Chapter 6
Sustainable Mobility

Fotini Kehagia

Abstract The EU's long-term outlook for transport in the EU and its associated emissions demonstrates that the 2050 decarbonization goals for the transport sector require not only incremental changes but a systematic change (EEA Transitions towards a more sustainable mobility system. EEA technical report, Copenhagen, 2016). The intensive problems that many urban areas are facing caused by the operation of the transport system such as traffic congestion, air pollution, degradation of the environment, etc. require a paradigm shift in the planning process. Banister (Transp. Policy 15:73–80, 2008) said that "transport planning has a crisis of identity and its future is uncertain, particularly as the increasing complexity of cities and societies make simple approaches to analysis, which views transport congestion as the problem and transport as the solution". Transport should have a basic role in achieving sustainable development. Towards this direction sustainable urban transport planning is a challenge.

Keywords Transportation • Sustainability • Economic growth • Urban mobility • Strategies

Transport and Sustainable Development: An Introduction

The concept of sustainable development is in danger of becoming everything
(Holden 2007)

Worldwide, cities evolve and change and increasingly face problems caused by transport and traffic. In Europe, a large majority of citizens live in an urban environment, with over 60% living in urban areas of over 10, 000 inhabitants. Urban mobility accounts for 40% of all CO2 emissions of road transport and up to 70% of other pollutants from transport [15]. Congestion in the EU is often located in and around urban areas and costs nearly EUR 100 billion, or 1% of the EU's GDP, annually [7]. The main challenges are the improvement of the performance of urban

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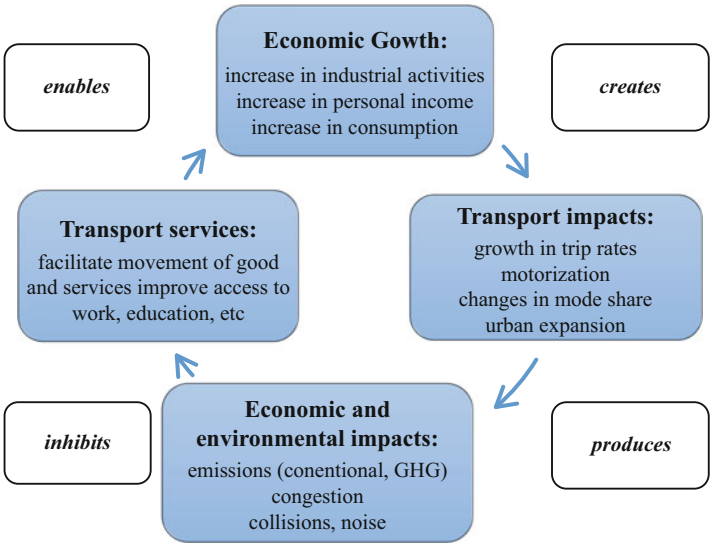

Fig. 6.1 The challenges of making mobility sustainable [39]

transport systems and the reduction of the negative impacts of transport activities on the climate, the environment and citizens' health, providing a more sustainable urban mobility.

Transport is fundamental to our economy and society. Moreover, it is an important factor in the context of sustainable development due to the pressure it places on the environment and its economic and social impacts. The basic principles of the definition of transport are given in Fig. 6.1, namely, whereas transport leads to economic growth, economic growth creates basic problems to the achievement of sustainable transport.

It has been three decades since the term "sustainable development" and "sustainability" appeared following the 1987 publication of the United Nations World Commission on Environment and Development (WCED) report, "Our Common Future", commonly referred to as the Brundtland Report. According to this definition, four different objectives have to be accomplished: safeguarding long-term ecological sustainability, satisfying basic human needs and promoting inter- and intragenerational equity [23, 37]. There has been extensive literature on the addressing of the meaning of the term which emerged from different disciplines such as economics, environmental studies, and sociology. The concept of sustainability has been interpreted in many different ways, often incompatible, but its principal element consists of an approach to development that looks to balance different, and often competing, needs against an awareness of the environmental, social and economic limitations we face as a society. Sustainable development has become the dominant paradigm of development in both developed and developing countries. The large number of definitions and interpretations which were made by scientists,

politicians and businessmen had as objective to use it as a potential solution for the myriad of global, regional and local problems of societies in the late twentieth century.

The concept of sustainability has been interpreted in many different ways, often incompatible, but its principal element consists of an approach to development that looks to balance different, and often competing, needs against an awareness of the environmental, social and economic limitations we face as a society. Sustainable development has become the dominant paradigm of development in both developed and developing countries. The large number of definitions and interpretations which were made by scientists, politicians and businessmen had as objective to use it as a potential solution for the myriad of global, regional and local problems of societies in the late twentieth century. Despite the vagueness of the interpretation of the term, sustainable development as an ideal is as persistent a political concept as are democracy, justice and liberty [27]. Holden et al. [25] address the appropriate indicators of each of the four objectives – dimensions of sustainability. Moreover, they assign threshold values that should be met in order for development to be deemed sustainable. The indicators and the suggested thresholds for the future of the four dimensions of sustainable development are presented in Table 6.1.

Since transport is a key driver in sustainable development, a new approach to transport policy-making in order to address the challenges of the future is needed. More specifically, an integrated approach to tackle the environmental impacts of transport consistent with the socio-economic development policies is needed [33]. Thus, a sustainable transport system must have the ability to support the constantly improved modern lifestyle with optimal management of resources for construction

Table 6.1 Dimensions, indicators and suggested 2030 threshold values for sustainable development [25]

Dimension	Indicator	2030 Threshold
Safeguarding long-term ecological sustainability	Yearly per capita ecological footprint[a]	Maximum 2.3 gha/capita
Satisfying basic human needs	Yearly per capita GDP PPP[b]	Minimum USD3350 (2000) per capita yearly
Promoting intragenerational equity	Gini coefficient[c]	Maximum 0.40
Promoting intergenerational equity	The amount of renewable to total energy in primary energy production[d]	Minimum 27%

[a]The Ecological Footprint tracks humanity's demands on the biosphere by comparing its consumption against the Earth's regenerative capacity

[b]Gross Domestic Product Purchasing Power Parity (GDP PPP) is about basic human needs. A high level of this indicates that countries have sufficient means to provide its inhabitants with the necessary services to meet their basic needs

[c]The Gini index measures the distribution of either household income or consumption spending in a country

[d]The fraction of renewable energy to total primary energy is used as an indicator for promoting intergenerational equity

and operation of transport systems (criterion of economic viability), the improvement of life quality (energy conservation, air pollution reduction and ensuring health) without restricting access (criterion of environmental sustainability) and finally ensuring an affordable, time-reliable, secure and flexible movement for all members of society (social sustainability criterion).

Sustainable Transport

There can be no sustainable development without sustainable transportation
(Gudmundsson [22])

Sustainable transport is an essential component not only because transportation is a prerequisite to development in general but because the operation of transportation systems has significant impacts on sustainability contributing substantially to a wide range of environmental problems (Table 6.2).

Although there is a growing global interest in the concept of sustainable transport, there is not a universally accepted definition for the terms to guide politicians in solving transport challenges. Sustainable transportation systems are the systems that derived from the concept of sustainable development, and they include its basic principles [3]. defines it as "transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs", while Pearce et al. [32] argue "transport and mobility with non-declining capital, where capital includes human capital, monetary capital and natural capital".

The initiative of the studies for sustainable transportation is derived from the Organisation for Economic Co-operation and Development (OECD) which in 1996 set in action the Environmentally Sustainable Transport (EST) project [29]. Since then, strategies, best practices and future visions of sustainable transport have been included in OECD's agenda. In 2002, in the framework of EST, the Environment Ministers of OECD member countries endorsed the guidelines for governments in order to develop and implement strategies towards sustainability in transport. In specific these guidelines provide a solution to making transport policy more sustainable, enabling economic development and enhancing quality of life without causing undue health and environmental impacts and depletion of finite resources [31].

Table 6.2 Transportation impacts on sustainability [28]

Economic	Social	Environmental
Traffic congestion	Inequity of impacts	Air and water pollution
Mobility barriers	Mobility disadvantaged	Habitat loss
Accident damages	Human health impacts	Hydrologic impacts
Facility costs	Community interaction	DNRR
Consumer costs	Community liveability	
Depletion of non-renewable resources	Aesthetics	

In 1996 in the publication of the World Bank entitled Sustainable Transport: Priorities for Policy Reform, the need for new challenges associated with transport policies to be faced in developing countries is presented [36]. It is acknowledged that transport is crucial to development, and World Bank operations have contributed to the creation of essential transport infrastructure in developing countries to improve access to jobs, education and health facilities and to facilitate domestic and international trade. New challenges facing transport sector have to be addressed:

- Changing standards for evaluating transport performance by travellers' needs
- Globalization of production and trade changes transport patterns
- Rapid motorization

In order the above mentioned challenges to be faced, it recommends the need to reform transport policies incorporating the idea of sustainability and to adopt policies that are more sustainable economically and financially, as well as environmentally and socially. Economic and financial sustainability requires that resources be efficiently used in the sector and that assets be properly maintained. Environmental and ecological sustainability requires that the external effects of transport are fully taken into account when public or private decisions are made that determine future development. Social sustainability requires that the benefits of transport improvements reach all sections of the community.

In the United States, many transportation agencies have shown an increasing interest in sustainable transportation. In 2001, the US Department of Transportation's Federal Highway Administration (FHWA) sponsored a study group that travelled to the four countries in Europe (Sweden, Germany, the Netherlands, the UK) to examine the way in which sustainable transportation issues are addressed [19]. Black [4] in Transportation Research Board Symposium on Sustainable Transportation in Baltimore conducts a systematic review of existing definitions on sustainable transportation. He argues that current transport system is no sustainable due to many parameters as diminishing petroleum reserves, global atmospheric impacts, local air quality impacts, fatalities and injuries, congestion, noise, low mobility, biological impacts and lack of equity. In 2011, FWA published a report titled *Transportation Planning for Sustainability Guidebook* to provide practices around the world and to examine how sustainability considerations could be better incorporated into transportation planning [20].

In Canada, Transports Canada (2007) thinks that a sustainable transportation system should be "safe, efficient and environmentally friendly" and in order to turn this system into reality, it requires integration of "economic, social and environmental considerations" into transportation policy-making [42].

The European Community has taken important steps towards the direction of a common transport policy in European countries. The Treaty of Rome in 1957 was the first step towards the generation of a Common European Transport Policy. The opening of transport market was the basic concept of the 1st White Paper of the Committee published in 1992. In 2001 the new White Paper "European Transport Policy for 2010: time to decide" was published [6]. One of the most important issues of White Paper is transport growth's gradual decoupling from

economic development. Research programmes concerning alternative transport modes, transport multimodality, renewable energy sources, new technologies for improved energy consumption and safety are developed towards the direction of sustainable and anthropocentric transport systems.

European Conference of Ministers of Transport (ECMT), an intergovernmental organization, contributes to the creation of a European transport system based on the principles of sustainable development. It proposes a number of measures to be applied in all member countries [18]. An accurate definition of a sustainable transportation system is one that:

1. Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health and promotes equity within and between successive generations
2. Is affordable, operates fairly and efficiently, offers a choice of transport modes and supports a competitive economy, as well as balanced regional development
3. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation and uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and the generation of noise

Holden et al. [25] have adapted the four main dimensions of sustainable development to the passenger transport sector, and they have identified suitable indicators and threshold values (Table 6.3). The total energy consumption per capita for passenger transport (all modes) is an indicator of ecological sustainability because all types of energy (renewable and non-renewable) cause a threat to long-term sustainability. In accordance with the Brundtland Report's low-energy scenario, the maximum threshold level was set at 5.6 kWh per capita per day. All people should have access to affordable and appropriate means of transport in order for basic transport needs to be satisfied (for work, health or education). Holden et al. [25] set 9.2 km daily as the minimum level, assuming that people having access to motorized travel above this level would be able to meet their basic transport

Table 6.3 Dimensions, indicators and suggested 2030 threshold values for sustainable passenger transport [25]

Dimension	Indicator	2030 Threshold
Impacts of transport activities must not threaten long-term ecological sustainability	Daily per capita energy consumption for passenger transport	Maximum 5.6 KWh per capita per day
Satisfying basic transport needs	Daily per capita travel distance by motorized transport	Minimum 9.2 km per capita per day
Promoting intragenerational transport equity	Public transport accessibility level (PTAL)	Minimum PTAL 3
Promoting intergenerational transport equity	The amount of renewable to total energy used for transport	Minimum 15%

needs. Intragenerational transport equity means that access to transport does not vary systematically across population groups. The challenge for such accessibility standards are needed to assess the performance of a transport network in terms of its success or failure to provide minimal levels of accessibility to all population groups. PTAL is a detailed and accurate measure of the accessibility of a point in the public transport network, taking into account walk access time and service availability. The PTAL is categorized from 1 to 6, where 6 represents an excellent level of accessibility and 1 a very poor level. Intergenerational transport equity requires that future generations be able to meet their transport needs. The amount of renewable to total energy used for transport is an indicator that future generations' transport needs can be met using alternative types of modes without the need for fossil fuel energy.

These threshold values for sustainable passenger transport define a four-dimensional space which Holden et al. call the "sustainable transport space" (STS). The performance of some countries addressing the challenge to satisfy two of the above thresholds is presented in Fig. 6.2. Sustainable transport is defined as the area in the lower right quadrant where the maximum and minimum requirements are met – i.e. per capita energy consumption is below 5.6 kWh/day and per capita travel distances is above 9.2 km/day. As it can be seen, the countries of Romania and Slovakia are included in the STS area, while the performance of Armenia and Albania (in the lower left quadrant) is out of STS, showing that the latter should focus on strategies towards increasing motorized travel per capita. However, this should be done taking into consideration appropriate policies referring to the

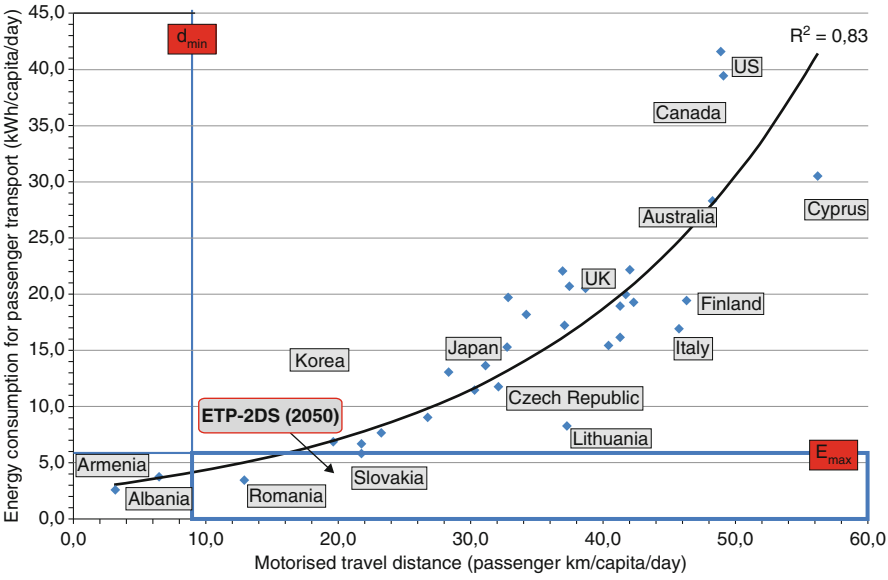

Fig. 6.2 The sustainable transport space (Data from [25])

sustainable land-use planning and to the promotion of public transport systems to ensure that the increased motorized travel remains at the lowest possible level of energy consumption. In developed countries, achieving sustainable transport creates different challenges. For example, Lithuania and the UK have comparable travel distances per capita but different energy consumption per capita, and consequently different strategies have to be implemented towards sustainability.

Sustainable Urban Mobility

Transport as Derived Demand or as Valued Activity?

(Banister 2008)

Urban Mobility and New Perspectives in Transport Planning

Urban areas constitute the living environment of the vast majority of the population. The quality of life in these areas should be as high as possible to support the growth and employment. Urban mobility is of growing concern to citizens. According to "Action Plan on Urban Mobility" [8], nine out of ten EU citizens believe that the traffic conditions in their area should be improved. The choices that people make in the way they travel will affect economic well-being of citizens, future urban development and urban environment.

Socio-economic factors are related with the transport mode used, as the increase in GDP leads to growth in car ownership (Fig. 6.3). However, in some wealthy cities like Hamburg and Helsinki, decoupling of these two parameters appears to have occurred.

Urban residents' mobility choices are strongly linked with density. In denser areas there is a higher prosperity to opt for alternative modes other than private cars (Fig. 6.4). The shorter trip distances associated with high-density areas naturally lend themselves to more walking and cycling. Higher-density areas also involve high concentration of activities, thereby allowing public transport to efficiently connect the locations where the origins or destination trips are concentrated.

Worldwide, car travel has increased over the past 20 years. Between 1995 and 2012, the rate of car ownership per 1000 inhabitants rose in all countries in Europe.

A recent survey of residents of 75 EU cities explored which mode of transport people use most often on a typical day [11, 38]. This survey does not cover the commuting zone and so it does not include people working in the city, but living outside the city. The results of this survey by mode of transport shows that the mean share of car use is below 30%, with Lefkosia having more than 70% and Paris less than 10%. In almost all the cities surveyed, at least 20% of the residents rely on public transport, while for 21 cities it was the main mode for more than half of the residents. The only city, where walking is the main mode of transport for the

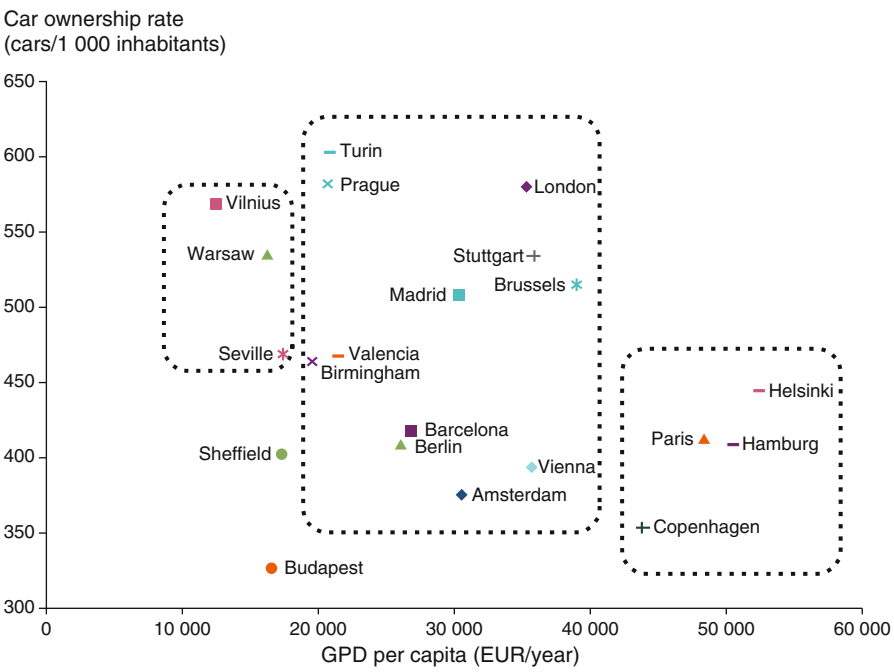

Fig. 6.3 GDP in relation to car ownership growth (EEA TERM 2013)

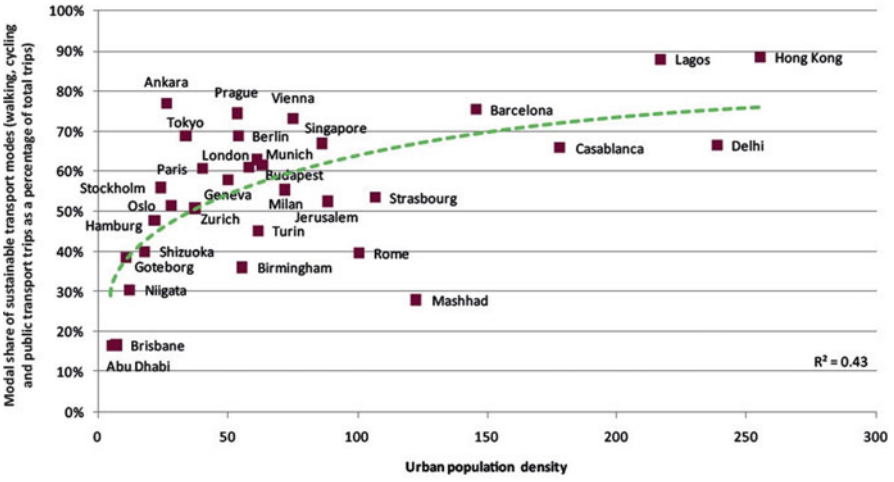

Fig. 6.4 Share of total daily trips undertaken by sustainable transport modes – walking, cycling and public transport – out of the total number of daily trips compared by urban population density in metropolitan area [38]

majority of residents, is Paris. Nevertheless, in two out of three cities, at least 25% of the population walk in most places. The survey showed that in half of the cities surveyed, cycling did not reach more than a10% modal share, in fourteen it reached a share of more than 25% and in three (Amsterdam, Copenhagen and Groningen) the share was even over 50%.

The developing and implementing policies of sustainable urban mobility is a great challenge. It provides a balanced service of conflicting and potential additional environmental, social and economic needs of the functioning of the city. Rethinking urban mobility involves optimizing the use of all the various modes of transport and organizing "co-modality" between the different modes of collective transport5 (train, tram, metro, bus, taxi) and the different modes of individual transport (car, motorcycle, cycle, walking). It also involves achieving common objectives in terms of economic prosperity and managing transport demand to guarantee mobility, quality of life and environmental protection [7].

In recent years, there was a shift from the conventional approach of the transport planning system, where key priorities were to increase mobility and minimize the travel time (physical dimensions in terms of mobility) to the new sustainable mobility approach which considers social dimensions in terms of accessibility and people. Priorities in this new approach are the increased access to various activities, the multimodal development of transport with upgraded hierarchy of the mobility of pedestrians and bicyclist and the ensuring of reasonable travel times leading to a reliable transport system which is now valued not only with economic but also with environmental and social criteria. The accessibility is secured not only by the appropriate development of transportation system but also of the land-use planning, where compactness and functional diversity contribute significantly towards its achievement. Banister [2] argues that the key policy objective becomes the reasonable travel time than travel time minimization. In these terms, the conventional planning strives to minimize travel time and thus to speed up traffic, whereas sustainable mobility attempts to realize reasonable and reliable travel times which may require slowing down movement. Transport policy measures can reduce levels of car use through the promotion of walking and cycling and the development of the new transport hierarchy by reallocating space to public transport, through parking controls and road pricing making thus easier to use public transport. The main differences between the conventional and new alternative approach in transport planning are presented in Table 6.4.

Sustainable Urban Transport Policies and Strategies

WBCSB in "The Sustainable Mobility Project" (2001) defies sustainable mobility as "the ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future" [39, 41].

Table 6.4 Contrasting approaches to transport planning [2]

The conventional approach – transport planning and engineering	An alternative approach – sustainable mobility
Physical dimensions	Social dimensions
Mobility	Accessibility
Traffic focus, particularly on the car	People focus, either in (or on) a vehicle or on foot
Large in scale	Local in scale
Street as a road	Street as a space
Motorized transport	All modes of transport often in a hierarchy with pedestrian and cyclist at the top and car users at the bottom
Forecasting traffic	Visioning on cities
Modelling approaches	Scenario development and modelling
Economic evaluation	Multicriteria analysis to take account of environmental and social concerns
Travel as a derived demand	Travel as a valued activity as well as a derived demand
Demand based	Management based
Speeding up traffic	Slowing movement down
Travel time minimization	Reasonable travel times and travel time reliability
Segregation of people and traffic	Integration of people and traffic

Urban transport systems are integral elements of the European transport system and, as such, constitute an integral part of the Common Transport Policy under Articles 70–80 EC Treaty. In addition, other EU policies (cohesion policy, environment policy, health policy, etc.) cannot achieve their objectives without taking into account urban specificities, including urban mobility. EU-funded initiatives, often supported by the Framework Programmes for research and technological development, have helped to develop innovative approaches which stimulate authorities at local, regional and national level to adopt the long-term integrated policies. The role of public authorities in providing the planning, the funding and the regulatory framework is essential. The main benchmark European policies in sustainable urban policies are:

1992 The Green Paper where the Commission of the European Union (EC) launched the concept sustainable mobility as the challenge to initiate a public debate on the issue of transport and the environment [17].

Sustainable mobility is a mobility in accordance with the principles and requirements of sustainable development. This introduces the two concepts: mobility and sustainable development. In order to understand the concept of sustainable mobility, it is necessary to understand both of these basic concepts. With the objective of contributing to a critical discourse, the overall perspective has again to be critical. Both concepts are complex and subject to large differences in understanding. Such differences can originate in perspectives and traditions given by various scientific disciplines. However, they can also have a more fundamental basis through

variances in value systems and preferences. The complexity only increases when the two are combined into one: sustainable mobility.

1992 The document on the future development of the Common Transport Policy: A Global Approach to construction of a community framework for sustainable mobility published by EC highlighted that achieving sustainable transport is a matter of reducing traffic intensity than transport volumes [12].

2007 The Green Paper "Towards a new culture for urban mobility" adopted by EC in order to set a new European agenda for urban mobility while respecting the responsibilities of local, regional and national authorities in this field [7].

It refers that urban mobility should make possible the economic development of towns and cities and in the meanwhile should secure the quality of life of their inhabitants and the protection of their environment. The main challenges that European towns and cities have to meet as part of an integrated approach for urban mobility are:

- Free-flowing towns and cities
- Greener towns and cities
- Smarter urban transport
- Accessible urban transport
- Safe and secure urban transport

However, in order the challenge facing urban areas in the context of sustainable development to be met, the need of creating a new "urban mobility culture" is imperative. A joint effort, setting up partnerships, will make it possible to encourage the search for innovative and ambitious urban transport solutions, new planning methods. Education, training and awareness rising have an important role to play towards this direction.

2009 The Action Plan in urban mobility is published by EC, providing a coherent framework for EU initiatives in the area of urban mobility. It proposes short- and medium-term practical actions to be launched progressively addressing specific issues related to urban mobility in an integrated way [8].

2011 In the White Paper 2011, entitled "Roadmap to a Single European Transport Area – Towards a competitive and resource-efficient transport system", the EC defines a long-term vision until 2050 for the transport sector [9]. It provided a solid ground for upcoming policy debates and actions and a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. Specifically, for the urban context, different strategy policies are suggested involving land-use planning, pricing schemes, efficient public transport services and infrastructure for nonmotorized modes and charging/refuelling of clean vehicles in order to address the sustainable mobility. The White Paper sets out specific urban targets:

- Conventionally fuelled cars will be phased out in cities by 2050, and their use will be halved by 2030.
- A target of CO2-free city logistics in major urban centres by 2030.
- Reducing road accident fatalities by 2030 by half and to zero by 2050.

Moreover, it is suggested that cities above a certain size should be encouraged to develop Urban Mobility Plans that should be fully aligned with Integrated Urban Development Plans aiming to address current and future transport needs sustainably.

2013 The Urban Mobility Package is published together with towards competitive and resource-efficient urban mobility [10]. With the Urban Mobility Package, the Commission reinforces its supporting measures in the area of urban transport by:

Sharing experiences, showcasing best practices and fostering cooperation

- Providing targeted financial support
- Focusing research and innovation on delivering solutions for urban mobility challenges
- Involving the member states and enhance international cooperation

The sustainable transport planning approach, contrary to the priorities of the conventional approach which are the encouragement of the use of private vehicles and the construction of additional road infrastructure, focuses on the promotion of the alternative means of transport, i.e. walking, bicycle and public transport, and sets as a primary objective the provision of mobility and information services as well as the better management of the existing networks [40].

Holden [23, 24] argues that there are three main approaches for developed countries to enter to sustainable passenger transport, efficiency, alternation and reduction, terms that can be characterized, respectively, as “travel more efficiently”, “travel differently” and “travel less”. Additionally, he presents fourteen theses regarding the roles of technology, public transport, green attitudes and land-use planning in achieving sustainable mobility.

Options to improve urban transport have been analysed in terms of three key approaches by Dalkan and Brannigan [5]:

- **Avoid** – the need to travel to access goods and services through efficient urban planning, communication technology, consolidation activities and demand management.
- **Shift** – where appropriate, people and goods moved towards more sustainable modes such as walking, cycling and public transport rail.
- **Improve** – the environmental performance of vehicles with the adoption of low-emission vehicle technologies and more efficient operation of vehicles.

The implemented strategies that aim at improving the performance of urban transport and reduce their environmental impacts have to be in a context of integrated approach taken into consideration the characteristics of each individual city [14, 15]. suggests strategies based on the three key approaches of Dalkan and Brannigen (Table 6.5).

Table 6.5 Strategies towards urban sustainability

Avoiding the need to travel	Supporting modal shift	Improving modal efficiency
Land use and planning	Increasing the share of walking and cycling	New mobility services
Information and communications (ICT)	Developing the use of public transport	Traffic management and integration
Access management	Alternatives to road freight	Driver behaviour
Consolidating supply and demand		Regulation and pricing

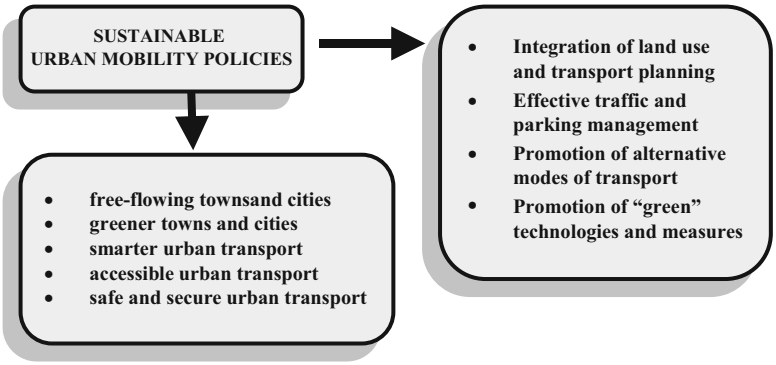

Fig. 6.5 Sustainable urban mobility strategies [34]

Four principles for the new approach of sustainable urban transport and development were presented by Banister [2]:

- Reducing the need to travel – substitution
- Transport policy measures – modal shift
- Land-use policy measures – distance reduction
- Technological innovation – efficiency increase

Sustainable transport can be achieved with a strong combination of the above principles, based on regulation, land-use development including planning and regulations, use of technology and information.

Policies in achieving sustainable urban travel have to be examined in a context of integrated approach taking into consideration land-use planning, effective traffic and parking management, reliable transport system, infrastructure for alternative modes of transport (cycling, walking) and promotion of "green" technologies [34] (Fig. 6.5).

However, many barriers to the implementation of an integrated approach of sustainable mobility are common and make the progress to be very slow. Banister [1] describes some of them:

- Application of general planning and car parking standards and prices which are
- inappropriate and unachievable in a town centre/high street context
- Reluctance of people to use public transport and cycle/walk, even for local trips
- Strong desire of urban residents to use their cars
- Fragmentation of the organization, integration and management of public transport
- Uncertainty over the funding of public transport and nonmotorized modes
- Separation of planning and transport functions within local authorities

The most important and widespread barriers are however the lack of political will and funding. Measures to overcome barriers are the raising awareness about the effectiveness of integrated approaches and creating individual culture to support the measures through active involvement and action [14].

Monitoring Sustainable Mobility in Cities

It was Agenda 21, the action plan adopted in 1992 at the United Nations Conference on Environment and Development in Rio, that first calls on countries as well international organizations to develop indicators as a tool to monitor sustainable development. In specific the implementation of indicators can provide a solid basis in order the complex and challenging idea of sustainable development can be determined and measured. Indicators are defined as statistics or quantitative measures designed to identify significant trends, point out problems, track the progress over time towards a specific vision-objective, contribute to the priority-setting and inform both the experts and the public about a complex phenomenon in simple way [13, 30].

Urban sustainability is a multidimensional concept that includes environmental, economic and political dimensions, and its assessment is a major challenge for political, transport and environmental authorities. The use of urban sustainability indicators constitutes internationally an important tool to assess sustainability and monitor the progress. The Institute for Environment and Sustainability of the EC Joint Research Centre after an extensive literature review developed a comprehensive indicator system in order to assess the sustainability of the transport activities. The WBCSD in the paper Mobility 2030: Meeting the challenges to sustainability proposes a framework of 11 different sets of indicators, measuring progress towards a set of seven “goals” to “improve the outlook” of sustainable mobility adopting policies in this direction.

Gillis et al. [21] examined sustainable mobility indicators across literature by the principles of neutrality and transferability. They gave a set of 22 indicators that cover different aspects of sustainable mobility that are applicable in different social

and economic contexts. All these indicators are positioned in a four-dimensional space a = (g,q,e,m) (g-global environment, q-quality of life, e-economic success, m-mobility system).

Karagiannakidis et al. [26] present the results of literature review of main sustainable urban mobility indicators. The plurality of indicators found in the literature and the considerable number of sustainable mobility indicator initiatives are the result of many parameters including the high interest in sustainability issues, the great complexity of the transport system and the specific features of each urban area. However, specific criteria have to be met in order for an indicator to be selected. Tafidis et al. [35] examined different criteria of indicators based on extended literature review. The main character is that an indicator should provide useful information concerning the performance in terms of social, economic and environmental sustainability (relevance to sustainability), while it has to be capable of illustrating even the slight changes. Indicators should be relevant to the policies, objectives and goals that are expected to measure and to illustrate the impact of transport-related policies. The structure of an indicator should be simple and transparent in order to be easily understandable either to experts, policymakers and other stakeholders or to the public. Moreover, an indicator should enable comparisons both between different urban areas and time periods. The latter but extremely significant criterion for selecting an indicator consists of the affordability, i.e. the necessary cost and time in order to collect the original required data and subsequently estimate the indicator's value. Affordability is considered to be dependent on the data availability, the data frequency and the data reliability (accuracy), and it comprises in most cases the weakest point during the selection process, as a result of the limited abilities in gathering data of many local authorities.

Pitsiava-Latinopoulou [34] proposes a comprehensive set of indicators that covers different aspects of sustainable mobility taking into account the four strategies, outlined previously (Fig. 6.5), for urban mobility. The main objectives identified were to integrate the transport policies and the land-use planning, reduce the use of private vehicle trips by promoting the use of public transport and of "green modes" walking cycling as well as the use of new technologies, improve the environmental quality and promote the urban economy (Table 6.6).

Good Practices

In European cities, potential solutions for sustainable mobility need to be drawn into a consistent and coherent mobility plan, integrated with other city plans and policies [14]. The 2013 Urban Mobility Package sets out a concept for Sustainable Urban Mobility Plans (SUMPs) that has emerged from a broad exchange between stakeholders and planning experts across the EU. New approaches to urban mobility planning are emerging as local authorities seek to develop strategies that can

Table 6.6 Sustainable urban mobility indicators [34]

Integration of land-use and transport planning	Effective traffic and parking management	Promotion of alternative modes of transport	Promotion of green technologies and measures
GDP per capita	Traffic volume	PT network coverage	Share of population exposed to values of Lden above 60 dB(A) or Lnight above 55 dB(A)
Population density	Modal split	PT modal share	Annual CO2 emissions per capita
Land-use mix	Occupancy rate of passenger vehicles	PT reliability, comfort, safety and security	Annual emissions of air pollutants (CO, NOx, SO2, VOC) per capita
Ratio of total number of jobs to the total population living in the city	Number of trips	Number of park and ride lots	Average age of vehicle fleet
Network connectivity	Total vehicle-km travelled	Share of household income devoted to PT	Share of vehicle fleet by engine technology and type of fuel
Share of population living within 500 m from PT stops	Average speed of passenger vehicles	Modal share of nonmotorized modes (walking, bicycle)	Share of heavy vehicles powered with CNG
Share of population living within 500 m from basic services	Average PT speed	Total length of PT, pedestrian and bicycle networks	Average concentrations of air pollutants and exceedances of air quality standards
	Number of road accidents	Pedestrian and bicycle volumes	
	Travel cost and average fuel consumption per vehicle	Total length of roads with traffic calming measures	
	Traffic noise levels	Walkability index	
	Emissions of air pollutants	Number of bicycle parking spaces	
		Number of road accidents involving vulnerable users	

stimulate a shift towards cleaner and more sustainable transport modes. The process for developing a SUMP was clearly set out in the guidelines developed by the Eltis Plus project. SUMP consists of four key stages covering analysis of the existing situation, setting improvement goals, developing a clear set of actions and implementing strategy. In developing these stages, they need to consider all aspects of mobility, both passenger and freight, and the wider economic development of the city [16]. Many of Europe's towns and cities are leading the way in addressing these issues. In each of the main policy areas, examples of highly successful approaches can be identified. Nevertheless, these good practices should not be taken for implementation as they are by every town or city, but they should be adopted to its individual specific characteristics and its individual needs (Table 6.7).

Conclusions

The need for transformations in mobility systems demands the "avoid, shift and improve framework" that is based on three directions: to rethink the need of mobility avoiding unnecessary trips, to shift to a more environmental-friendly transport mode and to improve the efficiency of transport modes. Implementing new technology, improving public transportation, increasing individuals' green attitudes, promoting sustainable land-use planning and implementing information and communication technology are all important elements towards the achievement of sustainable mobility. A comprehensive indicator system based on a number of different criteria such as policy relevance, continuity, compatibility, sensitivity as well as data availability, frequency and reliability is a robust instrument in order to assess the sustainability of the transport activities and the effectiveness of the implemented policies. However, as Holden [23] argues, changes towards sustainable mobility must start with the transformation of the attitudes and values of a large majority of people. Individual attitude in travel choices has to be changed as sustainable mobility is not just a goal but a change in direction of our lives.

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Table 6.7 Good practices in European cities

	With the elegantly designed, modern, highly functional and environmentally friendly tram system, Strasbourg has made a name for itself as a pioneer in urban transport. The city was one of the first in France to opt for a return to a transport system which had been abandoned in the second half of the nineteenth century and, in so doing, heightened its international reputation. 55.5 km of commercial tracks, 6 routes, 69 stations, 300,000 passengers daily
	Since 1962 Copenhagen's largest shopping area has been centered around Strøget in the heart of the city. Strøget is far and away the most famous street in Copenhagen. The walking street is 1111 meters long, making it Europe's longest pedestrian street. The street is a wonderful place to go shopping or simply to go for a pleasant stroll, taking in the sights and sounds of this vibrant city.
	Vienna has a well-developed public transport network with reliable, clean and convenient service. Buses, trains, trams and underground lines will take you almost anywhere in the city in no time at all.
	Vauban is a neighbourhood to the south of the town centre in Freiburg, Germany. The transport is primarily by foot or bicycle. Vauban limits car use through parking-free residential streets, spatially and fiscally separated parking and filtered permeability to prevent through traffic. Attractive alternatives include: Frequent rail-based transit system and extensive, high quality non-motorized transport infrastructure.

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