced travel distances and transport energy consumption, and that this could support greater use of public transport, walking and cycling. A wide range of research followed [59-74], eventually covering a wide range of built environment factors, including:

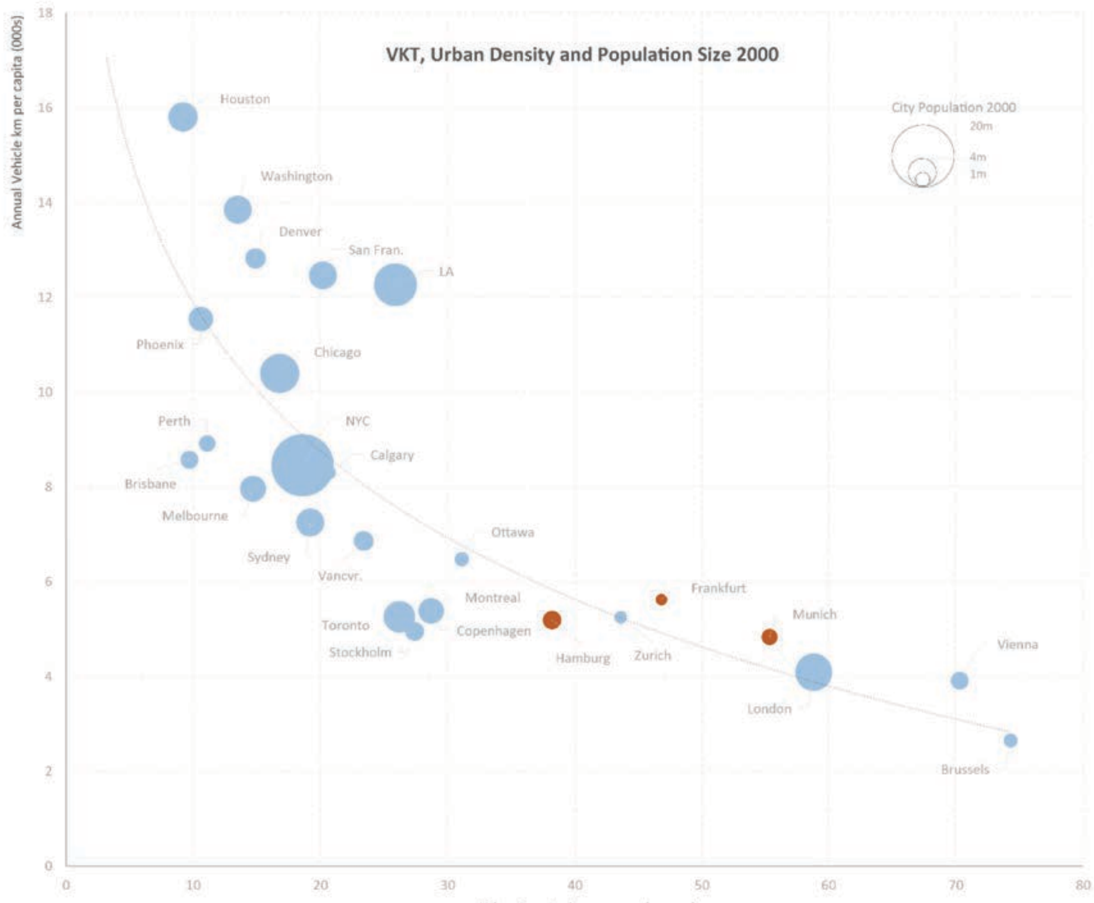
- Density: amount of development by area.
- Settlement size: urban area and population size the development is allocated to.
- The location of development: strategic location of development relative to other urban centres and transport networks.
- Jobs-housing balance and mix of use: the diversity and integration of land uses, proximity of housing, employment and other activities.
- Access to public transport: distance, time, cost and quality of the journey to public transport and to activities.
- Local neighbourhood and street design: permeability and connectivity of the neighbourhood and street.

Each of these variables are associated with different levels of travel. Different metrics of travel (by mode, distance, energy consumption, CO2 emissions), scales of analysis, and socio-economic and attitudinal variables have also been incorporated over time.

There have been attempts to understand the difficult empirical problem of causality (which variables influence which, and in what order), and some issues, such as transport CO2, have become central to the debate. The overriding interest is to understand the most effective urban form(s) – in terms of the design of new neighbourhoods and the retrofit of old neighbourhoods – which may help achieve greater sustainability in transport. There has been some debate in the literature, with some arguing that planning should not be used to influence travel or will have little impact [75, 76] – but these views are very controversial and tend to emanate from the classical economist viewpoint rather than urban planning viewpoint. Urban planning is now almost universally perceived as a critical part of effective transport planning – the walking city, public transit city and/or automobile city being closely associated with the urban structure that is developed.

Perhaps the key built environment variables is density as this is often correlated to the other built environment variables. There are many ways to measure density, but three common measures are used – population density (population per area), built-up area density (buildings or urban land cover per area), and employment density (jobs per area). There is a clear linkage between urban density and VKT at the city level, though of course other factors, such as fuel price and other urban design features, are also important to the travel that follows. All of the cities with low levels of VKT, below 6,000 vehicle kilometres per capita per annum have relatively high urban densities (Figure 27). A threshold for urban densities of at least 40-50 persons per hectare should be the target for most cities, and much higher in some contexts and particular neighbourhoods. Higher densities, at the home and workplace, allow public transport to be effectively developed as patronage levels can be ensured. Evidence from the USA suggests that a doubling of residential densities can reduce VKT by 5-12 per cent, and up to 25 per cent if combined with mixed uses, higher employment densities and improvements in transit [77]. This type of evidence is, of course, very context dependent – and we would expect different relationships in Europe and Asia relative to different built environments, infrastructure networks and cultural norms, with perhaps much more positive correlations between the built environment and travel due to the supportive infrastructure and societal context.

Figure 27: Urban population density, population size and VKT

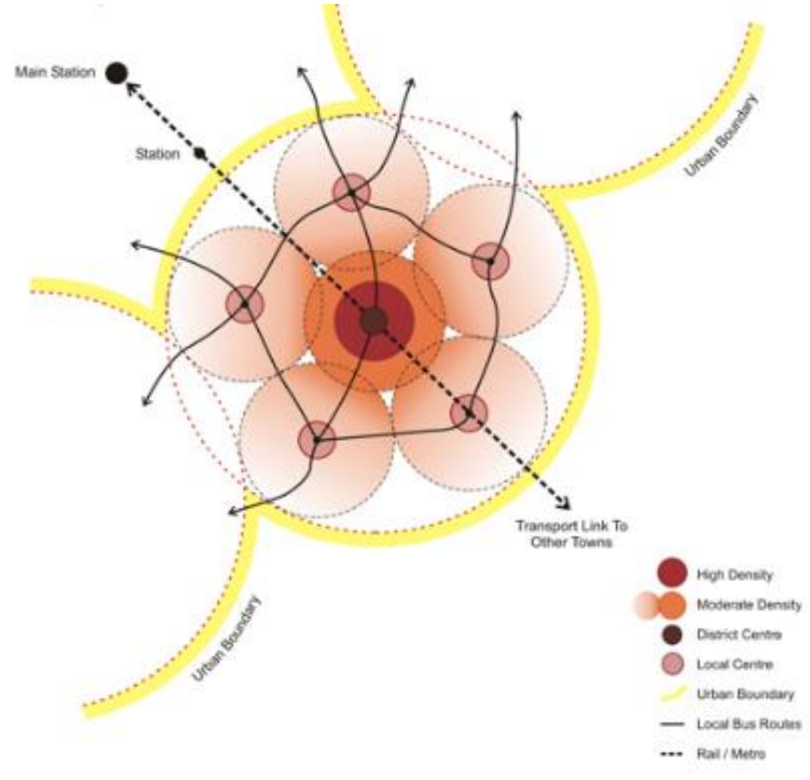


[12]

The urban structure and travel research has been hugely influential in practice, and has been applied through the related concepts of the compact city, polycentric city, transit orientated development (TOD), urban villages and the associated movements for urban renaissance (UK), new urbanism and smart growth (both USA).

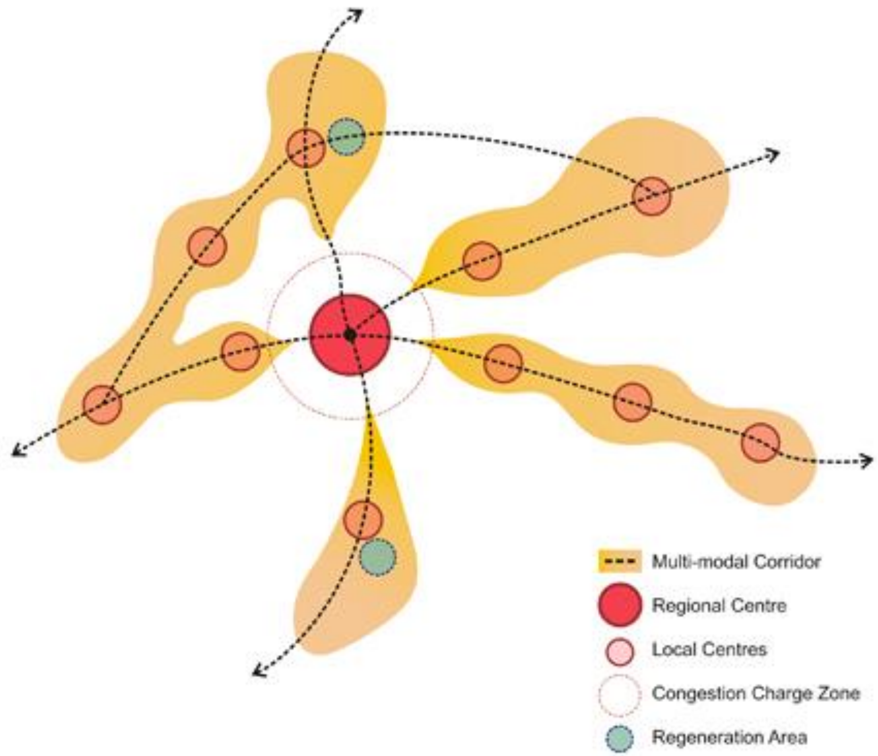
Master planning can be used to help set the development strategy for regions, urban areas and new neighbourhoods – and transport projects developed to integrate well with the planning strategy. The planning tools can cover the range of potential interventions, including density, mix of use, location of development and layout and design. Urban form and layout can be designed at different scales to influence travel, including for designing new development and for retrofitting existing development. Figures 28 and 29 illustrate how densities can be orientated around the public transport networks in new urban neighbourhoods and urban extensions and also at the metropolitan and regional scales [71]. Polycentric development (with multiple centres) can be developed in the larger urban centres.

Figure 28: Planning for higher densities around the public transport node



[71, based on 78]

Figure 29: Strategic planning – development orientated around the public transport network



[71]

4.4 Infrastructure needs and costs

Developing at higher densities, and in a compact form, uses land and infrastructure more efficiently, allowing reduced infrastructure and operational costs per unit of land [54]. Rapid urbanisation, and the often sprawling nature of development, means that infrastructure costs are very high in many cities, in the Western industrialised cities and also in the emerging cities in South America, Asia and Africa. The OECD [79] estimates that global infrastructure needs, including highways, public transport, water, sewerage and electricity systems, could reach US$120 trillion by 2050.

In China, nearly one billion people will live in urban areas by 2025, an increase of nearly 400 million from 2005. China will have 221 cities with more than one million inhabitants, compared with 35 in Europe today, and 23 cities will have more than 5 million inhabitants. This urban expansion is estimated to require 28,000 km of metros – the greatest construction of mass transit in history – but also 5 billion square metres of highways by 2025 [80]. In India, the urban population is projected to grow from 340 million in 2008 to 590 million in 2030. This is estimated to require a capital infrastructure investment of US$1.2 trillion, including 7,400 km of metros and 2.5 billion square metres of highways [81].

This is a very significant amount of expected new urban development, including extensive transport infrastructure development. The projections reflect the likely development type – sprawling cities served by an expanded highway network and limited public transport. This dispersed urbanisation trend, occurring internationally, places great demands on urban and transport planners. The focus on economic growth, with cities competing to attract new businesses, often with new residential areas and economic zones built on the urban edge, means that huge traffic growth is very likely.

There are many differences between compact development and dispersed development, as summarised in Table 4. Proponents defend urban sprawl as a fulfilment of consumer preferences, similar to automobile growth – ignoring that consumer preferences are shaped by the supply of particular forms of infrastructure, development form and advertising. The impacts of further dispersed development will only exacerbate the adverse problems of automobility – those of energy depletion, $CO2$ emissions, traffic casualties, local air quality, obesity, and loss of street space.

A further critical problem with urban sprawl is that it undermines the cost effective provision of public services. Spatially expansive developments lead to greater costs for extended highways and utilities such as water, sewage, electricity [82]. This is particularly significant in terms of transport infrastructure, as public transport networks also become more difficult to deliver, with too little patronage available for potential projects. The scale of infrastructure needed by different development types will differ by context, but estimates from the USA suggest that dispersed development would lead to 10 per cent more annual fiscal deficits, 8 per cent higher housing costs and a 10 per cent increase in highway length relative to managed growth [83]. Urban sprawl undermines wider public service provision, including education facilities, and police and fire services, simply by lowering the density of individual consumers.

A greater concentration of development, with an effective planning of urban development and public transport systems – including more extensive networks for Metro, Light Rapid Transit, informal transit, walking and cycling – would dramatically change transport infrastructure requirements internationally.

Table 4: Comparing compact, dispersed development and transport infrastructure cost

	Compact development	**Dispersed development**
Growth pattern	Largely urban infill with some urban extensions	Urban periphery (greenfield) development
Land use mix	Mixed land use	Homogeneous (single-use, segregated, zoned) land uses.
Scale	Human scale, smaller buildings, blocks and narrow roads	Large scale, larger buildings, blocks, wide roads
Public services (shops, schools, parks)	Local, distributed, accommodates walking access	Regional, consolidated, larger, requires automobile access
Transport	Multi-modal, extensive walking, cycling and public transport networks	Automobile-oriented, poorly suited for walking, cycling and public transport
Street design	Streets designed to accommodate a variety of activities; permeable to walking and cycling; traffic calming	Streets designed to maximize motor vehicle traffic volume and speed; hierarchical road network; cul-de-sac design in residential areas
Car parking supply and parking cost	Limited supply and high cost	Generous supply, low cost
Planning process	Planned and coordinated between jurisdictions and stakeholders, a strong planning system	Unplanned, with little coordination between jurisdictions and stakeholders – development is left to the market
Public space	Emphasis on the public realm, including high quality streetscapes, pedestrian environment, public parks, public facilities	Emphasis on the private realm, including private open space and gardens, shopping malls, gated communities, private clubs.
Transport infrastructure cost	Large cost – extensive highway investment and car parking provision over huge, dispersed urban conglomerations; little public transport, walking and cycling investment	Medium cost – very limited highway investment and car parking provision; extensive public transport, walking and cycling investment over smaller, compact and inter-linked polycentric urban areas

[based on 84]

4.5 Embedded energy consumption and CO2 emissions from infrastructure

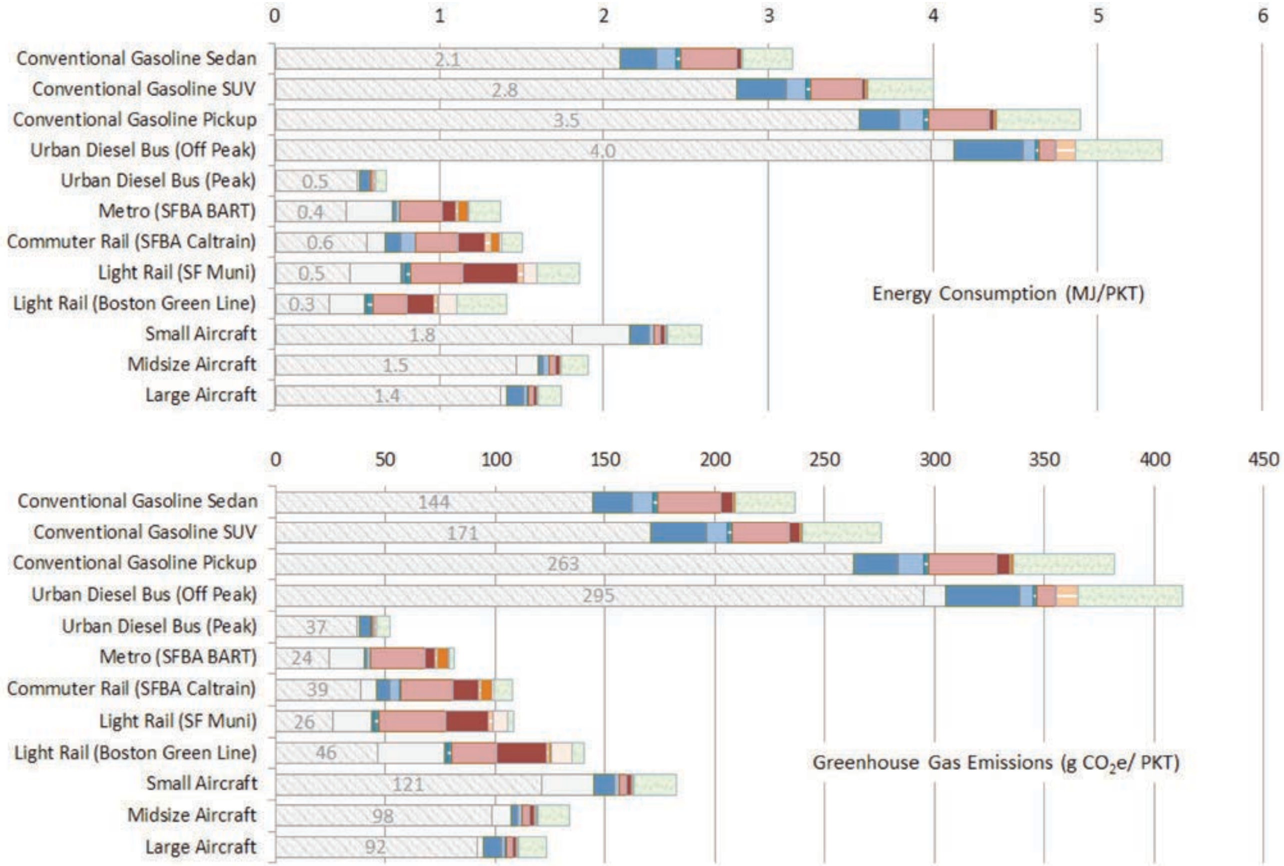
Infrastructure affects energy consumption and CO2 emissions primarily during three phases of the lifecycle: first, in construction; second, in use and operation; and third, at the end of life (including disposal, reuse and recycling) [51]. Though most research on mitigation pathways for reducing transport CO2 emissions focuses on the operation and use stage, the CO2 emissions embodied in infrastructure are very significant. Some materials used in construction contribute high levels of CO2 emissions – the manufacturing of steel contributing 9 per cent and cement 7 per cent of global CO2 emissions in 2006 [85]. Seemingly clean vehicle technologies, such as electric vehicles, can differ enormously in terms of well-to-wheel CO2 emissions, depending on the ultimate fuel source mix, such as coal, nuclear or renewable. Hence a focus on tailpipe emissions can greatly underestimate the problems. Further, estimating CO2 emissions from transport networks suffers from administrative boundary problems – emissions often extend beyond these, and trans-boundary travel can often be very large.

Globally the CO2 emissions embodied in built up infrastructure in 2008 is estimated to be 122 GtCO2 – and the average per capita emissions embodied in infrastructure in the industrialised countries is five times that in the Global South [86]. If this industrialised country level and type of infrastructure is implemented in the emerging countries, then CO2 emissions will rise very significantly – potentially adding another 470 GtCO2 [51].

Total lifecycle energy inputs and greenhouse gas emissions are estimated, in the USA, to contribute an additional 63 per cent for road, 155 per cent for rail and 31 per cent for air systems over vehicle tailpipe calculations. Due to the higher energy consumption and CO2 emissions per capita of private cars, relative to public transport, the LCA means that the private car becomes even more problematic in consumption and emissions. For example, a conventional petrol Sedan emits around 240 gCO2e/km in LCA relative to 144 gCO2e/km for vehicle operation only (Figure 30) [87].

Life cycle assessments (LCA) of transportation, including raw material extraction, manufacturing, construction, operation, maintenance and end of life vehicles, infrastructure and fuel, all need to be considered in considering the impacts of these development trends. Although the estimation of LCA impacts is likely to be complex, Chester and Horvath [87, p.1] remind us that: “decisions should not be made based on partial data acting as indicators for whole system performance.”

Figure 30: Energy consumption and greenhouse gas emissions per passenger km travelled



[87]

4.6 Governance

The feasibility of designing urban form and transport systems in an integrated manner depends to a large extent on the systems of governance available in different countries. This includes the policy frameworks, the measures adopted, and not adopted, and levels of funding. Even where there is apparent political support for designing environmentally and socially sustainable development and transport systems, the institutions may be ineffective in developing and implementing strategies, and the legislative framework and funding may be insufficient. It is only though effective governmental intervention, and strong city governments, such as found in some leading European cities, that progress can be made.

Governmental institutions tend to be weak where most opportunities lie, hence the critical importance of capacity building. In the Global South, frameworks for urban planning can be non-existent and funding for public transport systems can be difficult to source. But, of course, this spreads beyond the emerging cities – all cities where levels of VKT and transport CO2 emissions are currently high, and those where they are rapidly increasing, need a significant rethink.

5 The Automobile, Public Transport and Cycling Industries

Chapter summary:

- *The automobile industry achieves great status, and often large governmental subsidy, yet is concentrated in very few countries and is less significant to national economies than is commonly believed.*
- *The public transport and cycling industries are also very important, with similar numbers of employees globally. These sectors can be supported instead of the automobile industry in view of the much more positive impacts of travel by these modes.*

5.1 Levels of employment in the transport industries

The automobility system is supported and maintained by a complex range of government and related organisations in many countries. These include the motor manufacturers, the oil producers, the steel and cement industries, the development industry, and a range of consultants, governmental and trade organisations – all involved in furthering their joint vested interests in producing and selling more car units [88]. The motor manufacturing sector, in particular, is often perceived as a critical part of national Gross Domestic Product (GDP) and local economies. Governmental support includes subsidy and direct intervention with industry restructuring.

There are relatively high levels of employment associated with the motor industry. But, the automobile industry is concentrated in only a small number of countries, and even in countries with relatively large automotive sectors, such as the USA or Germany, contributions to national economies are small. For example, in Germany, the automobile industry accounts for just 4 per cent of total Gross Value Added (GVA)[4] output, and less than 1 per cent in the USA and UK [89].

The status of the motor industry outweighs its actual importance to national economies. The public transport and cycling industries are also very important as employers in many contexts, accounting for similar numbers of employees globally relative to the motor industry. The public transport and cycling industries can increasingly be supported by governments in view of the much more positive impacts of travel by these modes. Employment for these sectors is much more dispersed across different organisations within countries, but perhaps is less likely to be outsourced to cheaper employment markets and is less dependent on economic volatility and technological change.

[4] Gross value added (GVA) is the measure of the value of goods and services produced in an area, industry or sector of an economy. GVA is output minus intermediate consumption; hence it is a measure of the net value added to the economy.

These issues are further considered below:

- Global vehicle sales and production
- Automobile-related employment
- Public transport, sales and employment
- Cycle-related employment

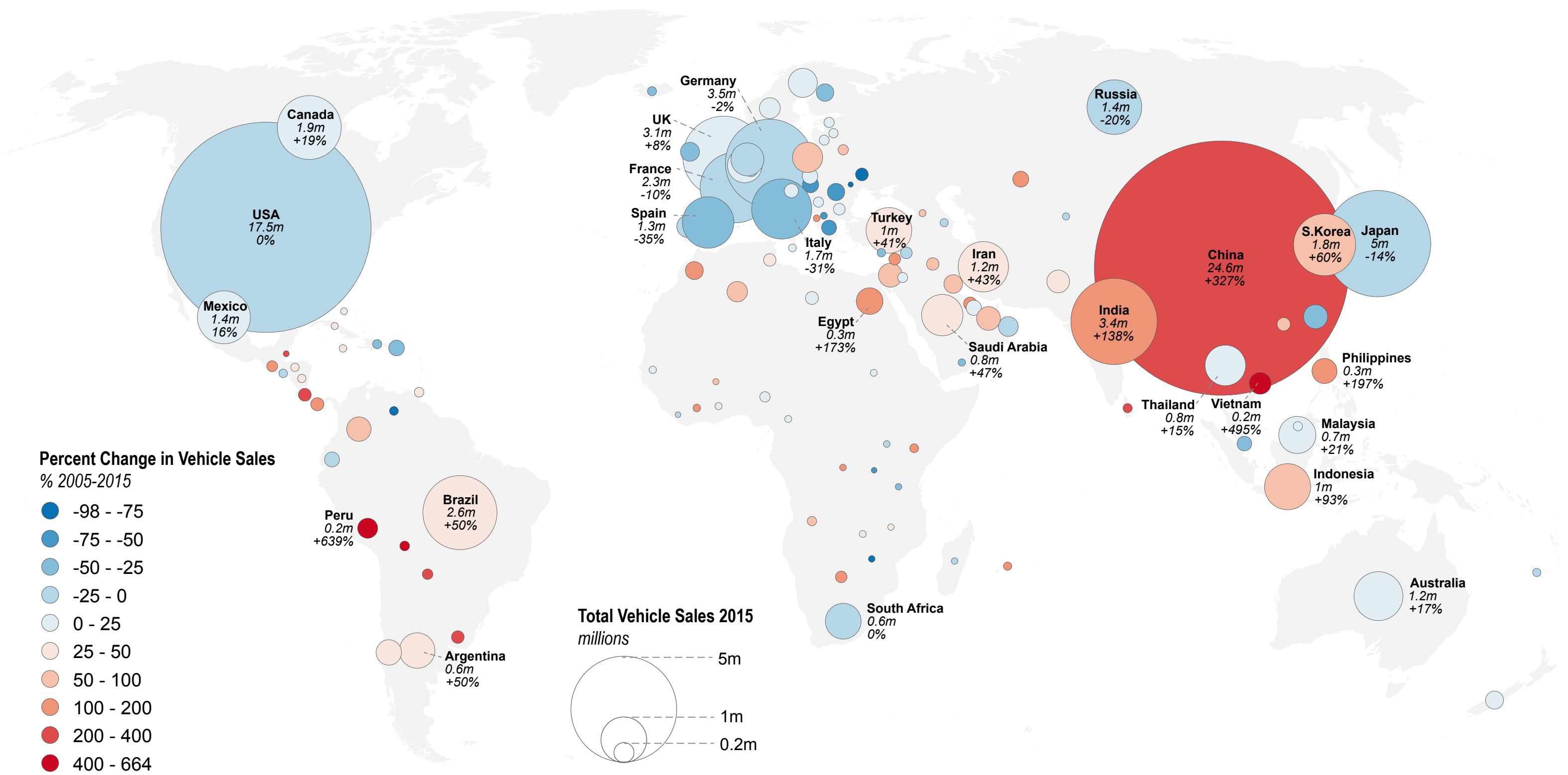
5.2 Global vehicle sales and production

The global automobile industry is a large business, but concentrated in only a few large countries. The North American, European and Japanese markets have previously been the strongest for vehicle sales, but this has since been overtaken by the China and increasingly India. Nearly 90 million vehicles, including 66 million passenger cars and 23 million commercial vehicles, were sold in 2015 (amounting to nearly 246,000 new vehicles every day). China accounts for 24.6 million vehicle sales (27 per cent of global sales and an increase of over 300 per cent between 2005-2015), Asia & Oceania for 44 million sales (49 per cent of global sales and an increase of over 115 per cent between 2005-2015), the United States for 17.5 million sales (19 per cent of global sales, but flatlining at 0.2 per cent growth between 2005-2015), and Europe for 19 million sales (21 per cent of total sales, and a reduction of 19 per cent between 2005-2015) (Figures 31 and 32).

Individual European countries account for an increasingly smaller proportion of global sales in recent years, but they still represent significantly-sized markets. For example, Germany accounts for 3.5 million sales (4 per cent of total sales, and a reduction of 2 per cent between 2005-2015) and the UK for 3.1 million sales (3 per cent of total sales, and an increase of 8 per cent between 2005-2015).

The global market has thus significantly changed in recent years. The automotive industry was hit hard by the financial crisis in 2008-2009, including the bankruptcy of General Motors in 2009. China and Asia & Oceania are now the dominant players; and have been since 2007, when sales overtook the cumulative United States, Canada and Mexico total [10].

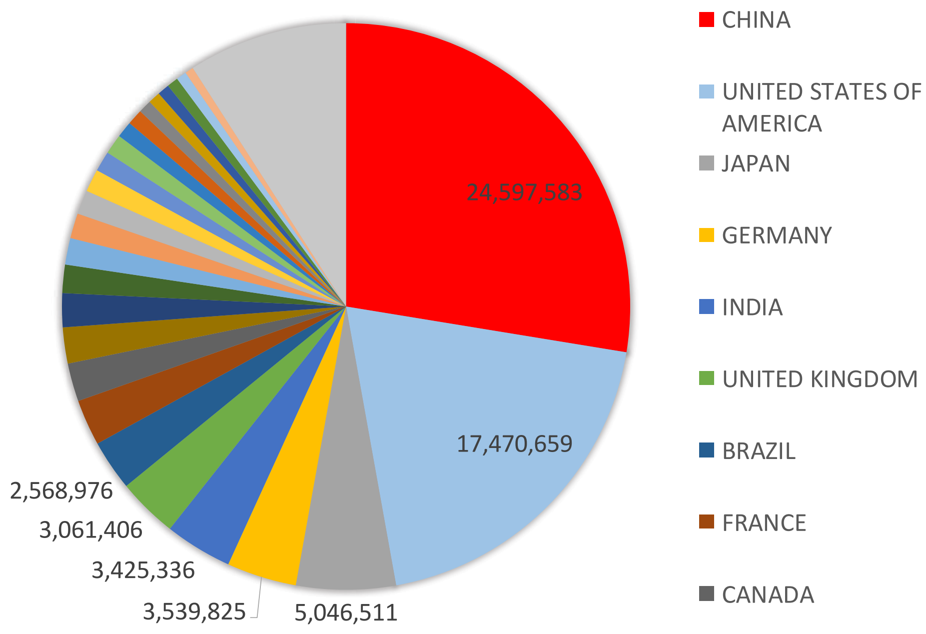
Figure 31: Global vehicle sales (global distribution)



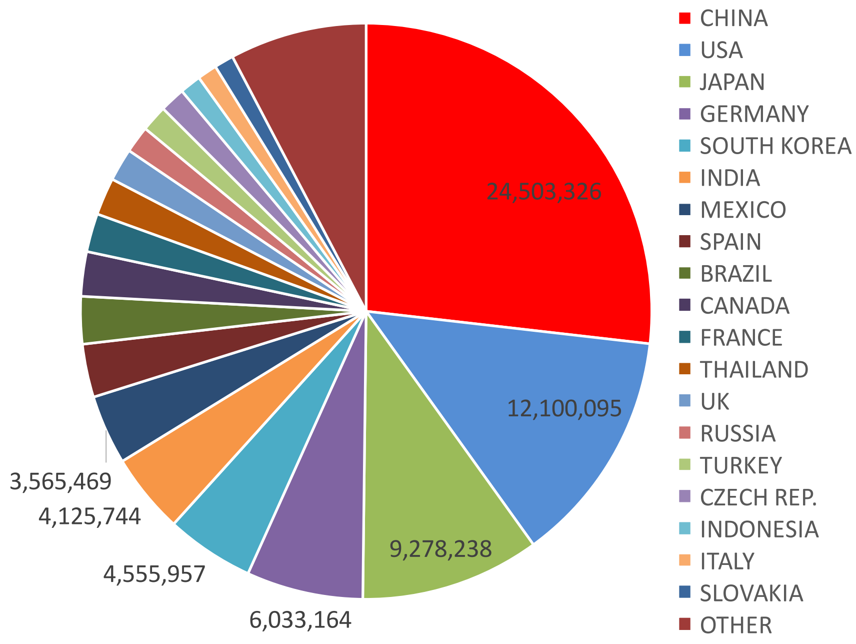
[10]

Figure 32: Global vehicle sales and production

New vehicle registrations and sales



New vehicle production



2015 data, new vehicle sales and production [10]

Over 90 million vehicles were produced in 2015, including 68 million passenger cars and 22 million commercial vehicles (amounting to nearly 249,000 new vehicles every day) (Table 5). Over a quarter of vehicles are now produced in China, and a half in Asia & Oceania. The number of countries that produce large vehicle fleets are, however, relatively few – only 19 countries produce over a million vehicles annually, and cumulatively this production amounts to 92 per cent of the global fleet.

[90, 91]

Table 5: Global vehicle production

Country	Cars	Commercial Vehicles	Total	% Change 2014-15
China	21,079,427	3,423,899	24,503,326	3.3%
USA	4,163,679	7,936,416	12,100,095	3.8%
Japan	7,830,722	1,447,516	9,278,238	-5.1%
Germany	5,707,938	325,226	6,033,164	2.1%
South Korea	4,135,108	420,849	4,555,957	0.7%
India	3,378,063	747,681	4,125,744	7.3%
Mexico	1,968,054	1,597,415	3,565,469	5.9%
Spain	2,218,980	514,221	2,733,201	13.7%
Brazil	2,018,954	410,509	2,429,463	-22.8%
Canada	888,565	1,394,909	2,283,474	-4.6%
France	1,553,800	416,200	1,970,000	8.2%
Thailand	772,250	1,143,170	1,915,420	1.9%
UK	1,587,677	94,479	1,682,156	5.2%
Russia	1,214,849	169,550	1,384,399	-26.6%

Turkey	791,027	567,769	1,358,796	16.1%
Czech Rep.	1,298,236	5,367	1,303,603	4.2%
Indonesia	824,445	274,335	1,098,780	-15.4%
Italy	663,139	351,084	1,014,223	45.3%
Slovakia	1,000,001	0	1,000,001	3.0%
Other	5,970,712	1,115,558	7,086,270	-
Total	68,539,516	22,241,067	90,780,583	1.1%

[10]

5.3 Automobile-related employment

The production of such large vehicle numbers requires a large motor manufacturing industry. In 2005, this involved the direct employment of more than eight million people in making the vehicles and the parts that go into them, with perhaps five times more indirectly employed in related manufacturing and service provision. Direct automobile-related employment accounts for around five per cent of the world's manufacturing employment.

Table 6 gives a breakdown by country, with the largest figures in China (with over 1.6 million employees), the US (nearly one million employees) and Germany (770,000 employees) [92].

[93-95]

Table 6: Automobile-related employment

Argentina	12,166	Korea	246,900
Australia	43,000	Malaysia	47,000
Austria	32,000	Mexico	137,000
Belgium	45,600	Netherlands	24,500
Brazil	289,082	Poland	94,000
Canada	159,000	Portugal	22,800
China	1,605,000	Romania	59,000
Croatia	4,861	Russia	755,000
Czech Republic	101,500	Serbia	14,454
Denmark	6,300	Slovakia	57,376
Egypt	73,200	Slovenia	7,900
Finland	6,530	South Africa	112,300
France	304,000	Spain	330,000
Germany	773,217	Sweden	140,000
Greece	2,219	Switzerland	15,500
Hungary	40,800	Thailand	182,300
India	270,000	Turkey	230,736
Indonesia	64,000	UK	213,000
Italy	196,000	USA	954,210
Japan	725,000		

[92]

5.4 Public transport sales and production

Public transport is undergoing a renaissance, with an increase in patronage on many inter-urban and urban networks – reflecting the move towards sustainable transport and urban living. The International Association of Public Transport (UITP) is expecting a doubling of public transport globally by 2025 [96], but even this may be an underestimation of the growth potential in public transport.

The public transport market is focused on particular parts of the world, with very different levels of commitment and investment by country. Many new rail and transit systems have been built recently, are under construction or are being planned. For example, there is much interest in the expansion of inter-urban rail, particularly high speed rail (HSR). China has the world's longest HSR network, with over 19,000 km of track (as at December 2015), accounting for two thirds of the world's HSR. The development of the system has been very quick, with the first commercial operation of China's HSR only in 2003. A network length of 30,000 km is planned by 2020. In comparison, Spain has a HSR network length of just over 3,000 km, Japan of 2,700 km, France of 2,000 km and Germany of 1,300 km.

For ail rolling stock orders, Europe is the largest regional market, closely followed by China. Table 7 gives available data from 2010 with projections to 2016.

Table 7: Annual rail rolling stock markets by region ($ billion)

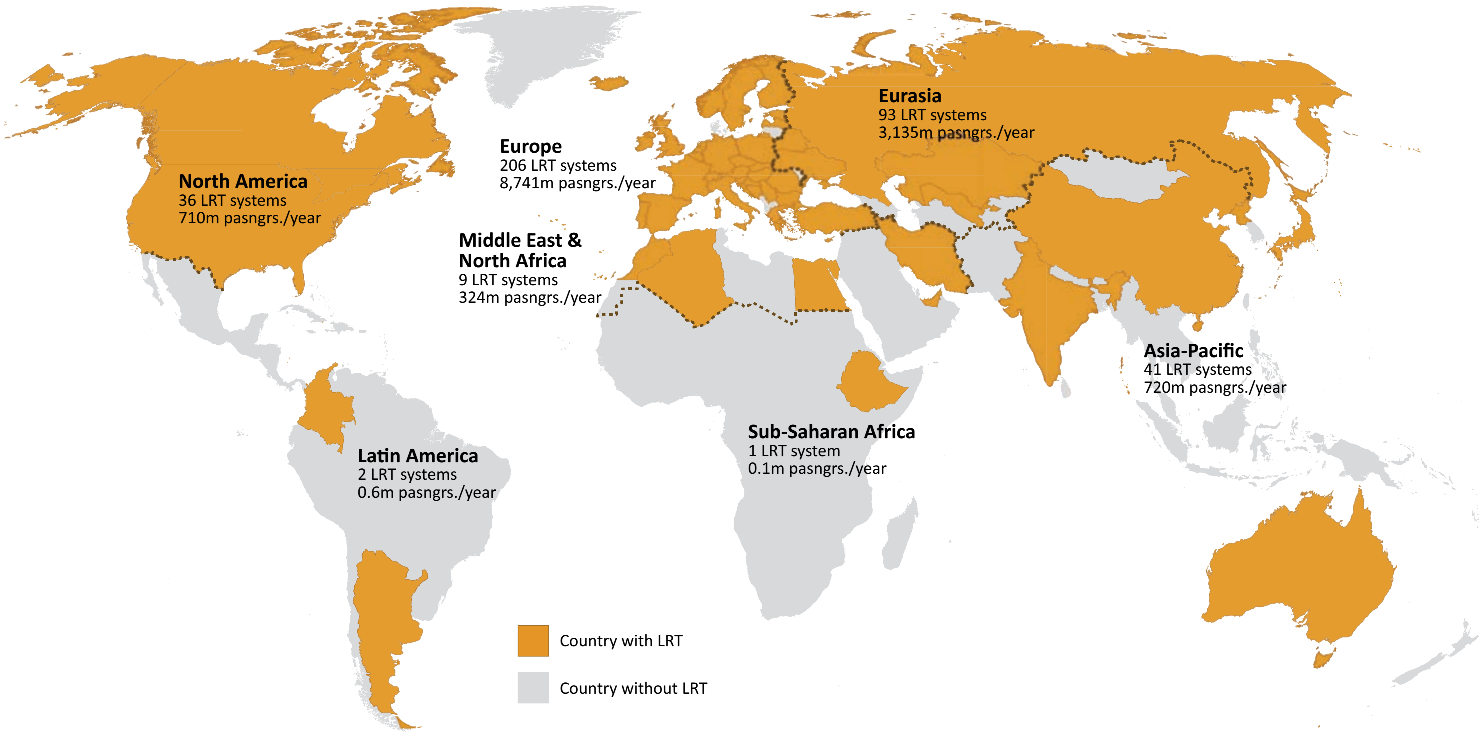
Region	2008-10	2011-13	2014-16
Europe	12.9	14.0	14.8
China	11.6	11.5	9.2
North America	3.7	3.8	4.6
CIS, including Russia	2.5	3.7	4.7
Latin America	1.8	1.0	1.4
India	1.4	1.9	2.3
Asia-Pacific, excluding China and India)	1.8	2.3	2.5

[97]

388 light rail transit (LRT) systems are in operation worldwide (Figure 29), with the majority in Europe (206), followed by Eurasia (93), Asia (41) and North America (36). Germany alone has 51 tramway (Straßenbahn) networks, including some of which have been upgraded to light rail standards (Stadtbahn). Together, LRT systems carry approximately 13.6 billion passengers every year (45 million passengers daily) [98] (Figure 33).

Bus Rapid Transit (BRT) can similarly give high quality public transport services, with fast and cost-effective services. Dedicated lanes, off-board fare collection and frequent operations can give metro-level capacities. 207 cities currently have BRT systems, with 5,470km of network length and over 34 million passengers per day, mostly in South America and Asia [99].

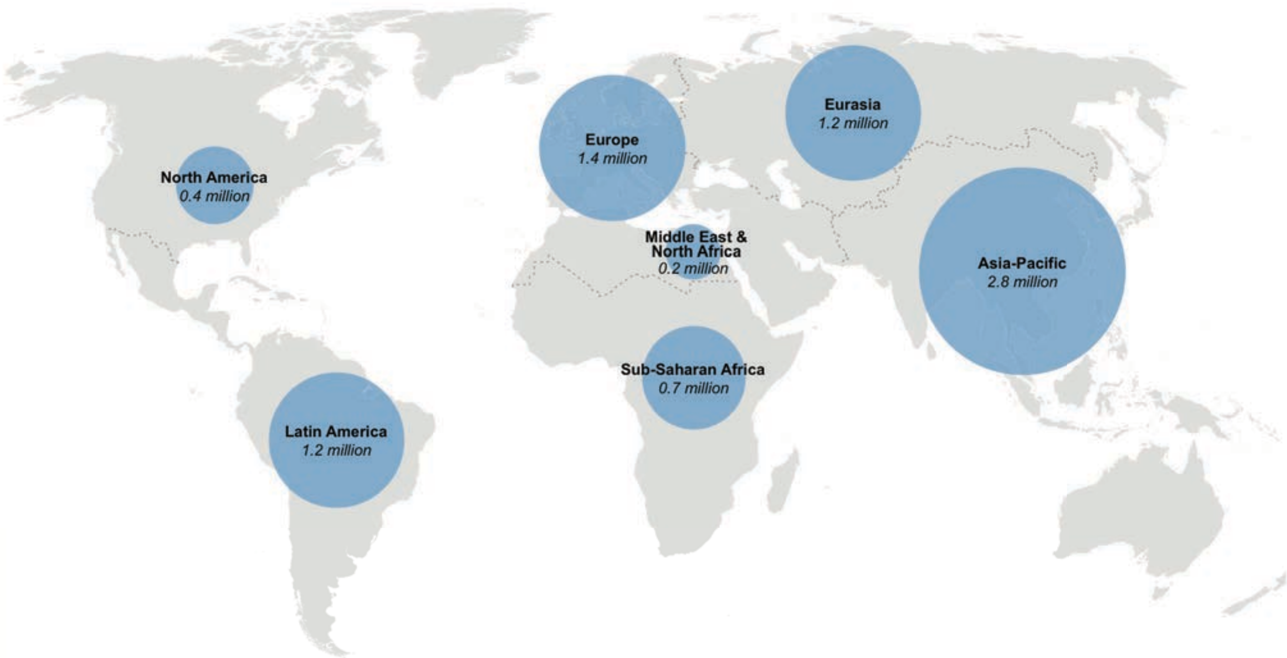
Figure 33: International LRT systems



[98]

Figure 34 gives employment by public transport operators globally in 2009 – amounting to 7.3 million people worldwide (full time equivalent). Eurasia has 6.8 jobs per 1000 urban residents while sub-Saharan Africa has just 0.25 jobs per 1000 urban residents. Public authorities running public transport employ around 300,000 people worldwide, and the number of jobs in the public transport supply chain worldwide is estimated at five million. In total, the public transport sector employs around 13 million people worldwide [96]. This is of a similar scale to automobile-related employment – both sectors providing direct employment to around 7-8 million people.

Figure 34: Employment by public transport operators by region



[96]

All of the major rail manufacturing businesses are sizeable employers, with estimates of jobs given below. At least half a million people are employed with public transport operators, not including any supply chain figures. The numbers in China account for at least half of these [97].

- Bombardier: approximately 33,800 rail-related employees, out of a total of 64,000 employees in 2010, with 75 per cent located in Europe.
- Alstom: 27,800 employees in the transportation division, out of 76,500 total employees, with 70 per cent located in Europe.
- Siemens: 19,000 employees in the mobility division, out of 434,000 total employees in 2006.
- China South Locomotive and Rolling Stock (CSR): 112,000 employees (merged with CNR in 2015 to create China Railway Rolling Stock Corporation Ltd (CRRC).
- China Northern Locomotive and Rolling Stock (CNR): 100,000 employees (merged with CSR in 2015 to create CRRC).
- Kawasaki: Kawasaki Heavy Industries has around 32,300 employees, including a railway manufacturing division.
- Transmashholding: around 57,000 employees in Russia in 2009.

There is also significant employment associated with bus-based public transport globally – but the figures are not available. Direct comparisons are difficult across the public transport and automobile manufacturing industries as the figures come from varied sources and are often estimated in different ways. However, the scale of direct employment is similar at around 7-8 million. Public transport plays an important part as a significant employer in many countries, but the employment is often distributed across different manufacturing businesses and city public transport operators. The contribution to national economies is largely unmeasured and certainly doesn't attain the status of automobile manufacturing. The major differences to the automobile industry are that the lobbying influence tends to be much smaller; and services are usually run by or on behalf of city authorities – hence there is less of a profit motive or potential. However, in the large public transport cities, such as Hong Kong, London, Munich, New York and Tokyo, the dense public transport networks are critical to the support of the city and national economies.

Employment numbers could be much higher if countries with low levels of public transport usage began to grow their networks and usage. Public transport organisations and private providers can be supported across the world, such as in China, Russia, France and Germany. Given the much more positive impacts of travel by public transport relative to the automobile, the public transport industry should be given much stronger support. This will involve a strong change in governmental approach in the countries with strong automobile industries, but it would mean that industrial strategy was more consistent with wider environmental objectives.

5.5 Cycle-related employment

Cycle-related employment is also significant internationally, yet the global employment figures are not known. In particular, there will be very large numbers in Asia, however, again this data is not available. In the EU-27, the countries with high cycle mode shares, unsurprisingly, experience higher levels of cycle-related employment. It is estimated that the cycling sector creates around 650,000 full-time equivalent jobs (EU-27, excluding Croatia). This includes jobs in the bicycle industry, bicycle retail, bicycle infrastructure and bicycle tourism. With a doubling of bicycle modal share, the employment potential could rise to more than 1 million full-time equivalent jobs, see Table 8 [100].

The value of global bicycle retail sales is estimated at US$47.4 billion for 2014. This includes bicycles of all categories, including e-bikes and adult and children's bikes, parts, accessories, footwear and cycling apparel. 133 million bicycles (including e-bikes) were sold, 36 per cent of these in Europe [101].

Cycle infrastructure investment is given in Table 9 – with a clear relationship evident between higher levels of investment (nearly €30 per capita per year in the Netherlands) and a high cycle mode share by trips.

The Netherlands and Denmark have the highest cycle mode shares by trips at 31 per cent and 19 per cent, and this is associated with higher levels of cycling jobs per 100,000 population. The Netherlands, for example, has 28,400 cycle-related full-time equivalent jobs; Denmark has 7,300 jobs; Germany has 211,000 jobs; and the UK has 57,000 cycle-related full-time equivalent jobs (Figure 35).

Table 8: Cycle-related employment

Subsector	Employment (FTE) today	Employment (FTE) with doubling of modal share
Bicycle retail (mainly sales and repair)	80,587	122,196
Bicycle industry (manufacturing and wholesale)	22,629	32,133
Bicycle infrastructure	23,417	36,484
Bicycle tourism	524,052	869,927
Bicycle services	4,224	8,448
Total	654,909	1,069,188

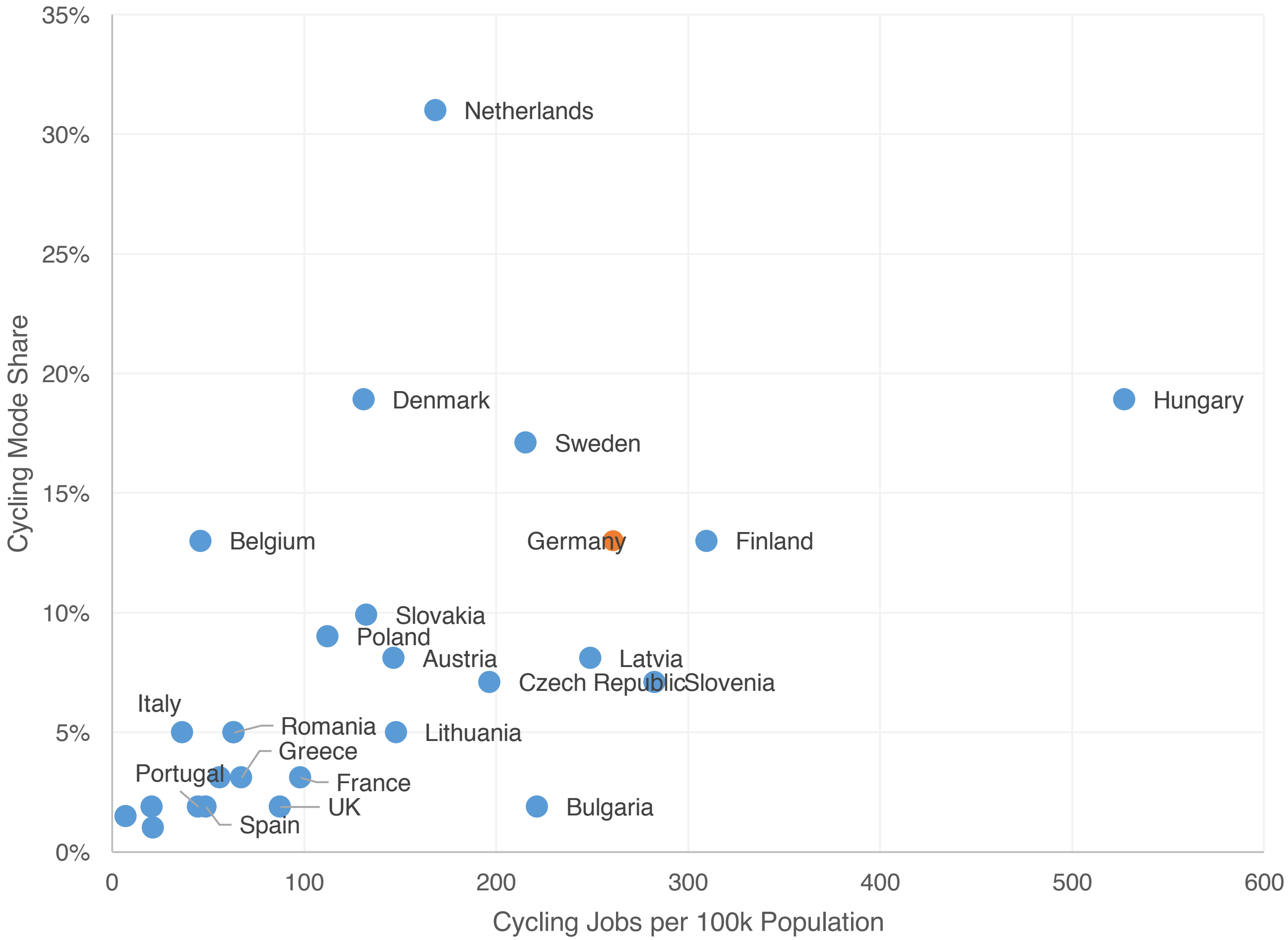
(European Cyclists' Federation, 2016)

Table 9: Cycle infrastructure investment

Country	Cycle mode share (no. of trips)	Investment per capita (€) per year
Flemish region	15%	17
Denmark	19%	18
Germany	13%	10.5
Netherlands	31%	29.0
UK	2%	2.4

(European Cyclists' Federation, 2016)

Figure 35: EU cycle employment by cycle mode share by country



(European Cyclists' Federation, 2016)

6 Frankfurt: Current Discourses on Travel

Chapter summary:

- *There is a poor understanding of the varied attitudes to travel and potential policy measures, reflecting the available infrastructure and built environment and also societal norms and values.*
- *Discourse analysis can be used to understand the differences in attitudes to travel – and to help develop policy measures to better target cohorts in the population.*

6.1 Mode shares – in German and international cities

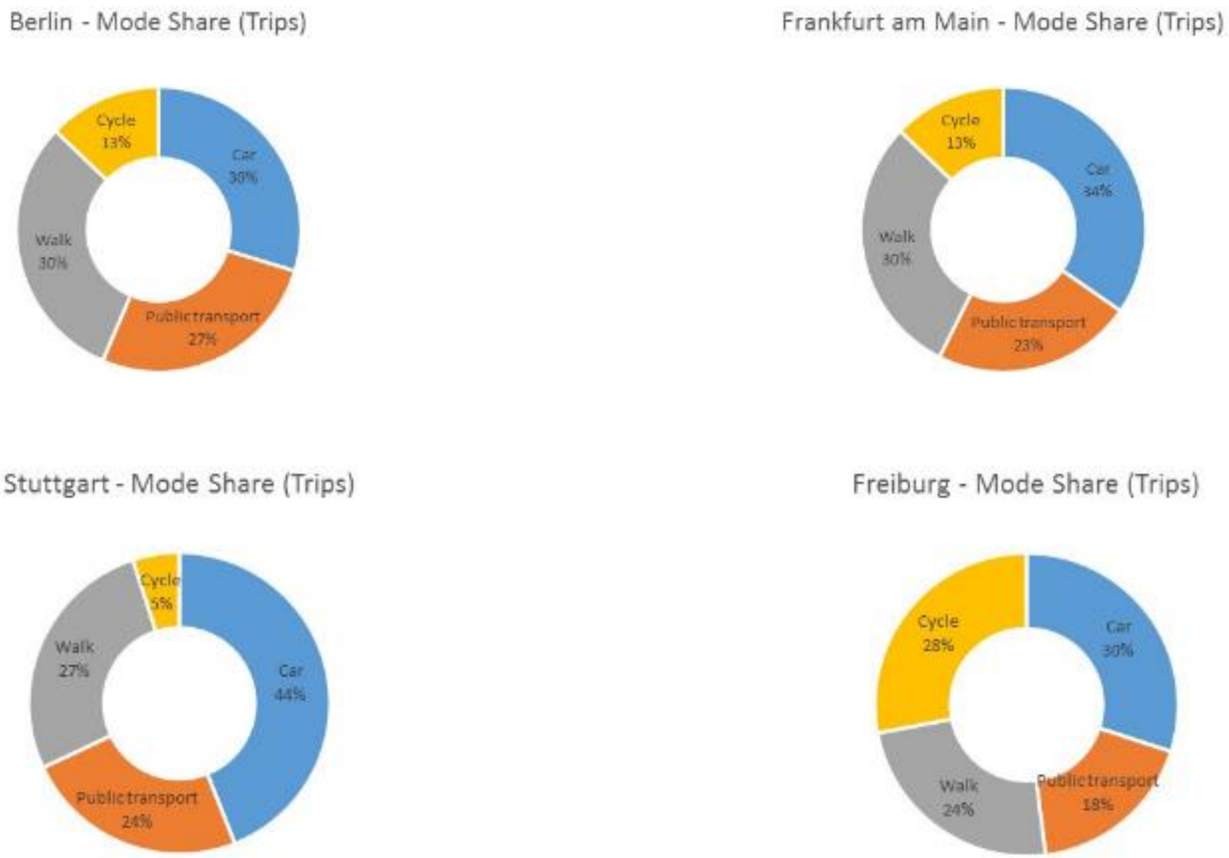
Germany already has a progressive transport system in many of its cities, with large investment in urban public transport, walking and cycling; and high speed rail connecting between cities. In Germany, 44 cities have tramway systems, called Straßenbahn, and Stadtbahn where they have been upgraded to Light Rapid Transit (LRT) standards. Most of these are upgrades on old networks developed from the late 1890s and early 1900s. Tramways are often combined with U-Bahn (Underground) and/or S-Bahn (suburban rail) systems to give a comprehensive network coverage. There are excellent LRT systems in Berlin, Cologne, Frankfurt, Freiburg, and some other cities, including some innovative tram-train systems in Karlsruhe, Kassel and Saarbrücken. This leads to a high public transport mode share and, together with good cycle networks and pedestrian provision, a high non-car mode share by trips across almost all cities, sometimes at around 70 per cent (Figures 36 and 37).

Similarly, in France, 27 cities have LRT systems, usually built as new systems rather than upgrades. Grenoble led the way with the development of its modern tram system, from 1987 onwards, and a series of cities have followed with very high quality projects, including Strasbourg, Bordeaux, Montpellier, Tours and Valenciennes. In the UK, there is a continual struggle to provide investment in such projects – there are just 9 cities with LRT projects, and network coverage and the quality in streetscape design is extremely limited. The mode shares follow the transport systems that are available – good public transport and cycle networks are usually associated with high non-car mode shares.

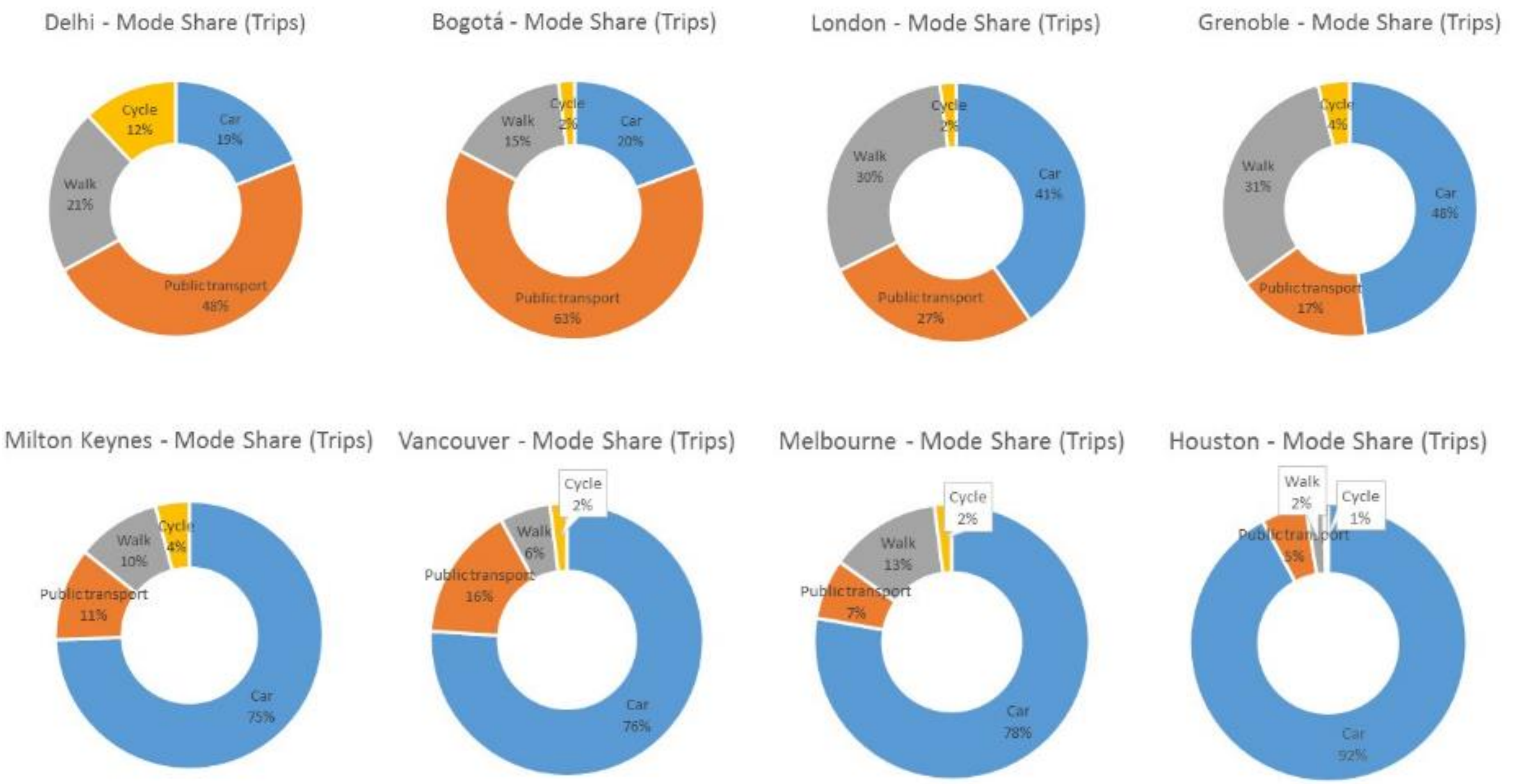
Example mode share by trips are also given for selected international cities in Figure 36[5]. There are very large differences in mode shares – with some of the car dependent cities, often from the North American context, having car mode shares > 75 per cent.

[5] Delhi data is for 2011; Bogotá, 2008; London, 2011; Grenoble, 2010; Milton Keynes, 2007; Vancouver, 2006; Melbourne,2007; and Houston, 2010.

Figure 36: Mode share in German cities and internationally

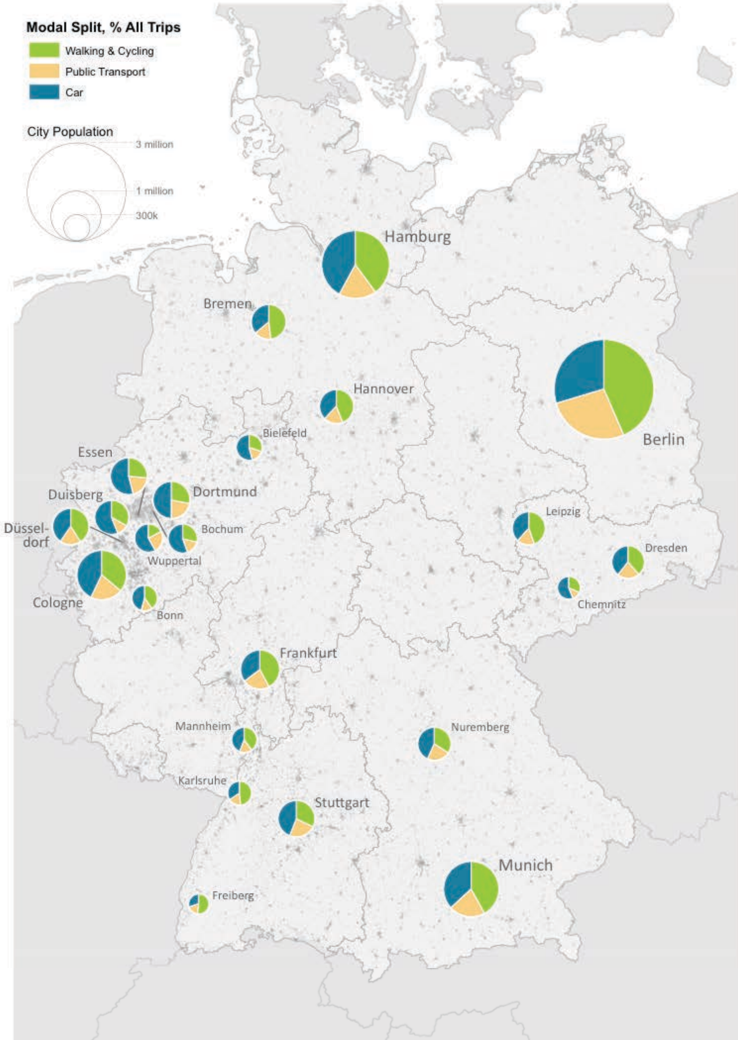


[102-105]


Delhi - Mode Share (Trips)
Car 19%
Public transport 48%
Walk 21%
Cycle 12%
Bogotá - Mode Share (Trips)
Car 20%
Public transport 63%
Walk 15%
Cycle 2%
London - Mode Share (Trips)
Car 41%
Public transport 27%
Walk 30%
Cycle 2%
Grenoble - Mode Share (Trips)
Car 48%
Public transport 17%
Walk 31%
Cycle 4%
Milton Keynes - Mode Share (Trips)
Car 75%
Public transport 11%
Walk 10%
Cycle 4%
Vancouver - Mode Share (Trips)
Car 76%
Public transport 16%
Walk 6%
Cycle 2%
Melbourne - Mode Share (Trips)
Car 78%
Public transport 7%
Walk 13%
Cycle 2%
Houston - Mode Share (Trips)
Car 92%
Public transport 5%
Walk 2%
Cycle 1%

[102-105]

Figure 37: Mode share and population in German cities



[103]

There is a fairly clear relationship between urban population density and car mode share in Germany (Figure 38). Though there are, of course, other factors contributing to mode share, as urban density increases, car mode share tends to fall. Frankfurt, Berlin and Munich all have less than 40 per cent car mode share and average urban population densities of over 3,000 inhabitants per square km.

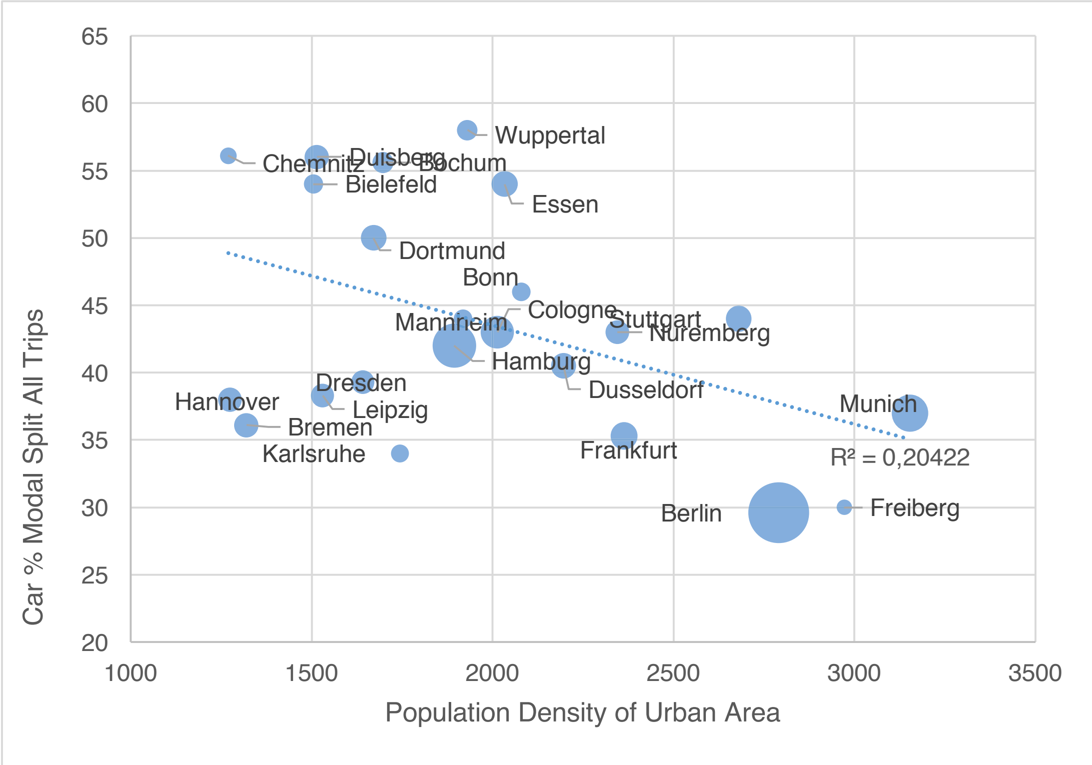


Figure 38: Car mode share in German cities relative to urban population density

[103, 106]

6.2 Travel as a cultural phenomenon

Greater environmental sustainability in travel appears difficult to encourage, and perhaps part of the reasoning is in the poor understanding of the impacts of car-based travel and the continued support given to the motor industry. But, the reasons for continued car usage are much more complex than this. Travel is, at least in part, a cultural phenomenon, a result of infrastructure, urban planning, individual attitudes, and societal norms and values [26, 45, 107, 108]. Infrastructure systems are relatively fixed and, even when new infrastructure is developed, it can take a wider package of policy measures to significantly impact on travel behaviours. Transport planning is usually focused on infrastructure planning and rarely considers the wider attitudinal and societal areas that also need to be shaped to significantly impact travel. There is some emerging research on segmenting travel users by attitudinal type [109-111], building on earlier work on travel planning and other 'smarter choice' measures in seeking to influence travel [112]. But implementation of actual projects which seek to influence user attitudes rarely gains the impetus required.

Building new public transport or cycling infrastructure within an unsupportive political and cultural context is unlikely to change behaviours significantly. For example, where peoples' ideas on travel have been shaped to use or aspire to using the private car (over years, through advertising and use of the mass media, etc.), or where the cost of public transport is too high, or there is too much traffic on the roads to cycle safely, or where new public transport links cannot sufficiently serve a dispersed built environment. Transport planning, if it is to be more effective in influencing travel behaviours, needs to be much wider in remit – considering the available infrastructure, urban planning, individual attitudes, and the wider cultural and political context.

Below, discourse analysis is used to examine the attitudes to travel and emerging projects in the case study city of Frankfurt. This is used to identify the major discourses evident and the different viewpoints. Transport planning should understand and respond to this type of detailed analysis of travel behaviours. This is not a method that is well used in transport planning, with only a few academic journal papers written on this topic [such as 113, 114, 115] – and discourse analysis is very seldom used in practice. But discourse analysis could have a much wider application in strategy development, for widening participation on project development, for project appraisal, and for developing packages of projects which might more significantly affect travel behaviours.

Methodology

30 in-depth face-to-face surveys were carried out in Frankfurt, undertaken at the Regionalverband, FrankfurtRheinMain (Regional Planning Authority) and Frankfurt University of Applied Sciences. The interviews each lasted 45-60 minutes, explored the attitudes to travel, travel choices, aspirations, and views on emerging policy measures, of individuals living and travelling in the city. The survey uses attitudinal statements to identify different discourses that are evident in the city. This helps illustrate the previous analysis and to examine what travel cultures are evident in the city. A discourse, for the purposes of this work, is viewed as:

"… a shared way of apprehending the world. Embedded in language, it enables those who subscribe to it to interpret bits of information and put them into coherent stories or accounts […] each discourse rests on assumptions, judgements and contentions that provide the basic terms for analysis, debates, agreements and disagreements." [116, p.9-10]

Q methodology is used to identify the discourses – a research method used widely in the social sciences, originally developed by psychologist William Stephenson [117, 118]. The process is as summarised below:

- Generation and selection of statements – the Q sample. These were generated using interviews with two experts in transport and urban planning in Frankfurt – one from Regionalverband, FrankfurtRheinMain; and one from Goethe University, Frankfurt.
- Administration of the Q sample to participants through the interviews.
- Statistical analysis of collected data to extract 'typical' Q sorts through factor analysis using Q software[6].
- Discursive interpretation of Q sorts.

Each statement within the Q sample is ranked from -4 (strongly disagree) to +4 (strongly agree), but also prioritised into a normalised distribution (Table 10) – hence respondents are forced to choose a set number of responses for each score. The forcing means that respondents have to think very carefully about their responses and scoring.

Table 10: Distribution of 'forced' rankings

Value	-4	-3	-2	-1	0	1	2	3	4
Number of statements	4	6	9	11	12	11	9	6	4

N=72

[6] PQMethod is used to factor analyse the responses and to develop the discourses, developed by John Atkinson and Stephen Brown, and adapted by Peter Schmolk. http://schmolck.userweb.mwn.de/qmethod/downpqwin.htm

Discourse analysis

The discourses vary markedly within Frankfurt, for example with different views on levels of support for car usage, public transport, walking and cycling, and city living. Four distinct factors, or discourses, were revealed:

- Discourse A: The Cycling Advocate
- Discourse B: The Public Transport Advocate
- Discourse C: The Multimodal Driver
- Discourse D: The Car Enthusiast

Table A1 in the Annex shows the factorised ranking of each statement in each discourse as constructed through PQMethod. As a result of the small sample size and non-random nature of participant selection used within Q methodology, the responses can only be seen as representative of the study sample – and not generalisable to Frankfurt as a whole. They do, however, provide a very interesting grouping of viewpoints from respondents in Frankfurt, and give us a rich understanding of attitudes to travel and potential policy measures in the city and region.

FRANKFURT: Much of the city is well planned for public transport, walking and cycling – but there is still a relatively high level of private car usage. It is difficult to encourage more people away from the car – and policy makers will need to think of innovative policy measures.

6.3 Discourse A: The Cycling Advocate

Discourse A is a major discourse formed by 13 respondents and is represented by the statements shown in Table 11[7]. Statements in brackets followed by an asterisk (*) are defining statements within the sort and can be seen as statistically unique at their associated ranking.

Table 11: Distribution of most agreed with, neutral, and most disagreed with statements for Discourse A

Rank	**Statements**											
4	14*	35	42*	62*								
3	34	38	43	44	59	68	17					
0	4	12	20	30	36	37	46	51	56	65	71	72
-3	2	3	6	11	31	40	5					
-4	5	7	13	60*								

The Cycling Advocate is the most anti-car of all discourses, believing first and foremost that it is simply not necessary to own a car in Frankfurt and that there are many other options available to the traveller (*14**) and that cars are given too much priority on roads (*62**). Additionally, they do not feel that they need a car for their day-to-day life (*13*), nor do they derive pleasure from driving (*2*). The discourse is predominantly pro-cyclist, with the Cycling Advocate stating that cycling is the best way to get around (*35*) and that they enjoy cycling regularly for exercise (*38*).

Alongside their personal preference for cycling, the Cycling Advocate strongly believes in a particular cycling-based ideal for travel and transport within society. They are adamantly against prioritising the private car on transport networks, strongly disagreeing that there should be cheaper parking spaces in Frankfurt city centre (*60**) or more residential car parking spaces (*11*), and that that there should be more investments made on the highway network (*7*). This is coupled with their desire for better cycling parking facilities across the city (*44*) and their belief that the gaps in the current cycle network should be filled (*34*) alongside providing more cycle hiring facilities (*43*).

Their 'worldview' also aligns with these statements, with the Cycling Advocate believing that a society where the majority of people cycle to work is ideal (*42**), while disagreeing with the idea that car ownership is a universal goal and a natural step in life's progression (*3*). This also is reflected in the Cycling Advocate's more neutral statements where less focus is given to the material or practical aspects of cycling such as riding new or fast bicycles (*36*) or cycling confidence in heavy traffic (*56*).

[7] One respondent loaded negatively onto this factor, suggesting their viewpoints are the polar opposite of those expressed in Discourse A.

FRANKFURT: Cycling can become a much more important mode in Frankfurt and many cities internationally – but facilities need to be of very high quality, allowing a safe and comfortable ride.

6.4 Discourse B: The Public Transport Advocate

Discourse B is a major discourse formed by 10 respondents and is represented by the statements shown in Table 12.

Table 12: Distribution of most agreed with, neutral, and most disagreed with statements for Discourse B

Rank	Statements											
4	19*	25	68	69								
3	26	34	44	45	47	54	28					
0	12	16	23	24	30	32	40	43	46	49	51	60
-3	8	9	10	13	37	48	2					
-4	2*	5	6*	31								

*defining statements within the sort

The Public Transport Advocate shares both pro-cycling and anti-car positions with the Cycling Advocate, while offering a different transport and travel preference worldview. In terms of its anti-car perspective, respondents dislike the symbolic and cultural offerings of the car (*2*, 5, 6**), disagreeing with car travel being perceived as safer (*8*) and being more comfortable than public transport when stuck in traffic (*9*). Respondents disagree with the idea that successful people tend to drive nice cars (*10*). This is a slight departure from the Cycling Advocate's position, which is focused much more on resisting private car infrastructure improvements, something that the Public Transport Advocate is neutral on (*60*).

While the Public Transport Advocate is pro-cycling – agreeing that cycle parking (*44*) and cycling routes (*34, 45*) should be improved they are neutral on other cycling issues and infrastructure positions (*43*) and are significantly more pro-public transport – particularly concerning infrastructure. The Public Transport Advocate strongly believes that more money should be spent to improve the U-Bahn, S-Bahn, and tram networks (*19**) and that the Frankfurt Hauptbahnhof needs to be redeveloped to allow better connections to other public transport services (*26*). They also believe that through ticketing should be prioritised to make a more seamless travel experience (*68*) and that, for some groups such as those with disabilities or mobility issues, it is currently difficult to use or access public transport (*54*). Finally, the Public Transport Advocate is also a strong supporter of pedestrianisation of the city centre (*69*) as walking is also an important means of travel to them (*47*).

FRANKFURT: Public transport investments can be instrumental to the development of attractive cities – part of a huge city beautification effort.

6.5 Discourse C: The Multimodal Driver

Discourse C is a minor discourse formed by 3 respondents and is represented by the statements shown in Table 13.

Table 13: Distribution of most agreed with, neutral, and most disagreed with statements for Discourse C

Rank	Statements										
4	1	2*	24	26							
3	6	12	25	35	54	57	14				
0	3	8	9	13	18	33	37	39	44	47	56	63
-3	7	20	36	41	55	61	40					
-4	40	58	71*	72*								

*defining statements within the sort

The Multimodal Driver is interestingly pro-cycle, pro-public transport, and pro-car all at once – they like to use all modes. But, first and foremost, the Multimodal Driver is pro-car, strongly enjoying the freedom and independence of driving (*1*) and driving as an enjoyable hobby (*2**). Respondents enjoy driving fast (*6*) and enjoy the practical utility and capacity of the private car (*12*). Aside from this, the Multimodal Driver also supports redevelopment of the Hauptbahnhof (*26*), enjoys the productivity of travel by public transport (*24*) and believes public transport should be more affordable (*25*). They disagree with investing more in the highway network for the private car (*7*), love cycling (*35*), while also feel that cyclists are the most vulnerable of all road users (*57*).

While the Multimodal Driver is generally pro-transport they are adamantly against increasing driving or living costs to benefit transport, such as through the introduction of road pricing schemes (*71**) or new forms of property or business taxation (*72**). They are also neutral on many positions which advocate improving cycling infrastructure (*33, 39, 44*), suggesting that, while they recognise the risks of cycling, they prefer the status-quo on the prioritisation of use of the road network.

FRANKFURT: Many people use different modes, including the car, public transport, walking and cycling, for different activities. The task is to reduce the use of the car down to very minimal average levels – perhaps to 1,000 km a year for those who continue to use a car.

6.6 Discourse D: The Car Enthusiast

Discourse D is a minor discourse formed by 2 respondents[8] and is represented by the statements shown in Table 14.

Table 14: Distribution of most agreed with, neutral, and most disagreed with statements for Discourse D

Rank	Statements											
4	5*	9*	10*	53								
3	12	15	43	44	60	69	1					
0	7	11	17	29	37	38	54	55	59	62	2	8
-3	16	23	50	51	65	72	31					
-4	31	36	39	52								

*defining statements within the sort

The Car Enthusiast strongly agrees with the auto-centric symbolism that supports and encourages private car ownership and use. The Car Enthusiast strongly enjoys driving nice or expensive cars (*5**) and strongly believes that if you are successful in life you tend to drive a nice car (*10**). They also prefer being in a car over a bus when stuck in traffic (*9**), enjoy the capacity and utility of the private car (*12*), believe it is hard to be truly independent without a car (*15*), and that there should be cheaper parking provided in Frankfurt city centre (*60*). They also do not believe that they would use low emission or electric cars if they became much cheaper (*16*).

The Car Enthusiast would prefer to live in a large urban area or city (*53*), but does not support increasing city centre densities (*65*) or focusing development in Frankfurt's regional centres (*51*). The Car Enthusiast also supports improving cycling and pedestrian facilities (*43, 44, 69*) suggesting that they are not anti-cycling. There is less support for public transport which the Car Enthusiast feels more neutral towards (*29, 54, 55*).

FRANKFURT: many people will continue to wish to drive cars – certainly in the dispersed cities. They should use low emission vehicles – and ideally the private ownership model disappears, so that car clubs and rental become more popular. In this way, it will be easier to encourage people to use the non-car modes for different types of trip.

[8] These respondents load very strongly to this factor (>0.90) suggesting this is an almost exact representation of their perspectives.

7 Conclusion: A Revolution in Transport

Chapter summary:

- *Designing cities for public transport, walking and cycling needs to be massively scaled up – we need a revolution in transport planning.*
- *There are many adverse impacts from the automobility system that are completely unacceptable, including energy depletion, CO2 emissions, traffic casualties, local air quality, obesity and health impacts of inactivity, and loss of street space to the car.*
- *Much more radical transport strategies can be developed – all cities should target at least 70-80 per cent of trips by public transport, walking and cycling – with the remainder of trips by low emission vehicles.*

LONDON: The public realm as a central part of the design of quality cities – large investment is given to improving the pedestrian experience. This is what makes attractive cities – in economic terms as well as environmentally and socially.

COPENHAGEN: Cycling facilities can be iconic to the design of the city.

DELFT: Cycling becomes the way of accessing everyday activities.

STOCKHOLM: Urban living needs to be attractive and affordable for all.

KASSEL: Innovative forms of public transport can be developed – including networks that link the city into the wider region, such as the regional tram-train systems in Germany.

FREIBURG: Transport planning is used to deliver attractive cities – it is well integrated with the urban plans for new neighbourhoods and regenerated areas. The tram or public transport route is the spine of the development.

FREIBURG: Instead of giving space to the car, the residential neighbourhood can have much open space provision.

MONTPELLIER: The public transport vehicle is not designed to the lowest cost specification – it is designed to complement the image of the city.

STRASBOURG: The quality of the city is massively improved – with transport positively contributing to the public realm.

BOGOTÁ: Public transport, of varying forms, becomes central to moving people in all cities globally.

SUZHOU: China may be the context where multiple modes of public transport are most required – and where the new innovations can be developed.

LONDON: Improving the experience of non-car based travel can be a focus for investment – use of public transport, walking and cycling is likely to be repeated if it is enjoyable.

VALENCIA: Radical streetscape and public space beautification schemes can be developed – such as creating strategic pedestrian and cycling corridors through the city.

7.1 Designing cities beyond the car

The taken-for-granted assumption that cities need to be designed around the automobile is being challenged in many contexts. Yet the infrastructure of a transport system built around the private car is a reality in most contexts – and it is only in a limited number of cities that serious investments are being made to develop high quality and extensive public transport, walking and cycling networks.

As Freund and Martin [88, p.4] reminded us: "to question the pervasiveness of auto use is, at worst, to be labelled a Luddite, an eccentric, or even an enemy of freedom. At best, one is likely to be dismissed as a critic of the necessary, the inevitable, or the trivial."

We are beginning to move beyond this central discourse – the discourse offered by the automobile industry, with individual views shaped by extensive advertising and a supportive media. There are still very high levels of motorisation in many countries, with the USA even reaching 809 vehicles/1000 population. In Europe, there are much lower levels of car ownership, such as in Germany (578), UK (575) and the Netherlands (550). China (102) and the other emerging countries have much lower levels of motorisation, but are usually rapidly increasing. Some countries, such as the Netherlands, have high car ownership, but relatively low levels of usage.

In the last few years there has been an emerging, albeit still marginal, trend of flattening and reducing VKT in European and North American countries – the phenomenon of peak car. It is hoped this is the start of a more significant trend that will involve deeper reductions in VKT and spread across many countries.

7.2 The rationale for change

The automobile has had its day – but the very adverse impacts of the automobility system mean that the private car can no longer be supported as a central mode of choice across all contexts. The car must be marginalised and investment in public transport, walking and cycling needs to be massively scaled up. The adverse impacts of automobility include:

- Energy depletion: increased levels of mobility are leading to huge demand for energy. In 2015, the world consumed 13,559 million tonnes of oil equivalent, an increase of 35 per cent on 2000 levels. The transport sector accounts for 23 per cent of this – and has grown at 2 per cent per year over the last decade. The vast majority of this (94 per cent) comes from oil based sources.
- CO_2 emissions: though some European countries are reducing national CO_2 emissions to a limited degree, the large emitters are dramatically increasing theirs, e.g. China emitted 10.5 $GTCO_2$ in 2014, a growth of over 300 per cent on 1990 levels. The transport sector is the key sector that is failing to contribute to reduced CO_2 emissions – even the progressive cities are only reducing transport CO_2 emissions marginally.
- Traffic casualties: around 1.25 million people die each year resulting from road traffic crashes and road traffic injuries – this approximates to 3,400 deaths per day. In addition, between 20-50 million more people suffer non-fatal injuries, with many incurring ongoing disabilities. This is a cost that cannot continue.
- Non-communicable diseases (NCDs) killed around 38 million people in 2012, representing 68 per cent of 56 million global deaths. These include cardiovascular diseases (mainly heart disease and stroke), cancers, respiratory diseases and diabetes. The most important risks to NCDs are high blood pressure, high concentrations of cholesterol in the blood, inadequate intake of fruit and vegetables, being overweight or obese, physical inactivity and tobacco use. Five out of six of these risk factors are closely related to diet and physical exercise and, in part, the level of active transport we take. Global obesity has more than doubled since 1980 – and physical activity is important to weight control.

We can no longer destroy our cities and lives to accommodate the private car. Using 20-30 per cent of the space in the city, or more, for highways and parking is a waste of valuable space and incompatible with urban planning objectives.

The recent enthusiasm for automated vehicles is unlikely to solve all of these problems – perhaps energy depletion and CO_2 emissions could be reduced if vehicles were clean; traffic casualties, in theory, could be reduced – but there are many technical issues to be resolved, including how roadspace priority is allocated in busy pedestrian areas. The lack of physical activity and impacts on the city fabric remain unresolved. Automated vehicles may appear to be a choice for the North American context, where the urban fabric is dispersed and where public transport is difficult to provide. But, certainly in Europe, the priority should remain on investing in state-of-the-art public transport, walking and cycling facilities.

7.3 Supporting growth in the public transport and cycling industries

The automobile industry gains great status, but in terms of impact on the economy this is overplayed. The public transport industry employs similar numbers and it is this that should be supported with government subsidy. Around 7-8 million people are directly employed in the public transport industry globally, with additional secondary employment. This can be much increased if public transport usage is doubled, or more, by 2025. In addition, cycling-related employment is becoming much more important – the cycling sector employs 650,000 jobs in the EU-27. With a doubling of mode share, this could rise to more than one million jobs.

7.4 Understanding and responding to discourses on travel

From our analysis of travel attitudes in Frankfurt, four distinct discourses are revealed:

- Discourse A: The Cycling Advocate – a major discourse, the most anti-car of all discourses, believing it is not necessary to own a car in Frankfurt, that cars are given too much priority on the road, and that cycling is the best way to get around. Respondents desire much better cycling facilities across the city.
- Discourse B: The Public Transport Advocate – a major discourse, both pro-cycle and anti-car, advocating investment in the U-Bahn, S-Bahn, tram networks and Frankfurt Hauptbahnhof.
- Discourse C: The Multimodal Driver – a minor discourse, being pro-cycle, pro-public transport and pro-car all at once. The primary interest is in favouring car usage, strongly enjoying the freedom and independence of driving, driving fast, and also the utility of the car. Respondents advocate investment in public transport, but do not believe the cost of driving should be increased.
- Discourse D: The Car Enthusiast – a minor discourse, strongly agreeing with the auto-centric symbolism that promotes car ownership and usage, enjoys driving nice and expensive cars – and believe that if you are successful in life you tend to drive a nice car. Respondents do not support increased densities or focusing development in the regional centres around Frankfurt.

Transport planning, to be more effective, needs to understand and respond to, this type of detailed analysis of travel behaviours. Strategy development might include such form of analysis, perhaps in tandem with greater participatory approaches to decision-making. Policy measures can be targeted at specific discourses – and the more enlightened discourses be encouraged and spread to wider contexts.

7.5 Developing more radical strategies

Despite the relatively good baseline for German and some other European cities, there is much more that can be done to achieve greater sustainability in travel. More radical strategies can be developed and implemented – a revolution in transport is required. But this must be tailored to the different attitudes and views on travel in each city, and societal views and norms can also be shaped to help develop more environmentally friendly travel behaviours.

Each city strategy will vary by context, reflecting different problems and opportunities, the different levels of awareness and debate, and developed in a participatory manner with the public. There is no single approach to transport planning that can be applied in different contexts. This is a key lesson from the automobile era – a Western-inspired approach to highway building was attempted in many contexts, including in South America and Asia, and the impacts have been catastrophic in almost all cities. A much greater sensitivity to the local context, and the particular problems, opportunities and policy objectives, is required when developing transport strategies.

A key approach in transport planning can be backcasting – where a sustainable transport vision is developed for 15-30 years in the future, in a participatory manner. A pathway and programme is developed back to the present year to help implement this future vision. This can help better ensure attractive, trend-breaking futures are achieved [26] (Figure 39). This is a very different approach to the current dominance of forecasting and of 'predict and provide'. Changing travel behaviours is likely to mean that we need to change the decision-making process in transport planning.

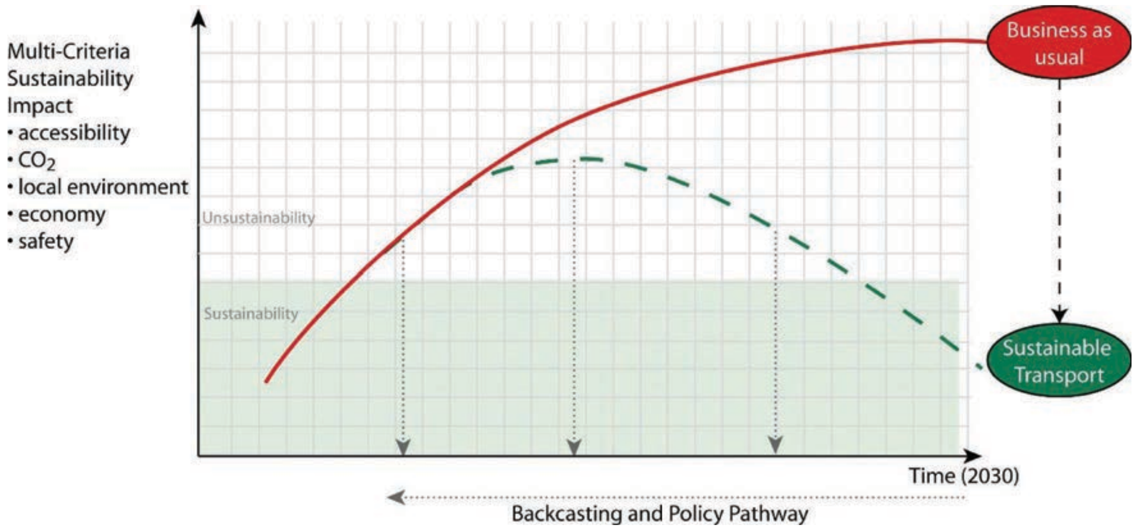


Figure 39: Backcasting and transport planning

[26]

Within a central vision, we propose that all cities can work towards two headline targets by 2025:

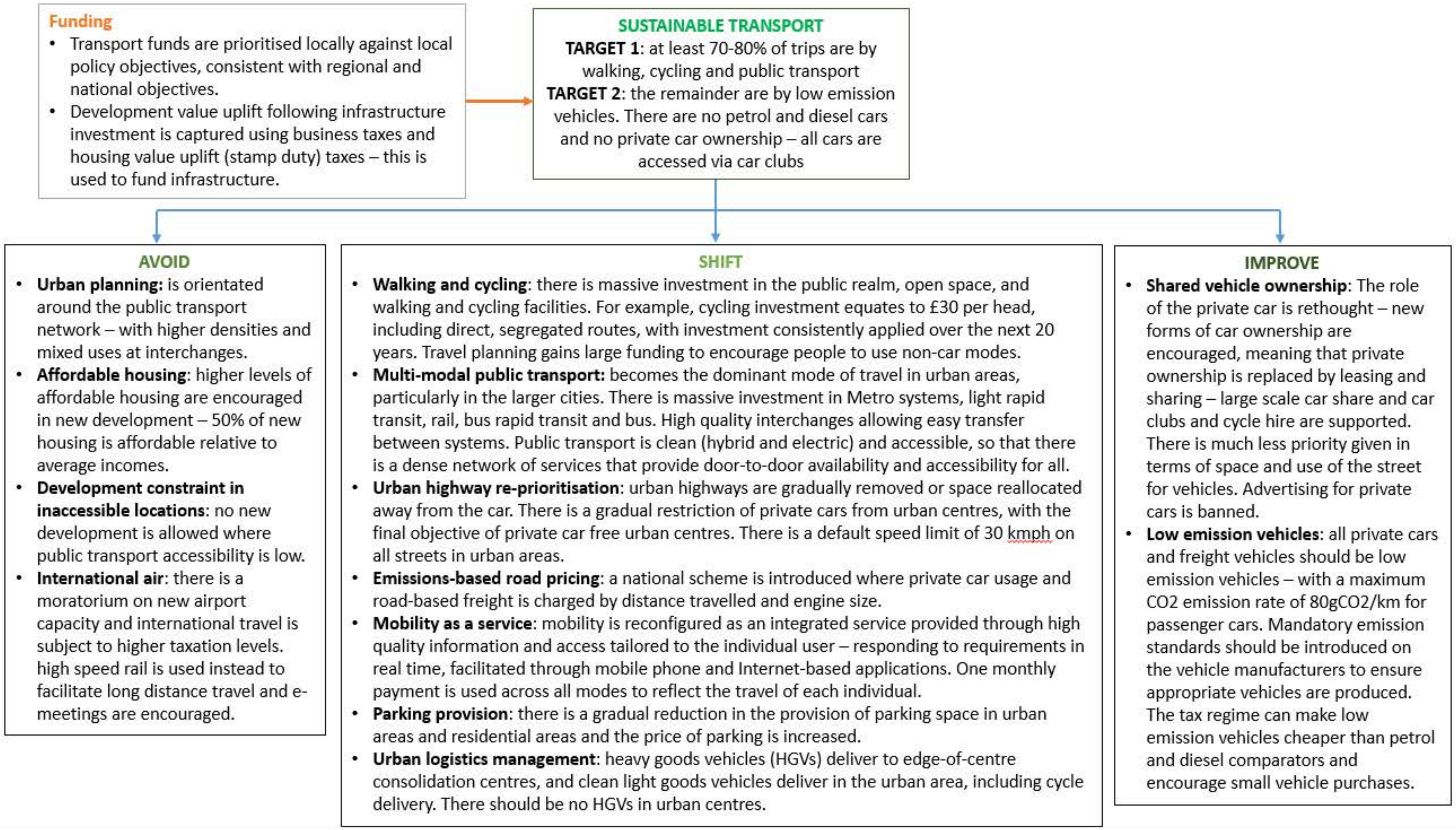
1. At least 70-80 per cent of trips are by public transport, walking and cycling.
2. The remainder of trips are by low emission vehicles. There are no petrol or diesel vehicles and no private car ownership – all private cars are accessed via car clubs.

To achieve these targets, a wide range of policy measures can be applied using the AVOID-SHIFT-IMPROVE typology [119, 120]. 'Avoid' measures seek to reduce the need for car-based travel and include urban planning; but also wider measures such as affordable housing, so that all income levels can live in attractive urban areas. The affordable housing issue is conventionally seen as being beyond the transport remit – but ignoring it has a large impact on travel behaviours, often leading to longer distances travelled. 'Shift' measures should include massive investment in public transport, with a range of different public transport modes developed in urban areas, including radial and orbital routes. There should be a very high investment in walking and cycling, so that the design of the public realm can be enhanced, and dense, segregated cycle networks developed. 'Improve' measures should seek to change the ownership model of vehicles to shared access and to also ensure all vehicles are zero emission vehicles (Figure 40).

Significant funding will be required in public transport, walking and cycling and the public realm – involving mode shift from the car and the beautification of cities. Funding should be decided largely against achievement of the target mode shares. If there is too high a share of private car usage, then more funding should be given to public transport, walking and cycling.

Sharing knowledge, learning from best practice projects and the emerging innovations, including use of benchmarking studies, will become a much more important part of transport planning.

Figure 40: Developing strategies to significantly improve the sustainability of travel



7.6 Changing transport planning practice

A revolution in transport planning will also require changes in transport planning practice. Even the terminology in transport planning is often unhelpful. Much of this was developed, from the 1920s onwards, as the private car became more popular and developed into a means of mass movement. In Germany, 'Verkehr' (with a contemporary meaning of transport or traffic) and mobilität (mobility) are well used. Verkehr was originally used to refer to the interaction of people in exchange or social relationship, but has since become synonymous with traffic [45]. As the systems of transport have changed, and automobility become dominant, then even the language surrounding travel became auto-centric. A more pluralistic view of travel is required – with a new language developed covering all modes of travel and users, and in particular the use of public transport, walking and cycling.

Linked is the use of metaphors to describe traffic and transport networks, such as blood circulating around the body or as the vascular system distributing water and nutrients through a plant [12, 45]. The highway has been viewed as an 'artery' for the city – with continuous flow therefore required. Where highways are subject to high levels of traffic they are viewed as 'congested', and 'bottlenecks' are seen as negative features, which should be removed. The unimpeded flow of traffic is conventionally seen as a product of successful transport planning. Even though a bottleneck performs a critical role for a bottle, this seems to be overlooked – without it, the liquid would spill all around. We should be asking ourselves, as transport planners, whether the bottleneck is actually performing a useful function – and whether it should be retained.

Investment in transport, usually in highways (but also large public transport projects), has been connected with concepts of growth and prosperity, core features of the capitalist society. Hence, transport planning has been framed in a way that means investment in the car could be justified most easily – and the popular discourse of highway investment was developed. The discipline of highway engineering and modelling followed – all with the objective of increasing the flow of traffic.

All of this might seem superfluous to a discussion on a change in the practice of transport planning – and in moving beyond the automobile system. But it illustrates the embeddedness of the debate in particular traditions. It leads us on to thinking how transport planning may change, with a much enhanced role of the social sciences, alongside the more conventional natural science perspectives. The practice of forecasting, the four stage model, cost-benefit analysis and project appraisal, all rooted in a transport planning discipline established to help develop an extensive highway network, all need some serious rethinking. Planning beyond the automobile is a major task – and it involves a fundamental rethink for many areas of transport planning research and practice.

The right to access every building in the city by private motor car was the right to destroy the city – and we can now see that planning for the car was a colossal mistake. We need to rebuild the city – with a compact urban form, and a huge investment in public transport, walking and cycling can take centre stage.

BOGOTÁ: We can start by closing parts of the city to traffic on a Sunday or at particular times of the week or year – such as in the Ciclovía in Bogotá. These events can demonstrate what can be done – and the benefits of much less traffic in the city. From here, much greater progress can be envisioned, debated and implemented.

ANNEX

Photograph and image credits

All photographs by Robin Hickman unless stated.

Photograph 6: The Arctic, Greenpeace
Photograph 7: Frankfurt, GIZ
Photograph 8: Frankfurt, Paul Fremer
Photograph 9: Frankfurt, GIZ
Photograph 10: Frankfurt, Paul Fremer

All diagrams by Duncan Smith unless stated.

Figure 22: Street traffic and social interaction (Donald Appleyard, 1981)
Figure 23: The private car and inefficient use of space (Cycling Promotion Fund, Canberra, Australia)
Figure 30: Energy consumption and greenhouse gas emissions per passenger kilometre travelled (Mikhail Chester, Arizona State University)
Figure 39: Backcasting and transport planning (Robin Hickman and David Banister, 2014)

Advertising images
Poster advertising Ford - The General Utility Car, c.1912 (colour litho), Cuningham, Oswald Hamilton (1883-1935) / Victoria & Albert Museum, London, UK / Bridgeman Images, The General Utility Car, Advertisement for the Oldsmobile Olds Sixty, 1939 (litho), American School, (20th century) / Private Collection / Peter Newark American Pictures / Bridgeman Images, You Ought to Own an Olds, Bridgeman Art Gallery
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Table A1: Statements and Associated Scores for the Four Constructed Discourses in Frankfurt

No.	Statement	Factor by Discourse			
		A Cycling Advocate	B Public Transport Advocate	C Multimodal Driving Enthusiast	D The Car Addict
1	I enjoy the freedom and independence of driving	-1	-1	4	2
2	Driving is an enjoyable hobby for me	-3	-4	4	-1
3	Car ownership is a universal goal and a natural step in life's progression	-3	-2	0	2
4	Driving is tiring and stressful – time spent driving is often the worst part of my day	0	-1	-3	-2
5	I enjoy driving nice or expensive cars	-4	-4	-1	4
6	I like driving fast and get a kick out of driving	-3	-4	3	2
7	We still need to invest more in the highway network – there is too much congestion and we need more space for cars	-4	-2	-3	0
8	I feel safer in a car – it is the safest way to get around	-2	-3	0	-1
9	Being in a car stuck in traffic is better than riding a bus stuck in traffic	-2	-3	0	4
10	If you are successful in life you tend to drive a nice car	-2	-3	-1	4
11	Residential car parking spaces are much too difficult to find – more spaces are required	-3	-1	1	0
12	I like the carrying capacity and utility of the car (for luggage and other passengers)	0	0	3	3
13	I need a car for my day-to-day life	-4	-3	0	-1
14	It is not necessary to own a car in city like Frankfurt – there are many other options to travel around	4	1	2	1
15	It is hard to be truly independent and flexible without a car	-2	-2	2	3
16	I would use a low emission car or electric car if they became much cheaper	1	0	2	-3

17	Car clubs are an ideal model of car ownership – they mean I do not need to buy my own car	2	-1	-1	0
18	I only travel by car for recreational trips and holidays – never to go to work	1	-2	0	-1
19	We should spend more money to improve the U-Bahn, S-Bahn and tram networks	2	4	1	-1
20	Public transport is the only feasible way to get around in the city	0	-1	-3	-2
21	I use public transport as it is much cheaper than a car in the long run	1	1	-2	1
22	The U-Bahn, S-Bahn and tram are much too crowded to enjoy travelling on them at the peak times	-2	-2	-1	-2
23	The current public transport network is not good enough to make car ownership unnecessary	-1	0	2	-3
24	An important part of travelling on the U-Bahn and S-Bahn is the capacity to read, write and use my phone throughout the journey	2	0	4	1
25	More affordable public transport is a necessity – fares are currently too high	-1	4	3	-1
26	Frankfurt Hauptbahnhof needs to be redeveloped to allow better connections to other public transport services and a better gateway into the city	2	3	4	-1
27	Much more investment is required in extending the tram system – extending the U-Bahn is too expensive	-1	1	1	1
28	Investing in high speed rail between urban areas is more important than improving highways	2	2	2	2
29	It is important to improve tangential public transport links around the city, such as the Regionaltangente West	2	2	1	0
30	The Frankfurt–Mannheim high-speed rail proposal is an important investment and should be implemented	0	0	1	-1
31	It is really only the poorest people in society that use the bus regularly	-3	-4	-1	-4
32	I enjoy travelling on the bus	-1	0	-2	-1

33	I would cycle more if there were much better cycling facilities	-1	1	0	-2
34	It is critical to fill in the gaps in the current cycle network	3	3	2	1
35	I love cycling – it is the best way to travel around	4	-1	3	1
36	I would love to ride the newest, fastest bicycles	0	-2	-3	-4
37	Being a cyclist says a lot about someone's character	0	-3	0	0
38	I enjoy cycling regularly as it gives me exercise	3	-2	1	0
39	Cycling on the road is too dangerous and there are no adequate facilities for cycling	-1	2	0	-4
40	I don't cycle because the weather is too wet and cold for too much of the year	-3	0	-4	-2
41	Cycling to work isn't feasible due to distance or the need to arrive at work in professional attire	-2	-1	-3	-2
42	A society where the majority of people cycle to work is ideal	4	1	-1	1
43	I enjoy using cycle hire, such as Call a Bike, and we should have more of these facilities provided	3	0	-1	3
44	We need much better cycle parking facilities across the city – with more cycle parking spaces at key locations	3	3	0	3
45	The proposed long distance cycle routes, such as from Frankfurt-Darmstadt, are important to developing a regional cycle network and encouraging more people to cycle	2	3	1	1
46	You should be able to walk anywhere you need to go	0	0	-2	1
47	Walking is my favourite means of travel	-1	3	0	2
48	I only tend to walk as it is free – I much prefer other modes of travel	-1	-3	-1	-2
49	I would much prefer if I could walk, cycle and use public transport all of the time – and never travel by car	2	0	-2	-1
50	I prefer to work at home and do it whenever I can	-1	-1	-2	-3
51	It is important to locate new development in the Frankfurt region in the large and medium-	0	0	2	-3

	sized centres, and not in rural areas				
52	I would prefer to live in a smaller country town or rural village community	-2	-2	-2	-4
53	I would prefer to live in a large urban area or city	1	1	1	4
54	It is difficult to use public transport – many of the stations are not accessible for those with disabilities or mobility difficulties	-1	3	3	0
55	I would use the bus – but it is difficult to find out where bus services run from and to	-2	-2	-3	0
56	I would not feel confident cycling in heavy or fast-moving traffic	0	2	0	-1
57	Cyclists are the most vulnerable of all road users	1	2	3	-1
58	My preferred mode of transport is influenced by daily weather conditions	1	1	-4	2
59	Roads and streets are a public good and should be used more democratically – there should be much more space for pedestrians and cyclists	3	2	2	0
60	We should provide cheaper parking spaces in Frankfurt city centre	-4	0	-1	3
61	Taxis are important and should be given greater priority on our roads	-2	-1	-3	-2
62	Cars are given too much priority on roads	4	2	-1	0
63	I believe there should be more space for car clubs – with more rental vehicles parked on residential streets	1	1	0	2
64	We need many more segregated cycle paths in Frankfurt	1	2	1	1
65	We need higher densities in town and city centres, with mixed employment and residential uses – so that people can work and live locally	0	1	1	-3
66	It is important to expand Frankfurt Main airport as an international hub and to help generate employment in the city	1	-1	-2	2
67	Integrated timetabling is critical to encourage more people to use public transport	1	2	2	1
68	Through ticketing is important to creating a more 'seamless' travel	3	4	-1	2

	experience				
69	We need more pedestrianisation in the city centre – it is important to reduce traffic in the retail areas	1	4	1	3
70	One way streets should be opened to cyclists travelling in both directions	2	1	-2	-1
71	We should introduce a road pricing scheme for Frankfurt and the region – where cars are charged by distance travelled	0	-1	-4	-2
72	New forms of taxation, on businesses or residential property sales, are required to fund more investment in transport schemes	0	1	-4	-3

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