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METHODOLOGY AND STATISTICAL ANALYSIS OF SUSTAINABLE TRANSPORTATION CRITERIA FOR CERTIFICATION SYSTEMS

vorgelegt von

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Executive Summary

Achieving sustainability has become one of the fundamental goals of many urban transportation systems in the past two decades. The emerging concept of sustainability has developed enormous interests among researchers and practitioners to develop a sustainable transport system. While many have focused on developing an appropriate definition of a sustainable transport by measures and indicators of sustainability to assess if a transport system is moving towards or away from sustainability, many others have put forward different strategies to make a transport system sustainable. Defining sustainable transport and identifying indicators are important to make this concept more correct, focused, and measurable.

This study tries to measure and monitories urban transportation sustainability from viewpoint of an urban planner. The question comes out from the relation between urban transportation sustainability and usage of public transportation. How these two facts link to each other? Are there any logical relations between usage of public transportation and sustainable development? How we can define specific indicator for measuring sustainability of transportation or on the other words, how can we standardized indicator to measure and monitor the urban sustainable transportation?

For response, exceeding questions two cities are selected which have a similarity and differences in structure and data sets. Our approach is to draw upon a raft of suitable analytical techniques to find out the approach base for comparison of structure between different cities, and then to apply the examples to examine the degree to which specified policy targets might be met in the future. The analytical framework includes Descriptive statistics, correlation and Regression analysis, and application of sustainable transportation indicator for case studies distributions.

The techniques proposed to provide a starting point for that dialogue toward more appropriate policies and their monitoring. It can be concluded that the new approach of sustainable transportation indicator for measuring sustainability of transportation is highly correlated with selected variables, which indicates that the new indicator has meaningful applicability to be used as indicator for transportation certificate system. This methods can be used for measuring, monitoring, and evaluating the sustainability of urban transportation for different areas and used the results as a standardize indicator for transportation certificate system for comparing and ranking the transportation sustainability of different cities. In addition, the result of this study can be used as for monitoring and assessment of plan for (SUMP) Sustainable urban mobility planning.

Zusammenfassung

Die Erfüllung von Nachhaltigkeitsanforderungen hat sich in den letzten zwei Jahrzehnten zu einem grundlegenden Ziel für die Gestaltung vieler städtischer Verkehrssysteme entwickelt. Mit seiner Bedeutungsentwicklung hat das Konzept der Nachhaltigkeit das Interesse von Forschern und Praktikern der Stadt- und Verkehrsplanung angestachelt, eben auch nachhaltige Verkehrssysteme zu entwickeln. Während sich viele dieser Akteure auf die Entwicklung einer geeigneten Definition für nachhaltigen Verkehr anhand von Maßnahmen und Indikatoren zur Nachhaltigkeitsbeurteilung - etwa im Sinne der Frage „ob sich ein Transportsystem in Richtung Nachhaltigkeit entwickelt oder davon wegbewegt" - konzentriert haben, hat eine Reihe anderer Fachleute an unterschiedlichen Strategien gearbeitet, die Transportsysteme künftig nachhaltiger zu machen. Die Definition nachhaltigen Verkehrs und die Ableitung entsprechender Indikatoren sind von Bedeutung, um dieses Konzept noch valider, noch zielgerichteter und noch besser messbar zu machen.Außerdem: Städte und Stadtteile als die Bezugsbasis nachhaltiger Entwicklung entwickeln eine starke Bedeutung im Hinblick auf die Förderung nachhaltiger Stadtentwicklung. Die nachhaltige Entwicklung in den Teilbereichen ist die Voraussetzung für die Realisierung nachhaltiger Entwicklungen auf höheren räumlichen Ebenen. Diese Diskussion wird mehr als kritisch, wenn wir uns mit den Bemühungen befassen, Nachhaltigkeit zunehmend "teilräumlich" zu messen. Jenseits des Versuches, „urbane Nachhaltigkeit" zu analysieren oder zu beurteilen, stellt sich die Frage, wie weit es Sinn macht, sich mit der „Nachhaltigkeit des Verkehrs" oder noch enger mit der „Nachhaltigkeit des Stadtverkehrs" oder ganz eng mit der „Nachhaltigkeit des öffentlichen Stadtverkehrs" zu befassen.

Natürlich könnte diese Herausforderung durch den Vorschlag einer grundlegenden Struktur von Leistungsindikatoren und analytischen Methoden gelöst werden. Der Gegenstand der Betrachtung wäre dann, die Fachliteratur im Hinblick auf nachhaltigen städtischen Transportangebote auszuwerten, die Ergebnisse gemäß ihres Platz auf einer geographischen Skala zu klassifizieren, einen allgemeinen Rahmen vorzuschlagen, der die Definitionen und Ziele für Nachhaltigkeit mit geeigneten Kennzahlen und Analyseverfahren zu verbinden und deren Anwendbarkeit anhand einer Fallstudie zu demonstrieren. Der hier gewählte Ansatz bezieht sich im Gegensatz dazu auf eine Reihe geeigneter Analyseverfahren, um eine Grundlage für den Vergleich der Strukturen verschiedener Städten abzuleiten, und um anschließend anhand von praktischen Beispielen überprüfen zu können, zu welchem Grad bestimmte politische Ziele in der Zukunft erfüllt werden. Dieser Analyserahmen umfasst Analysen der deskriptiven Statistik und grafische Methoden, raumbezogene Statistiken, Korrelations- und Regressionsanalysen, eine Auswahl geeigneter Prognosemodelle auf Basis von Zeitreihen-Census Daten mit robusten Parametern und die Anwendung von nachhaltigen Verkehrsindikatoren anhand von zwei Beispielen für unterschiedliche Fallstudien.

Ein solcher Ansatz ist bewusst umfassend gewählt und er wird anhand der Strategien für einen nachhaltigen Stadtverkehr in Abstimmung mit der räumlichen Struktur der Städte behandelt. Dennoch ist dieser Ansatz für die Entwickler von Strategien und für Politiker räumlich ausreichend detailliert, da die Analyse für die strategischen Einheiten von örtlichen Regierungen vorgenommen worden ist. Darüber hinaus wird die Notwendigkeit deutlich, Nachhaltigkeit auf lokaler und auf nationaler Ebene gemeinsam anzugehen. Die vorgeschlagen Techniken können dem Start eines Dialogs dienen, mehr geeignete Strategien und deren Monitoring zu erreichen. Das oben beschriebene Verfahren kann zur Messung, Überwachung und Bewertung der Nachhaltigkeit von Stadtverkehr für unterschiedliche Einsatzbereiche eingesetzt werden. Die Ergebnisse können als Indikatoren für ein standardisiertes Zertifikatssystem oder für den Vergleich und das Ranking der Nachhaltigkeit der Verkehrsangebote verschiedener Städte genutzt werden. Darüber hinaus können die Ergebnisse dieser Arbeit zu Überwachungs- und Bewertungsaufgaben im Rahmen der „Sustainable Urban Master Plans (SUMP)" der Europäischen Union herangezogen werden.

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1. Introduction

Achieving sustainability has become one of the fundamental goals of many urban transportation systems in the past two decades. The emerging concept of sustainability has developed enormous interests among researchers and practitioners to develop a sustainable transport system. While many have focused on developing an appropriate definition of a sustainable transport by measures and indicators of sustainability to assess if a transport system is moving towards or away from sustainability, many others have put forward different strategies to make a transport system sustainable. Defining sustainable transport and identifying indicators are important to make this concept more correct, focused, and measurable.

However, identifying and developing strategies towards sustainability is the key to move forward since those are real steps in shaping a sustainable transport system. Developing an indicator system for measuring transport sustainability has been broadly discussed. The typical examples are The Transport and Environment Reporting Mechanism (TERM) published annually by the European Environment Agency (EEA) since 2000 (EEA, 2000). and also Sustainability urban mobility plan (SUMP) published by The European Commission initiated a three-year project running from May 2010 to April 2013 to accelerate the large scale uptake of Sustainable Urban Mobility Plans in Europe with the help of guidance, awareness-raising activities. Similar to the EU's contribution, the Centre for Sustainable Transportation (CST) initiated the Sustainable Transportation Performance Indicators (STPI) project in 2000 to monitor the state of transport sustainability in Canada (Gilbert and Tanguay, 2000). Most literature has reported indicators for nationwide transport sustainability, and there has been a lack of literature reporting indicators designed to monitor the development of sustainable transport at the local level.

In addition, cities and city districts (as the base of sustainable development) have such a stronger role in the advancement of sustainable urban development that sustainable development in districts is the precondition for the realization of sustainable development at higher levels. In general, there are two main approaches which are opposite, but complement each other in some ways, top-down and bottom-up, Top-down views determining the general objectives and main aspects of sustainable development at national and international levels, and also details and small objectives of regional and urban levels. On the other hand, bottom-up views, determining the functional strategies and execute projects at regional and local levels; supporting and monitoring at national and international levels. Doubtless, several intermediate levels will eventually be required, although the number is far from clear at this time. It is abundantly clear that both top-down and bottom-up strategies must be integrated effectively or neither will work well.

This discussion is more than pedantic when we enter into “sector-specific” efforts to measure sustainability. Difficult questions can be raised as to whether there is any real value in attempting to analyse a sector’s “sustainability.” Beyond attempting to analyse or assess “urban sustainability,” can we further attempt to look at transport sustainability, or more narrowly urban transport sustainability, or more narrowly still, public urban transport sustainability?

Of course, the challenge could be solved by proposing a framework of performance indicators and analytical methods. The objectives are to review the literature on urban sustainable transportation, to classify it by geographical scale, to propose a general framework that links definitions and objectives for sustainability with appropriate performance indicators and analytical techniques, and to demonstrate their applicability with a case study. Our approach is to draw upon a raft of suitable analytical techniques to find out the modelling base for comparison of structure between different cities, and then to apply the scenarios to examine the degree to which specified policy targets might be met in the future. The analytical framework includes, Descriptive statistics exploratory and graphical methods, Spatial statistics, Regression analysis, Selection of suitable predictive models based on time-series Census data with robust parameters and Application of sustainable transportation indicator two scenarios for case studies distributions.

Such an approach is deliberately aggregate is dealt with strategies for sustainable urban transportation (compared with the zonal level of structure of cities). Nevertheless, the analysis is suitably rich in spatial detail for strategists and policymakers because the analysis is undertaken for the strategies units of the local government. Furthermore, the need is emerging to address sustainability collaboratively at the local level and at the national level. The techniques proposed to provide a starting point for that dialogue toward more appropriate policies and their monitoring. This methods can be used for measuring, monitoring, and evaluating the sustainability of urban transportation for different areas and used the results as a standardize indicator for transportation certificate system for comparing and ranking the transportation sustainability of different cities. In addition, the result of this study can be used as for monitoring and assessment of plan for Sustainable urban mobility planning.

The dissertation is structured as follows. Section 1 has focused on introductions, issues, objectives, research questions, methodological approach, and the structure of the dissertation. The section 2 reviews several models of sustainability, different interpretation of sustainable development and indicators for sustainable development. Section 3 has focused on the brief history and introduction of certification systems, then the certification process, certification types, their criteria and rating system are all reviewed and results of analysis and comparison of these systems along with the advantages and disadvantages of them which will be helpful for assessment of the main subjects of “sustainable transportation criteria” are discussed. Section 4 reviews the transportation planning and different aspects of sustainable transportation. Section 5 focuses on role of indicators and on defining and characterizing sustainable transport, and presents the major indicator selection for measuring urban sustainable transportation criteria. Section 6 reviews the methods of analytical approach. Section 7 focuses on the analysis of sustainable transportation criteria of case studies and comparison of sustainable transportation indicator, section 8 concludes the research and analysis, and finally, section 9 is focused on the overall result and questions that are still open for future research.

1.1 Research approach

Governments set the policy framework for individual travel behaviour through targeted transportation and other non-transportation policies. Daily transportation decisions are made by individuals within the policy and incentive frameworks. This dissertation tries to measure and monitories urban transportation sustainability from viewpoint of an urban planner. The question comes out from the relation between urban transportation sustainability and usage of public transportation. How these two facts link to each other? Are there any logical relations between usage of public transportation and sustainable development? How we can define specific indicator for measuring sustainability of transportation or on the other words, how can we standardized indicator to measure and monitor the urban sustainable transportation?

For response, exceeding questions two cities are selected which have a similarity and differences in structure and data sets. It is worth to mention that factors other than transportation policies may also help to explain the monitoring and measuring sustainability of transportation. These include spatial development patterns, social, economic, and environmental factors. Differences and similarities in these variables and Usage of public transportation are explained by a statistical analysis.

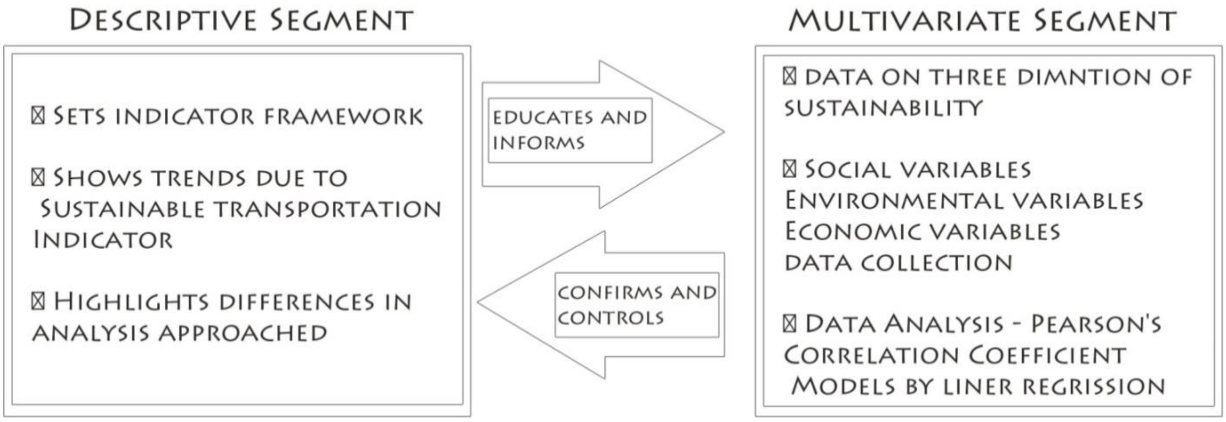


Figure 1 : Research Approach
Source: own evaluation

The analysis consists of two major parts (see figure 1). First, trends time series in sets of indicator behaviour in both cities are introduced. Then, similarities and differences in three dimension of sustainability affecting public transportation - (cycling, and walking both are important as much as public transportation usage but because of lack of datasets in our case studies we just analysed our cities by using the data of usage of public transportation such as : buses and metros) - are compared and analysed. Second, a correlation and regression analysis based on 12 uniquely comparable variable from 2002 to 2010 highlights differences and similarities in individual trend behaviour in both cities. The 12 datasets are enriched with variables relating to define specific indicator for measuring sustainability of transportation.

The two parts of the analysis complement one another. Differences towards of sustainability of similar individuals in both cities in the years between 2002 and 2010 are explaining within their specific spatial development and sustainable transportation indicator contexts. The interpretation of current sustainability situation is only possible in the context of historical trends.

Prior studies in this field have mainly relied on aggregate level comparisons of cities and nations. The disaggregate studies that do exist were obstruct by incomparability of data and data collection methods, or missing policy and spatial development variables. This dissertation is unique because it provides both a comparison of the two macro level sustainable urban transportation with trends time series, and adds a statistical and multivariate analysis of sustainable transportation behaviour based on 12 enriched micro-level variables, which also include variables relating to sustainable transportation and certificate systems. This combination of descriptive and correlation and regression analysis results in a rich examination of sustainable transportation indicator and its determinants suitable quantity criteria for certificate systems.

1.2 Academic and Practical Interest

The academic interest of the dissertation lies in developing strategies of sustainable urban transportation by determination of suitable quality and quantity indicators, which have an effect and play a key role for measuring sustainability in the sector of public transportation.

A considerable point after extensive review of the literature shows that national governments are concerned with sustainability issues at the national or global scale ~for example, global climate change! Elsewhere, we have considered all geographical scales, merely noting here the dominance in the literature of indicators at the global and transnational scales. In a search for indicators at the urban scale and the local government areas that make up metropolitan regions! We have not found previous work. Therefore, the lack of data and information intellectually motivate me to focus my research in this case.

Key issues related to sustainable transport indicators and assessment methodologies offer a basic theoretical backdrop to the idea of sustainable transport. In other words, how it could it be measured and where such a measurement effort fits into "performance based" transportation planning. This dissertation identifies some of the key issues related to putting these ideas "into practice," including: development of meaningful indicators, techniques for assessing possible interventions, differences and similarities of techniques for examining various sustainability "dimensions," establishing appropriate baselines for developing counterfactuals, and implications for technical capabilities and decision-making.

Nowadays, urban governments show considerable interest in formulating policies for a more sustainable transportation sector, but on the other hand, the urban policy makers, planners, and practitioners always cited lack of an action plan and strategies for choosing a right action for reaching sustainable development. Indicators are frequently defined as quantitative measures that can be used "to illustrate and communicate complex phenomena simply, including trends and progress over time" (EEA, 2005). During the last two decades, measurement of sustainability issues by indicators has been widely used by the scientific community and policy-makers. Development of sustainable development indicators was first brought up as a political agenda issue at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. The UNCED policy declaration Agenda 21 requested countries at the national level and international governmental and non-governmental organizations at the international level to develop indicators in the context of improving information for decision-making (United Nations, 1992, Chapter 40). Since then, indicators are thought to be important tools for measurement of different aspects of sustainable development, including transport related issues.

The integration of transport issues into sustainability indicator sets and development of transport specific indicators is currently observed in many international initiatives. A number of international organizations have been involved in the development of indicators aiming to achieve a more sustainable transport on the local, regional, and global levels. The differences observed in the mission and policy priorities of various organizations are accordingly reflected in the selection of indicators. However, the three-dimensional framework of indicators based on economic, environmental, and social impacts is a common way to perform an impact-based analysis of transport activities. The numerous efforts towards defining and measuring sustainable transport – efforts consistent with performance-based transportation planning, which itself reflect a move towards more comprehensive multi-dimensional transportation plan – are pushing policymakers in the right direction. Yet, there are still lacking a satisfying operational definition of sustainable transport, which is a basic fundamental requirement for measuring any concept. This dissertation tries to define a roadmap for monitoring the current transportation plans and present new criteria based on statistical analysis to measure transportation sustainability.

1.3 Methodological approach

The methodological approach we will follow for the case study research is composed of three main steps: 1) Case studies design 2) Case studies selection and 3) Case studies analysis.

Each step of our methodological approach is briefly described here below.

1.3.1 Case studies design

Case studies enable a rich and in depth description of data that, besides providing evidence, can enable the discovery of theory. Research design should offset the intrinsic limits of case studies and respond to the needs of using them to inform extrapolations. Solid evidence from case studies is the cornerstone to go beyond earlier extrapolations (European Commission 2007b; Cullen et al 2008) by embedding them into empirical realities. Therefore, a careful research design is crucial particularly for what concerns the more in depths case level evidence and corresponding case studies.

In this regard, it should be underlined in fact that, first, generalisation from case studies may be of dubious credibility if the cases are not selected according to a reasoned research design and especially when the cases are exemplary (best practices) rather than representative of the average situation in a given field. The purpose of case level evidence is not only that of building a case study, rather they must provide evidence to be used to generate the scenarios and coefficients for eventual quantitative extrapolations. As such, they cannot be only best practices otherwise; the generated case level evidence will bias the extrapolations. (See figure 2.)

Second, case studies should be context embedded in the sense of reflecting the peculiarities of the sectors they operate and of their size. This requires a careful selection of cases to reflect sectorial and size difference and, thus, enable more granular and credible extrapolations.

Third, case studies selection should be transparent (to allow other to replicate it in the future) and used systematically. The reasoned is approach to research design that will be applied to this research, inspired by the sustainable transportation indicators of the social, economic, and environmental research. It will produce a limited set of case level evidence from which input for extrapolation. It will not be possible to be extracted in a systematic way; however, the reapplication of the principle of solid research design to any future real world case will enable a steady collection of case level evidence and build the fundamental basis for further qualitative and quantitative research. Therefore, our approach, while ensuring a high quality output for this specific research, will also achieve the outcome of setting the basis and agenda for future research and studies in this field.

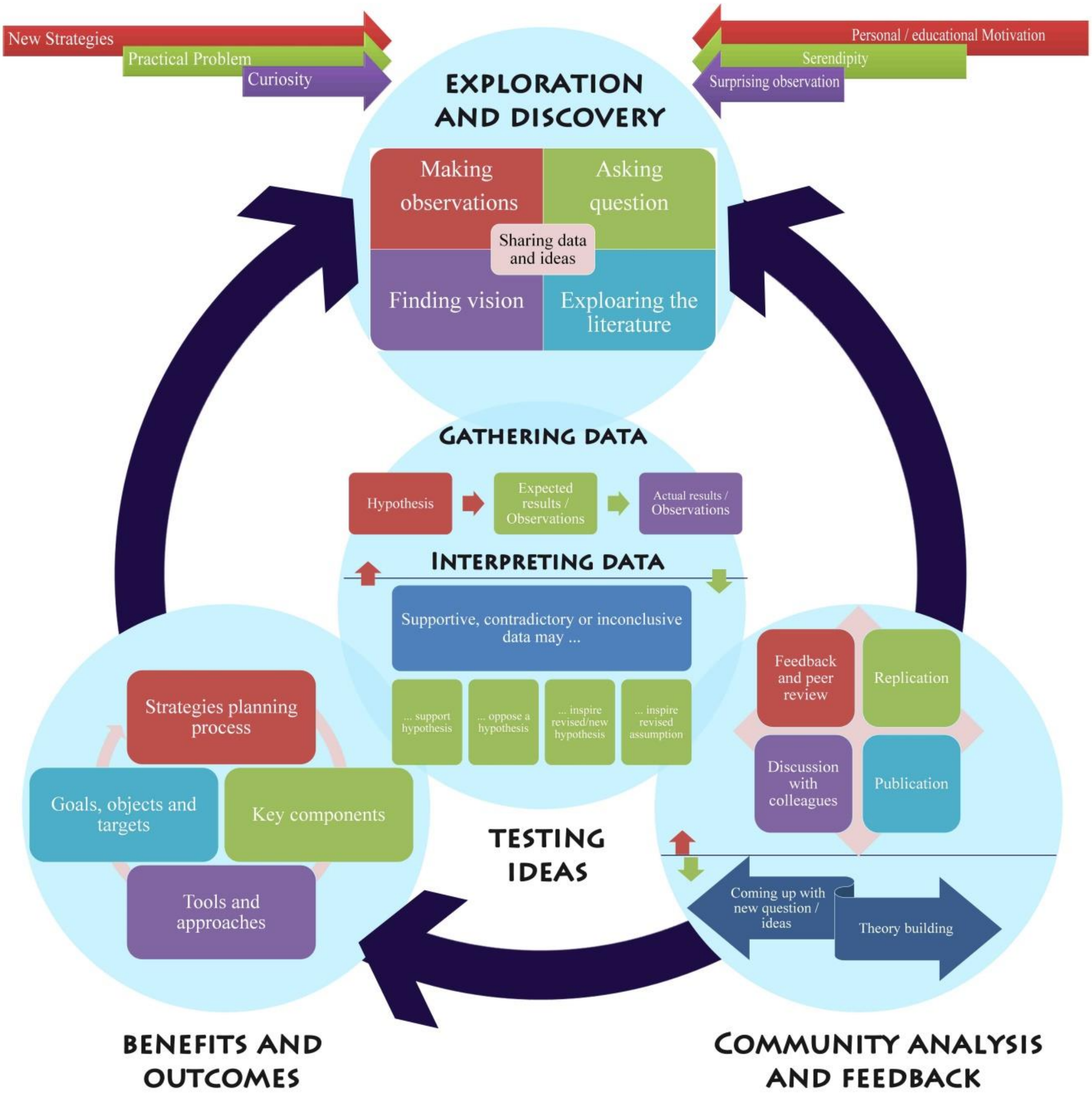


Figure 2 : Methodological approach

Source: own evaluation

1.3.2 Case studies selection

From the typology of case study, approaches developed by Yin (2003) we will adopt the multiple-cases embedded approach, where several cases embedded into different contexts are considered in order to increase the potential for generalisation and to check evidence from case studies among each other. This approach is adopted to investigate a general phenomenon that it is known to take different forms in different contexts. In our case we assume that certificate system's shall influence (according to our hypothesis), the kind of cities benefits can achieve and to some extent the magnitude of costs. So the specific case studies will be chosen as the context where multiple cities effects shall be generated. On the other hand, also size matters and this will be considered in the selection of cases within each sustainable transportation indicator model. In order to maximise the possibility to generalise from case level evidence and to provide relevant input for extrapolation, the selection of cases will respond to two methodological criteria:

1) Representation, within each context (sustainable transportation indicator model) cases will be selected to be representative of different EU and US cities. Moreover, similar and different sustainable transportation indicator models will be chosen as the context for multiple cases;

2) Contrasting situations, In order to maximise the extraction of theory and generalisation cases should be chosen as to represent contrasting polarised situations (Eisenhardt, 1989). Having positive and negative cases with respect to a given phenomenon, it is the equivalent of using a control group in experimental research design. In each given context (sustainable transportation indicator model), we will select two case where significant governance changes seems to be towards of sustainability. For our purpose, this will provide different reference points for the coefficients and scenarios assumptions needed for further extrapolations and will avoid the bias of looking only at exemplary cases.

The final element to consider in case study research design is the number of cases. In this regard, the literature does not establish any specific threshold to produce solid results. Given the nature of the problem and the exploratory nature of this research, and the two principles defined earlier: contrasting situations and representation of sectors (policy area) and context (sustainable transportation indicator), it derives that for this specific research; we would select two cases. For this purpose, in collaboration with city transportation information about a number of potential case studies in the domain under investigation have been collected through an exploratory mapping survey ,fact books, contact with responsible persons based on specific evaluation criteria defined a limited number of cases will be selected for deeper assessment.

1.3.3 Case studies analysis

The analysis of case studies will be produced (in a narrative manner but indicating when possible already available quantitative data in terms of inputs-outputs and outcomes of the specific initiatives). This will allow for identification of data available and required and eventually the design in a future step of a survey to be conducted on a larger scale in order to gather quantitative data on the specific cases). In order to eventually link this to an impact assessment model (based on the system of indicators designed and the measurement framework under development, see chapter 6).

For this purpose, we will follow the principle of methods and data triangulation typical of case studies research. Qualitative and quantitative data within a single case, as well findings of different cases, will be triangulated to confirm findings. We will also extend the principle of triangulation in the sense of checking case level evidence against the aggregate statistics and information gathered and vice versa and eventually linking case level evidence to aggregate extrapolations. For case studies, this means we will gather all kind of available evidence (quantitative metrics from administrative records, quantitative estimates produced by the involved stakeholders, qualitative judgements, etc.). Given the rich description that case studies provide and using the triangulation principle, we will gather evidence and/or attempt to construct estimates on benefits of specific Sustainable transportation enabled data and look at the influences these have on the sustainable transportation indicator and the certificate system process in each specific policy domain.

1.4 Objectives

The scope of this dissertation is to study Methodology and Statistical Analysis of Sustainable Transportation Criteria for certification System to develop a set of indicators for measurement and evaluation of transport sustainability performance, which can be used in Certification systems. First, the scope of measurement of transport sustainability is defined by outlining the major characteristics of a sustainable transport system. After defining the indicator quality criteria, currently existing transportation sustainability indicators initiatives are reviewed. The major ones include the EC Sustainable Development Indicators, the EC ETIS indicator study, the EEA TERM indicators, Eurostat transport indicators, transport indicator sets of OECD, US EPA, World Bank, UNECE and VTPI transport related indicators. Mainly based on these indicator initiatives a set of transport sustainability indicators is developed. Transportation systems provide access, mobility and other benefits, while at the same time putting pressures on the human and natural environment. Making progress towards more sustainable transportation systems and mobility patterns, simultaneously increasing the economic prosperity and quality of life, are policy aims shared by countries. Nevertheless, how do we know if our transportation systems are in fact becoming more or less sustainable, and how do we know if the transportation strategies are helping to achieve the goals they are meant to serve? Such questions have increased the demand for indicators to measure the performance of transportation systems and strategies the major themes of the indicator framework proposed in the current study are presented as well as the logics behind is explained in the context of case studies of Dortmund and Portland. The indicator of 12 sets are consequently analysed according to Statistical Analysis scheme.

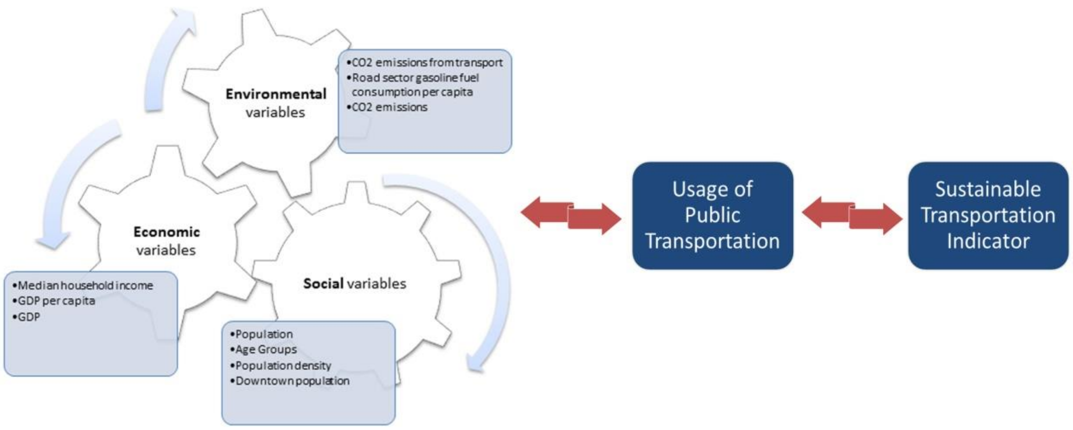
The principle aims of this dissertation are:

1) To reflect the major international indicator initiatives developed in the EU and other international organizations for monitoring and measuring sustainability of transportation.

2) Based on the existing information to propose a set of indicators, which are suitable for the assessment of sustainable transportation criteria used in certificate system performance.

The introduction of a core set helps to keep the indicator set manageable, whereas the larger set allows the inclusion of additional indicators that enable countries to do a more comprehensive and differentiated assessment of sustainable development.

Core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that is either readily available or could be made available within reasonable time and costs. Conversely, indicators that are not part of the core are either relevant only for a smaller set of countries, provide complementary information to core indicators or are not easily available for most countries.

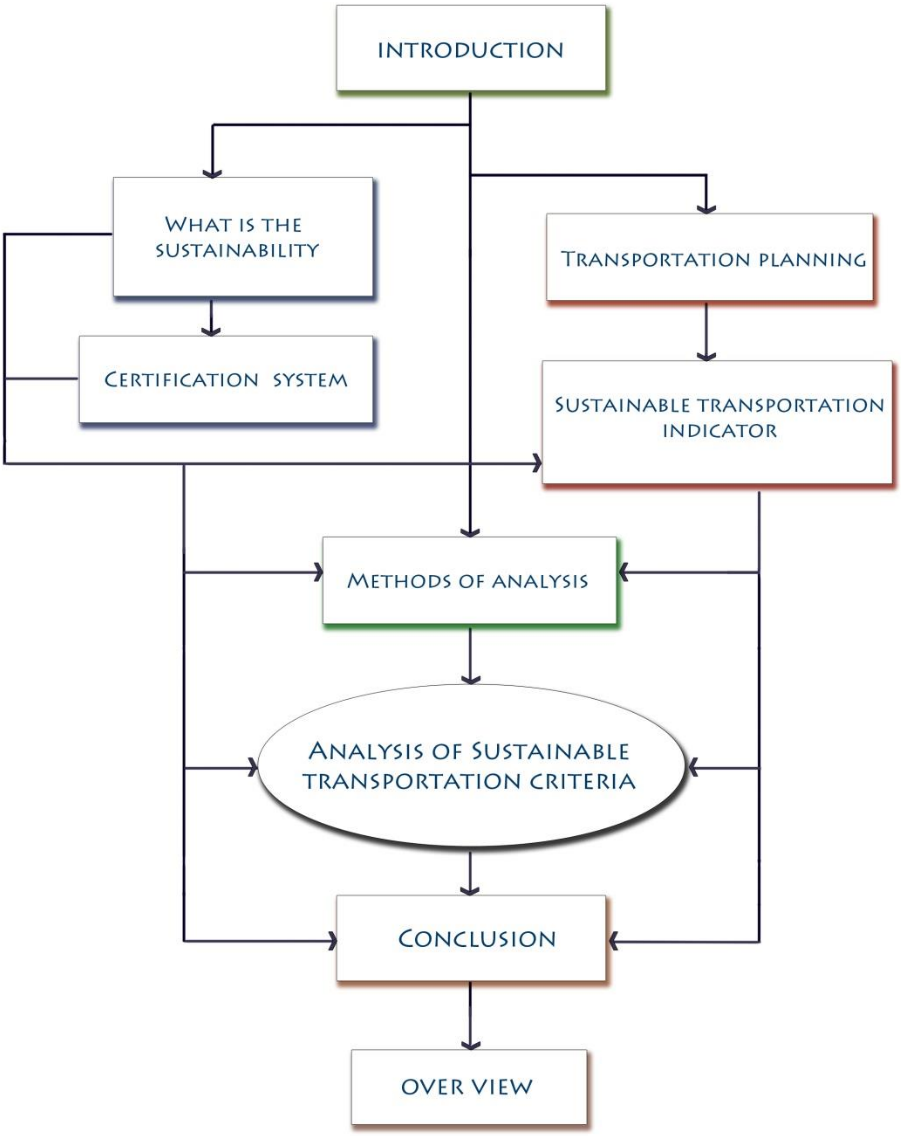


Source: own evaluation

In this research, we try to approve that the usage of public transportation have significance relation with sustainable transportation indicator and can be used as a tool for measuring and monitoring a situation of sustainability in different cities, also this indicator can be used as standardized indicator for using in certification systems.

1.5 Research Structure

The dissertation is structured as follows. Section 1 has focused on introductions, issues, objectives, research questions, methodological approach, and the structure of the dissertation. The section 2 reviews several models of sustainability, different interpretation of sustainable development and indicators for sustainable development. Section 3 has focused on the brief history and introduction of certification systems, then the certification process, certification types, their criteria and rating system are all reviewed and results of analysis and comparison of these systems along with the advantages and disadvantages of them which will be helpful for assessment of the main subjects of "sustainable transportation criteria" are discussed. Section 4 reviews the transportation planning and different aspects of sustainable transportation. Section 5 focuses on role of indicators and on defining and characterizing



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sustainable transport, and presents the major indicator selection for measuring urban sustainable transportation criteria. Section 6 reviews the methods of analytical approach. Section 7 focuses on the analysis of sustainable transportation criteria of case studies and comparison of sustainable transportation indicator, section 8 concludes the research and analysis, and finally, section 9 is focused on the overall result and questions that are still open for future research.

2. What is sustainability?

2.1 Introduction

Sustainable development has been the subject of considerable research over recent decades. In indigenous communities, the notion of sustainability is often rooted in tradition and heritage. Because of growing global concerns over environmental sustainability, the topic of sustainable development has been largely investigated in the context of environment and impacts of development on environment sustainability. Economic development, such as economic growth of communities, including social and political aspects, is also covered in the literature, and a wide range of studies across multiple locations exists. The word sustainable is used frequently and in many different combinations, sustainable development, sustainable growth, sustainable community, sustainable industry, sustainable economy, agriculture etc. However, what does it actually mean? What are the issues of sustainability and sustainable development? How we can interpret sustainability? What are the different models of sustainability? How we can measure the sustainable development?

This chapter aims to cast light on these questions by providing an integration of literature relevant to the area. This is followed by a brief review of definitions and dimensions of sustainable development reviewed then different interpretation of sustainable development, and indicators for sustainable development are studied. Central to the research of achieving sustainable development is the ability to evaluate the sustainable development potential of different policies and projects, as well as to identify the trends that are, or are not, sustainable, trends that pose severe or irreversible threats to our future quality of life. Sustainable development indicators are the most frequently used tools in this context. The chapter draws together the various strands and provides an overview of the main conditions and issues concerned with indigenous sustainable development.

2.2 Dimensions of sustainability

The word sustainable is used frequently and in many different combinations, sustainable development, sustainable growth, sustainable community, sustainable industry, sustainable economy, agriculture etc. However, what does it actually mean?

Sustainable development was used for the first time in the 1980 IUCN report, *World Conservation Strategy: Living resources for sustainable development*. The perhaps most commonly quoted definition within today's extensive Sustainable development literature is the popularization and the definition of the concept made by the World Commission on Environment and Development published in 1987 in the report *Our Common Future* also called the *Brundtland Report:*

> *Sustainable development is development that meets the needs of current generations without compromising the ability of future generations to meet their needs. It contains within it two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs (WCED, 1987:43)*

In 1992 the United Nations Conference on Environment and Development, held in Rio, established Sustainable development as a common goal of human development for the roughly 160 countries that attended the meeting, which then became manifest in the action program Agenda 21. Since 1992 Sustainable, development has become a widely used concept and goal in international, national, regional, and local politics.

The roots of the sustainable development concept can be found in the emerging environmental consciousness of the 1960s and in the identification of the link between economic development and environmental degradation and pollution. This development was closely related to the replacement of the optimism about the creation of a modern technological utopia with a new understanding of the forces contributing to the world's problems.

Like other development approaches, sustainable development is about the improvement of the human condition, yet unlike many of the others, it does not only emphasize economic growth, but it stresses the importance of a balance between economic growth and environmental protection. The general understandings of Sustainable development are compromise two dimensions: the notion of development (to make better) and sustainability (to maintain). Sustainable development is classically explained as the balancing between environmental, economic, and social aspects of development (Goodland and Daly, 1996). These three aspects are frequently defined as the three pillars of Sustainable development.

One important difference from other macro theories of development is the underlying philosophy that what is done now to improve the quality of life of people should not degrade the environment (in its widest bio-physical and socioeconomic sense) and resources such that future generations are put at a disadvantage. The emphasis on the world's poor also implies a link between environmental concerns and economic- and social development over both space and time. If earlier development theories focussed on the economy, the use of Sustainable development has, thus far, in politics, practice and research emphasized its environmental dimension. Today the concept of Sustainable development has broadened its perspective, with more emphasis now being put also on the social dimension (European Commission, 2002).

Another important aspect of sustainable development is that it is seen as a participatory process. Sustainable development has not assumed to be imposed by a small minority of technocrats or policy-makers from above. This idea is embodied in Principle 10 of the Rio Declaration on Environment and Development where it is stated that; Environmental Issues are best handled with the participation of all concerned citizens. Part of the emphasis in creating sustainable development has consequently been to include stakeholders in the determination of what needs to be done and how (Guy and Kibert, 1998).

Sustainable development may thus be seen as incorporating three different aspects:

- Balanced development (trade-offs between social, environmental and economic interests should be taken into consideration).
- Equity and shared responsibility extended over time and space
- Participation

2.3 Different interpretations of sustainable development

The definition of sustainable development or the categorization of different aspects of Sustainable development may seem to be simple and straightforward. Some scientists have even made more or less successful attempts to derive a common understanding of Sustainable development using natural science as a base. However, when asking scientists the question, how much pollution can nature withstand, the answer is not straightforward, but instead rather depends upon which scientific discipline, geographical scale and time perspective is adopted. Although a desire for the improvement of the human condition and a concern for future generations rests at the heart of Sustainable development, the details of what this balancing between economic, environmental and social aspects implies in practice has been open to much debate. The major reason is that there are disagreements between different groups of people as to how to strike a balance between the economy, the environment, and society. The chosen perspective is critical here, and as soon as more than one person is included then, by definition interpretations multiply. What is one person's definition of Sustainable development is another's despoliation, degradation and exploitation, as is the case for natural resource extraction at the global level (Dahl, 1997). To understand sustainable development it is important to understand these differing interpretations. Several attempts have been made to categorize these differences (Dahl, 1997, Allenby et al, 1998). These categorizations include a number of basic questions: What assumptions are made concerning the relationship between humankind and nature – does nature, have a value in itself (intrinsic value) or only in relation to human interest. These basic and often unconscious and tacit assumptions have direct implications for the choice of Sustainable development policy and action (Stenmark, 2002). How much pollution can naturally withstand? What does equity and shared responsibility mean? What should be the time scope and the geographical boundaries of responsibility? What is understood as sound economic growth? What is the role of the economy in Sustainable development? To what extent should the public be involved in decision-making? Finally, and perhaps the most basic question of all: what is seen as the good life?

The interpretation of Sustainable development is in some instances based on, for example, very different basic ethical assumptions, or basic assumptions on the nature of the economic system. Some stress the ability of growth and a free market system to solve the problems, other stress the importance of equality between people, yet other groups stress the importance of equity between all living beings. In the Sustainable development literature, it is common to distinguish between weak and strong sustainability (Bell and Morse, 1999). Weak sustainability is based on the idea that welfare is not generally dependent on a specific form of capital and can be maintained in most cases by substituting manufactured capital for natural. Strong sustainability on the other hand, derives from a different perception where it is not so evident to substitute manufactured capital for natural. The arguments for the position of strong sustainability relate to environmental characteristics such as irreversibility and uncertainty.

There are also differing interpretations as to the societal mechanisms causing unsustainable development, thus what ought to be changed. Two main poles can be identified (Falkheden, 2000). The first looks upon environmental problems as societal problems. In this approach, referred to as ecological modernization, it is assumed that economic growth and environmental management can be made compatible through the integration of ecological considerations into established institutional arrangement and ways of thinking (Hajer, 1995). The other poll assumes that environmental problems are the result of profound cultural problems that can only be changed through changes more radical in our economic systems, and in the conditions of production distribution. It is assumed here that changes in our perceptions of reality and in our perceptions of our relation to nature are needed (Falkheden, 2000). This line of thought questions some of the main elements of the western paradigm of development. (Concept from Hettne 1983 in Falkheden 2000)

One of the most profound lines of thought concerns economic growth and development also how this relates to the Sustainable development (Friman, 2002). In recent years, economists have tackled this issue somewhat differently. The different lines of thought – environmental economics and ecological economics – also illustrate the two poles described above. Environmental economics builds upon mainstream neoclassical theory and generally views GDP-growth (Gross Domestic Product) and Sustainable development as compatible. However, this compatibility depends upon what kind of production and consumption is promoted or allowed. Growth is perceived as a prerequisite for prosperity, but it is also acknowledged that growth has negative environmental impacts. In order for GDP-growth to be sustainable, accurate pricing is needed. There also seems to be an agreement among environmental economists that there is no reason to believe that environmental policies will affect long-term economic growth (Goldin and Winters, 1995 in Friman, 2002). Ecological economics criticize the assumptions above and their protagonists' claim that it is not enough to consider the external effects and otherwise continue as usual. If cost internalization were implemented fully the visibility of environmental problems would increase and the incentives for diminishing them would increase (Friman, 2002). Nevertheless, these strong forces, i.e. powerful producer- and consumer interests, aim at the maximization of profits and at keeping prices low. Thus, the process of economic growth is in itself, creating stakes opposing the internalization of environmental costs (Booth, 1997 in Friman, 2002).

The environmentally based Kuznets Curve has been used by environmental economists to prove the relationship between a decrease in environmental stress and high-income levels. The inverted U curve implies that environmental stress is initially an impact on growth. At a certain income level, however, the curve turns downwards and thus environmental stress gradually decreases. This is interpreted as illustrating the possibility that countries or regions could 'grow' out of their environmental problems. Both environmental and ecological economists have however together be stated that caution should be applied in drawing conclusions from the findings behind the Kuznets Curve (Arrow et al, 1995). "While they do indicate that economic growth may be associated with improvements in some environmental indicators, they imply neither that economic growth is sufficient to induce environmental improvement in general, nor that the environmental effects of growth may be ignored, nor indeed, that the Earth's resource base is capable of supporting indefinite economic growth. In fact, if this base were to be irreversibly degraded, economic activity itself could be at risk." One of Friman's conclusions from his discussion of the different lines of economic thought in relation to Sustainable development is that there is agreement "that [the] environmental effect of growth must not be ignored" independent of the economic line of thought referred to above.

When discussing different interpretations of Sustainable development in relation to varying lines of economic thought, the concept of sustainable growth needs to be mentioned. Recently this concept has entered the Sustainable development discussions. There are however, a number of different views prevalent amongst economists as to whether this concept is an oxymoron or not. Friman (2002) concludes that the interpretation of sustainable growth as a prospect or as an oxymoron will depend upon two things: the conception of the nature of the economic system and whether or not growth and develop are given distinct definitions. If the economic system is viewed as a subsystem and growth is defined as a quantitative change of the physical dimensions of the economic system, while development is defined as a qualitative change, the concept of sustainable growth becomes inherently contradictory. If development and growth are however seen as concepts that cover the same phenomenon (but refer to different contexts Friman 2002, argues that in conventional economic language 'growth' is used for high-income nations and development for low-income nations. He also points out however that surprisingly few of the economists, that discuss Sustainable development actually define the concepts of growth and development.) and the economic system is not viewed as a subsystem (but rather as a free-floating system in relation to the system Earth) sustainable growth becomes a necessary and prosperous concept, if Sustainable development is taken seriously (Friman, 2002).

2.4 The operationalization of sustainable development is context dependent

It has been argued that the attractiveness of the concept of sustainable development lies in its elusiveness (Redclifts 1987:4; O'Riordan 1988). The elusiveness of the concept of sustainable development has been functional when the main concern is to drive through a broad consensus or to attain a minimum commitment to some broad understanding of change. However, its utility has been shown to diminish when trying to operationalize the concept with a view to undertaking more exact macro-economic, political, or social changes. This problem was one of the most important challenges discussed at the '10 years after Rio' UN conference, in Johannesburg in 2002.

In the Sustainable development, literature of today it becomes ever clearer that to understand and to operationalize sustainable development, it is crucial to move away from literary or scientific definitions and towards a process, which recognises the diversity of perspectives (Meppem and Gill, 1998). The details of what compromises Sustainable development should be understood as something highly context specific, as it would be illogical to expect the same conditions to apply everywhere. The interpretation and operationalization of the broad understanding and definition of Sustainable development into sustainable regional development therefore has to be done in the specific context of each individual region. It also needs to be based on explicit standpoints concerning the unsustainable development patterns in the region and a vision, goal of where the regional development is aiming at from a Sustainable development point of view.

2.5 Models for Sustainable Development

Moving towards sustainable development presents tremendous challenges. Man has all the tools necessary for achieving it. However, we tend to forget that in order to survive, we need to adapt to nature and not vice-versa.

We need to develop the ability to make a choice that respects the relationship between the three “ES” – economy, ecology, and equality. If all the three “ES” were incorporated in the national goals of countries then it would be possible to develop a sustainable society.

Models help us understanding the concepts of Sustainability better. Achieving Sustainable development thus, requires more effective, open, and productive association among the people themselves. Models help us gather, share, and analyse information; they help coordinating work; and educate and train professionals, policymakers and the public in general. The following are some of the constructive models for understanding Sustainable development.

2.5.1 Three Pillar Basic Models

This is one of the most well-known models created using the three dimensions -Economy, Environment and Society. The diagram shows three interlocking circles with the triangle of environmental (conservation), economic (growth), and social (equity) dimensions. Sustainable Development is modelled on these three pillars. This model is called ‘three pillars’ or ‘three circles model’. It is based on considering the society, but does not explicitly take into account ‘human quality of life’.

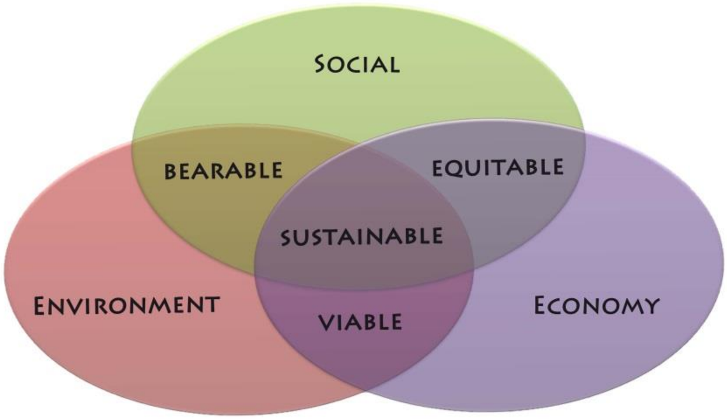


Figure 3 : Dimension of Sustainability
Source: Johann Dréo, 2006

2.5.2 The Egg of Sustainability

The ‘Egg of Sustainability’ model was designed in 1994 by the International Union for the Conservation of Nature, IUCN (cf. Guijt & Moiseev 2001). It illustrates the relationship between people and ecosystem as one circle inside another, like the yolk of an egg. This implies that people are within the ecosystem, and that ultimately one is entirely dependent upon the other. Just as an egg is good only if both the white and yolk are good, so a society is well and sustainable only if both, people and the eco-system, are well. Social and economic development can only take place if the environment offers the necessary resources: raw materials, space for new production sites and jobs, constitutional qualities (recreation, health etc.). Ecosystem is therefore to be regarded as a super coordinated system to the other dimensions of the triangle or prism models: social, economic, and institutional.

These latter can only prosper if they adapt themselves to the limits of environmental carrying capacity. Thus according to this model:

Sustainable development = human well-being + ecosystem well-being

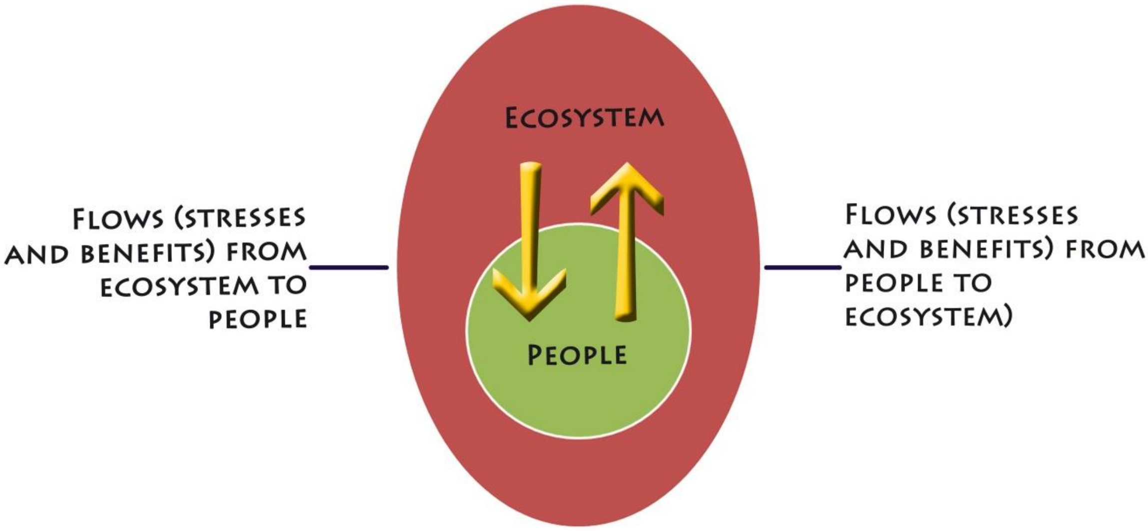


Figure 4 : The Egg of Sustainability

Source: Own representation based on Robert Prescott-Allen, in IUCN, 1995

2.5.3 Atkisson's Pyramid Model

The Atkisson Pyramid process supports and accelerates the progress from identifying the vision of sustainability, through analysis and brainstorming and agreements on a credible plan of action.

The Structure of the Pyramid guides through the process of first building a firm base of understanding, searching for and collecting relevant information and ideas, and then focusing and narrowing down to what is important, effective, doable, and something that everyone can agree in.

The Atkisson's Pyramid is a blue print for the Sustainable development process. Its five steps or levels include:

- Level 1: Indicators- Measuring the trend
- Level 2: Systems- Making the connections
- Level 3: Innovations- Ideas that Make a Difference
- Level 4: Strategies: From Idea to Reality
- Level 5: Agreements: From Workshop to Real World

This model is designed to help groups of 20-40 people move quickly up the sustainability learning curve, from basic principles and frameworks, to systems analysis, to innovative strategies for action. Along the way, groups practice cross-sectorial teamwork, make linkages, generate dozens of new ideas, and work toward an "Agreement" which is a set of actions they agree to follow through within the real world. (AtKisson, Believing Cassandra (Earthscan, 2010).

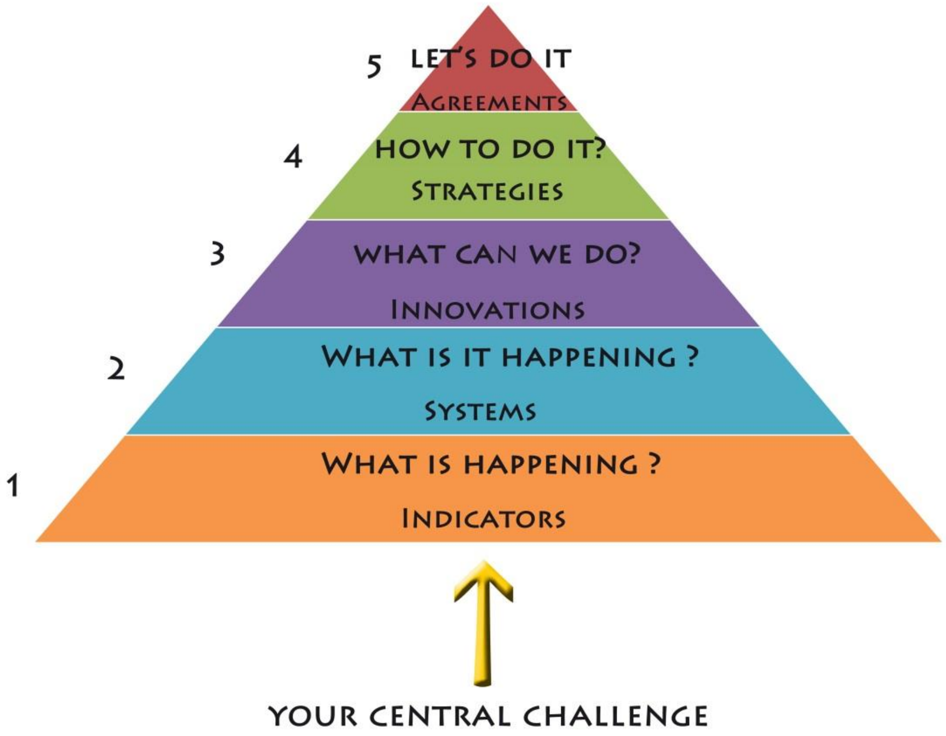


Figure 5 : Atkisson's Pyramid Model
Source: Atkisson Inc.

The same process can be carried out for the other two components- Society and Economy and then we can come up with the Agreement by making interlink ages between all the three components.

2.5.4 Prism of Sustainability

This model was developed by the German Wuppertal Institute and defines Sustainable development with the help of four components economy, environment, society, and institution. In this, model the inter-linkages such as care, access, democracy, and eco-efficiency need to be looked at closely as they show the relation between the dimensions which could translate and influence policy.

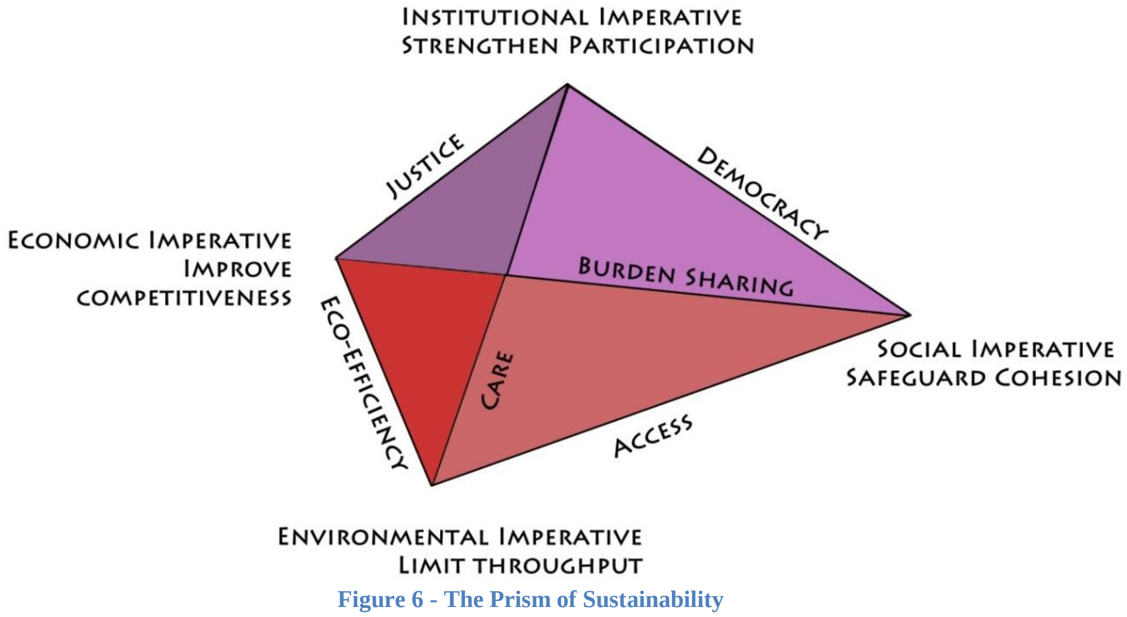


Figure 6 - The Prism of Sustainability
Source: Spangenberg, Wuppertal institute, 1998

In each dimension of the prism, there are imperatives (as norms for action). Indicators are used to measure how far one has actually come in comparison to the overall vision of Sustainable development. This is described in the following diagram.

Kain (2000, p. 25) had however criticized this prism, arguing that 'the economic dimension tends to include assets emanating from all four dimensions, thus, adding confusion to the description and analysis'.

2.5.5 The Amoeba Model

The Amoeba Approach is a model used to visual assesses a system's condition relative to an optimal condition. The model is circular with the various indicators positioned around the outside. Lines radiate from the centre to the indicators, on a continuum from unsustainable (in the centre) to sustainable (the outside of the circle). A circle would indicate the optimum conditions. This type of model allows simultaneous assessment of different indicators, and easy comparison between components of the system.
"The Amoeba Model" is a powerful technique for accelerating the innovation process and training to be far more effective in achieving Sustainable development.

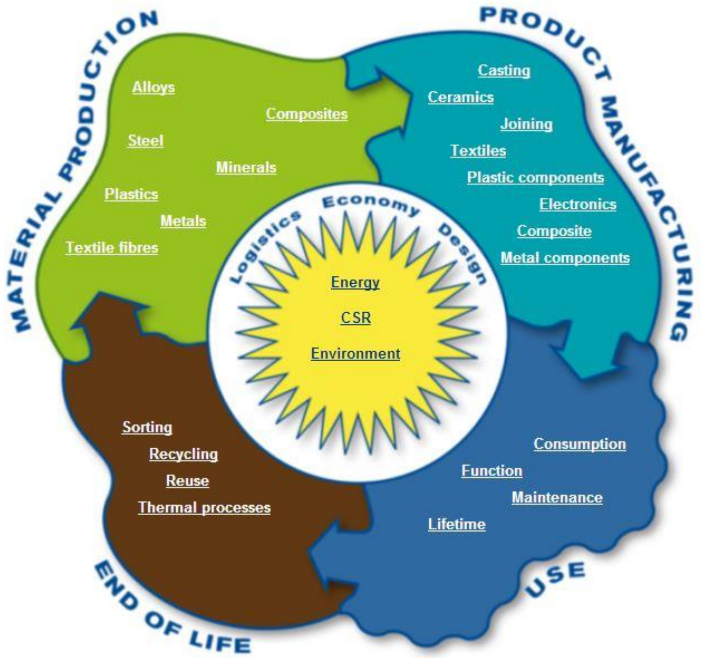


Figure 7 : The Amoeba Model sustainability
Source: AtKisson, Believing Cassandra (Earthscan, 2010)

2.6 What is an indicator for sustainable development?

There are many tools and methodologies designed to measure and communicate progress towards Sustainable development. One of the most popular tools is indicators and indices, an index being an amalgam of more than one indicator. A sustainable development indicator (Sustainable development) can generally be understood as a quantitative tool that analyses changes, while measuring and communicating progress towards the sustainable use and management of economic, social, institutional and environmental resources. An indicator is something that points to an issue or condition.

Its purpose is to show how well a system is working towards the defined goals. An indicator can also be used in an evaluation, assessing if a development project takes into consideration aspects of Sustainable development. Indicators are normally seen as something quantifiable and in that sense an indicator is not the same thing as an indication. This does not mean that there can be no qualitative indicators. The choice between quantitative and qualitative indicators depends mainly on the purpose of the indicators, though quantifiable indicators are more frequently used (Gallopin 1997).

Traditional measures such as, unemployment rates, economic growth rates, the percentage of the population below the poverty line, rates of homelessness, crime, asthma. Alternatively, figures on volunteer working, political involvement, air pollution, water quality and the level of toxins in fish, illustrate only partial changes in one discrete part of society without bringing to our attention the many linkages that exist between such diverse issues. When society, the economy, and the environment are seen as separate and unrelated parts, there is a risk that the problems identified within each sphere also are viewed in an isolated manner. Such a piecemeal approach has several unwanted side effects. For example, the solution to one problem may make another problem worse. Thus, creating affordable housing may be good, but when the new housing is built in areas far from workplaces, the result is increased traffic and pollution. A piecemeal approach may also create opposing groups. Moreover, it tends to focus on short-term benefits without monitoring long-term effects. For example Gross Domestic Product (GDP) measures the amount of money being spent, the higher the GDP the better the overall economic well-being. However, GDP only reflects the amount of economic activity and can rise when the overall community health is being impaired. Chambers et al (2000) have argued that the next generation of indicator-producers most likely will focus more specifically on the assumptions lying behind them and move from being librarians who organise information in categories into being plumbers who focus on how the different categories are interconnected and what the trade-offs among them may be. Instead of having this “one-problem, one-indicator” approach, Sustainable development should thus aim to develop a framework that tries to bring the economic, social and environmental aspects of society together, emphasising the links between them.

Understanding the three parts and the linkages between them is thus the key to developing and using sustainable indicators. For example, highways or other types of infrastructure result in more commuting and better regional integration, which in turn leads to a more dynamic work force and less unemployment, but also to more environmental pollution. An indicator that would be able to measure the trade-offs between infrastructural construction and environmental pollution would thus be highly interesting from the perspective of Sustainable development. Sustainable indicators should therefore point to areas where the linkages between the economy, the environment, and society are weakest. They should also reflect the fact that the economy, society and the environment are tightly interconnected. Figure 8 is one such example of how regional Sustainable development could be conceptualised as a web of interactions between different aspects of the three pillars of Sustainable development.

The natural resources, either locally provided or imported in the form of raw materials or energy, provide the material for production on which industry and jobs depend. The number of jobs affects the poverty rate, while the poverty rate is related to crime. Air quality, water quality, and materials used for production have an effect on health. Health problems, whether due to general air quality problems such as exposure to toxic materials, have an effect on worker productivity and thus contribute to the rising costs of health insurances.

Sustainable development is thus requiring an integrated view of the world, in relation to the different aspects of Sustainable development as well as in relation to time and scale and to who is involved.

Figure 8 : The interaction between different aspects of the three pillars of Sustainable development.
Source: Eurostat (2001): UNCSD Sustainable development indicators

Table 1: Eurostat sustainable development indicators

SOCIAL DIMENSION		
Theme	**Sub -theme**	**Indicator**
Equity	Poverty	Population living below poverty line
		Measures of income inequality
		Unemployment rate
		Youth unemployment rate
		Social benefits per capita
	Gender equality	Female to male wage ratio
	Child welfare	Child welfare
Health	Nutrition status	Nutritional status of population
	Illnesses	Mortality due to selected key illnesses
	Mortality	Infant mortality
		Life expectancy at birth
	Sanitation	Population connected to sanitation system
	Healthcare delivery	National health expenditure
		Immunization against childhood diseases
Education	Educational level	Levels of educational attainment
	Literacy	Low qualification levels
Housing	Living conditions	Numbers of rooms per capita
		Household composition
Security	Crime	Reported crimes
Population	Population change	Population growth rate
		Population density
		Net migration rate

ENVIRONMENTAL DIMENSION		
Atmosphere	Climate change	Per capita emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone depleting substances
	Air quality	Air pollutants in urban areas
Land	Agriculture	Agricultural area and organic farming
		Nitrogen balances
		Use of agricultural pesticides
	Forests	Total forest area
		Wood harvesting ratio
	Urbanization	Growth of built up area
Ocean, sea and coasts	Coastal zone	Eutrophication of costs and marine waters
	Fisheries	Fish catches by selected over-exploited species
Fresh water	Water quantity	Intensity of water use
	Water quality	BOD concentrations in selected rivers
		Quality of bathing waters
Biodiversity	Ecosystem	Protected area as a % of total area
	Species	Number of threatened species
ECONOMIC DIMENSION		
Economic structure	Economic performance	Per capita GDP
		Investment share in GDP
		Value added by main sector
		Inflation rate
	Trade	Net current account
		EU and international markets
	Financial status	Public debt
		Aid to developing countries
Consumption	Material consumption	Material consumption

and production patterns	Energy use	Per capita *g*ross inland energy consumption
		Renewable energy sources
		Intensity of energy use
	Waste generation and management	Generation and disposal of municipal waste
		Generation of industrial waste
		Generation and disposal of hazardous waste
		Generation and disposal of radioactive waste
		Recycling of waste: paper and glass
		Waste treatment and disposal facilities
	Transportation	Passenger transport by mode
		Freight transport by mode
	Environnemental protection	Environnemental protection expéditeurs
INSTITUTIONAL DIMENSION		
Institutionnel capacity	Information Access	Internet Access
	Communication structure	Communication Infrastructure
	Science and technology	Expenditure on research and development
	Nature disaster preparedness and response	Risks to human and natural capital

Source: Eurostat (2001): UNC Sustainable development indicators

2.6.1 Methodologies for measuring sustainable development

As we have already noted, the definition of sustainable development fundamentally depends upon in which context it is being used, and not least, by who is defining it. The creation of Sustainable development indicators is something essentially delicate. Nevertheless, a number of tools and methodologies have been designed to help gauge progress towards Sustainable development, but given the disparity of views already described here there is no textbook providing a methodology that is generally accepted and applicable across regions (Mitchell, 1996).

The UN list of indicators arising out of the Rio conference is perhaps the most prominent example. In 1995, the UN Commission on Sustainable Development (UNC Sustainable development) adopted a Work Programme on indicators and related methodology (UNC Sustainable development, 1996). 59 indicators and methodology sheets are available today. In the EU system, Eurostat and the European Environment Agency (EEA) have used these 59 UN indicators as the basis for the EU Sustainable development list of 63 indicators (Directorate-General for the Environment, 2000, European Commission, 2001.

There are also several types of general indexes available. One example of a general index is the Index of Sustainable Economic Welfare (ISEW). In order to get a more complete picture of what economic progress is, the ISEW subtracts from the Gross Domestic Product consequences of economic activity that have negative environmental impacts and adds to the GDP the value of significant activities such as unpaid domestic labour, which is based in the average domestic pay rate. The ISEW accounts for air pollution by estimating the cost of damage per ton of five key air pollutants. It accounts for the depletion of resources by estimating the cost to replace a barrel of oil with the same amount of energy from a renewable source. It estimates the cost of climate change due to greenhouse gas emissions per ton of emissions. The cost of ozone depletion is also calculated per ton of the ozone depleting substance produced. Additionally, adjustments are made to reflect concerns about unequal income distribution. Some health expenses are considered as not contributing to welfare, as are some educational expenses. It is a highly ambitious index but as with GDP, the ISEW bundles together a tremendous amount of information thus leading to a lack of transparency.

2.6.2 Methodologies for measuring sustainable regional development

Regions are today seen as having an increasingly important role in sustainable development. This focus is justified firstly by the important role of regions as intermediaries between the national and local levels and secondly by the growing consensus that Sustainable development is an essential criterion within future regional development (Clement et al, 2003).

Although sustainable regional development (SRD) represents a relatively new field, substantial knowledge and expertise in SRD already exists within an emerging body of literature (EC, 1998, ENSURE, 2000, Schleicher-Tappeser et al, 1999). In parallel with the EU activity in this field, the theoretical and practical development of SRD has been supported by a series of multidisciplinary conferences and international workshops as well as by the creation of European networks for sustainable regional development (Clement et al, 2003). The process has pointed at the differentiated experience between countries and regions. In the case studies of SRD projects referred to by Clement et al, it has been found that the greater commonalities correspond to the difficulties encountered, whereas the more positive characteristics are differentiated between projects. One major common difficulty was the time and energy spent on persuading others of the value of such a Sustainable development approach as well as on agreeing upon a common understanding of SRD.

Despite the difficulties experienced in coming to a common understanding of SRD in the numerous case studies undertaken, the integration of Sustainable development into the evaluation criteria of development projects funded by the Structural Funds has been a big step towards attaining a communal methodology. The key document attempting to rationalise SRD is the EU Thematic Evaluation on the Contribution of the EU Structural Funds to Sustainable Development (EC, 2002). This research provides tools and methodologies to assist regions, Member States and the EU in assessing the sustainability of development plans and enhancing the sustainability of Structural Funds programmes in the 2000-2006 periods. It is also intended to act as a guide in the preparation of Structural Funds policies beyond 2006. As we discussed in section two, the conceptualisation of Sustainable development as three pillars (the economy, society and the environment) can be translated into four types of capital. The EU system uses 'the four capital approach' to develop a discussion on the trade-offs between them. The report contains a sustainability assessment matrix specifying criteria against which to evaluate policies, programmes, or projects. Finally, a project pipeline checklist provides questions for programme managers and monitoring committees designed to generate projects that contribute more efficiently to Sustainable development.

2.6.3 What constitutes a good indicator for sustainable development?

The term indicator has a certain technical feel to it. It invokes numbers and statistics that are mainly used and understood by specialists and technocrats. It is certainly true that for Sustainable development indicators there has been, and still is, an emphasis on selecting indicators deemed to be relevant largely by applying a list of indicator rules defined by technicians (Bossel, 1999, Bell and Morse, 2003). Such lists of technical criteria are common in the Sustainable development literature and they stress for example that an indicator should be:

- Specific: Indicators must relate to the desired outcome, i.e. fit the purpose for measuring.
- Measurable: Indicators should preferably be open to measurement in a quantitative manner.
- Pedagogical: Indicators should be practical and designed for those who are going to use them.
- Sensitive: Indicators must readily change as circumstances change.
- Reliable: The information that an indicator is providing must be reliable. Data upon which the indicator is based must therefore be collected using a systematic method.
- Based on accessible data: In order to create good indicators it is important that the necessary information available or can be gathered on a regular basis and while there is still time to act.
- Cost-effective: The cost of accumulating necessary data should not exceed the benefits of using the indicator.
- Relevant and Usable: Indicators should show what is needed to know. This includes the need for a clear definition of the objective that the indicators are meant to achieve. It also means that it is important to focus on those issues that a region, or a regional development project, can control or influence or that is of specific importance to the project.

Taking into consideration previous discussions on Sustainable development, the technical and rather dry criteria above are clearly not sufficient to evaluate whether an indicator is a good Sustainable development indicator or not. Other criteria more closely related to the essence of Sustainable development must be used as a complement. Such criteria could for example be to question to what extent an indicator takes into account the linkages between the different capitals of sustainable development. What extent an indicator is sensitive to stakeholder participation in the SRD process? Alternatively, what extent it accommodates responsibility across geographical areas and time scales?

As Sustainable development is a rather complex matter, the following section will present a list of 12 questions as a tool to promote "Sustainable development-type thinking" and help to include as many aspects of Sustainable development as possible (adapted from Hart 1999, Bell and Morse 2003 and Bell & Morse 1999).

A good indicator does not mean that it is possible to answer a definitive "yes" to all questions but in the daily life of a programme for regional development, the main task would be to identify projects. In total, can contribute to all three pillars (and four capitals) – and can in particular, avoid granting funds to projects that are beneficial for only one or two aspects while effectively contradicting the others. The same is true for the use of Sustainable development at any geographical level, as well as for small and large development projects. It is however crucial to take into consideration the fact that each project is unique and therefore such examples should only be seen as that, i.e. *as examples of a way of thinking.*

1. Does the indicator address the wise long-term use of natural resources – renewable and non-renewable, local or from distant sources – which the region relies on?

It is important to check if the indicators take into consideration a wise long-term use of the ecosystems or natural resources upon which the region is dependent. One region may depend on forestry for resources and jobs. An indicator that measures the rate of timber harvest relative to the renewable harvest rate would consequently be relevant. In a region that relies on metals for its main industries, an indicator of the cyclical use of its non-renewable resources would thus be appropriate, for example, the percentage of energy-use that is renewable. Another example could be a region dependent on fishery, where an appropriate indicator could be measuring the harvest relatively, i.e. the renewable harvest or the fish catches by selected overexploited species. In a region where farming is the dominant economic sector, it is relevant to measure the percentage of agricultural land that is sustainably managed. Another example could be an indicator that takes into consideration the level of nitrogen in drinking water, or the level of eutrophication in lakes, rivers or the sea, depending on where a region is geographically situated.

2. Does the indicator address the wise use of aesthetic qualities – the beauty and life-affirming qualities of the natural and cultural environment – that are important to the region?

This question addresses the wise use of the aesthetic qualities of a region. For a coastal community that relies on tourism for part of its economy an example of such an indicator could be measures of the number of tourists that can be served by the area without damaging its natural beauty. Another example could be the area of green space per person in the region. Aesthetic qualities also include the cultural environment, buildings, monuments and the "man-made nature" (see also question 6).

> *3. Does the indicator address the use of the region's human capital – the skills, abilities, health, and education – of the people in the region?*

This question addresses the importance of evaluating the use of a region's human capital, the skills, abilities, health, and education of its people. Indicators that measure population development and migration rates are but two examples. Other examples could be rates of graduation form secondary education or educational dropout, or the 'awareness' of environmental problems.

> *4. Does the indicator address the use of a region's social capital – the connection between people, the relationships of friends, families, neighbourhoods, social groups, business, governments, and their ability to cooperate, work together, and interact in positive and meaningful ways?*

This questions draws attention to the importance of evaluating a community's social capital. One way to do this is to measure the ability of the community to work together. Examples of indicators are the voting rate, the amount of volunteerism, or the number of public-private partnerships in the region.

> *5. Does the indicator address the wise use of a region's manufactured capital – the human made materials (buildings, parks, communication infrastructure, and information) that are needed for quality of life and the region's ability to maintain and enhance those materials with existing resources?*

The manufactured capital is a product of natural capital and social capital, because raw materials come from somewhere, and human skills, abilities and cooperation are needed to produce manufactured objects. Examples of indicators taking into consideration a region's manufactured capital could be the amount of money spent on public transport or on waste management (particularly important after the EU directive banning household waste deposition).

An indicator could also take into consideration several Sustainable development capitals simultaneously. For example, an indicator measuring the number of new housing units that use sustainably produced building materials that are affordable with an average family income take into consideration the natural, manufactured, and social capitals at the same time.

> *6. Does the indicator provide a long-term view of the region?*

This question aims to draw the focus onto the long-term view of the region. One way to test whether an indicator provides a long-term view is to consider what the indicator trend would show after 20 years, and whether that would be consistent with, or relevant to, a sustainable region. However, a time perspective of 20 years is often difficult as for example regional programmes generally only last for 4-7 years.

However, the long-term view is important when defining indicators. Adopt a time perspective when evaluating the natural resource use and the ecosystem services could be one way to incorporate this aspect into a Sustainable development.

> *7. Does the indicator address the issue of economic, social, or biological diversity in the region?*

It is believed that an economic, social, or environmental system that is diverse usually withstands stress better than a homogenous system. A community that relies mainly on a single type of industry is therefore seen to be less stable and less sustainable compared to one whose economy is diversified. A monoculture forest is less able to withstand diseases and environmental stress than a forest that has diverse types of trees and plants. It is important to note that the terms economic diversity, social diversity, cultural diversity and biological diversity should not be interpreted as an indicator of sustainable development. They are issues, areas or categories for which indicators can be developed, but they are not indicators. Examples of indicators of diversity include the number of different industries in the community, the number of jobs at different wage levels, and the number of birds in the annual bird count.

> *8. Does the indicator address the issue of equity or fairness – either between current residents of the region (intra-generational equity) or between current and future residents (inter-generational equity)?*

This question addresses the issue of equity. Indicators measuring either intra-generational equity (equity among people living now) or inter-generational equity (equity between today’s generation and future generations) are relevant here. One measure of intra-generational equity is the difference in income of the 20 % of the population at the top of the income scale and the 20 % of the population at the bottom of the scale. A measure of inter-generational equity is the utilisation of land or key natural resources and the possibilities for future generations to have access to these resources.

> *9. Does the indicator measure a link between the dimensions of Sustainable development (economy, society, and environment) in a region?*

This question addresses the extent to which the linkages between a community’s economy, environment, and society are taken into consideration when creating a set of Sustainable development. These themes are relevant for all questions and should not only be taking into account in a special set of indicators.

One example of an indicator that links economic and social aspects would be the number of jobs paying a living wage. An example of an indicator that links the economy and the environment is the number of tourists that can come to a region without the local environment being negatively impacted. Such an indicator could be the number of people that the water treatment plants can handle. Moreover, the percentage of households using crops that do not require maintenance in the form of fertilisers and pesticides is an indicator that links the environment with social behaviour. Measuring car density at rush hours would be another indicator that links environmental and social aspects.

10. Does the indicator measure development that takes place at the expense of another region or community or at the expense of global sustainability?

Any development that indicates that we are going to be better off by making someone else worse off is not sustainable. This does not mean that one region cannot be better than another can. An already established type of indicator that focuses in particular on comparing sustainability between different areas is the ecological footprint (EF). An EF describes a spatial unit (e.g. community, region, or country) in relation to its impact in terms of the land area required to support it. This is distinct from the physical footprint, the physical land area occupied by the spatial unit. The EF is usually expressed quantitatively as a plot of land area required to maintain the unit. The larger the EF the greater the resources required to maintain the unit's existence (Bell and Morse, 2003, Wackernagel and Rees 1996, Wackernagel et al, 1999, Chambers et al, 2000). The EF can be a simple and visually striking device to show inequality between geographical areas at different scales. There are however several problems with using EF as a measure for Sustainable development. It is for example possible to interpret EF in terms of competitive ability; those with large footprints can be seen as more competitive and hence successful (Bell and Morse, 2003). Despite these drawbacks, an EF is a striking indication as to whether one regions' wealth exists at the expense of another region, or of global sustainability. EF ensures that the boundary of a system is widened beyond the physical limit of a spatial unit, while also allowing a discussion about global sustainability to take place in terms of spatial units that people can readily engage in (Lewan, 2002).

11. Does the creation and use of the indicators include involvement of the stakeholders in the region?

The participation of stakeholders is one important aspect of sustainable development. In case studies on SRD it has been shown that the most successful projects were those where the actors on the local level was involved form the outset, while 'top-down' approaches were seen as generally being less successful (Clement, 2001). Participation could entail many things, ranging from an active involvement in the creation process to a more passive acceptance. The Sustainable development literature is full of case studies and methods of how to engage stakeholders, which for example can take form in focus groups, citizens' juries, study circles, community conventions, consensus conferences, and planning cells to name a few (Bell and Morse, 2003).

Including this question in the checklist may serve as a showstopper as it is crucial for every Sustainable development project to consider, before starting and while working, who is going to participate in this process and what should be their roles.

12. Are the indicators formulated in a form that is proactive?

Sustainable development includes the idea of development, i.e. change. It is consequently important that the indicators serve as a warning with regard to undesirable trends and changes rather than plainly measuring an existing state. Several studies have shown that Sustainable developments are often not designed well enough to promote change (Astleithner, 2003).

2.7 Conclusion and interpreting the concept of sustainable development

Over the past decade the world has woken up to the fast depleting non-renewable resources, loss of biodiversity, land degradation, increasing air pollution, ozone depletion, fast disappearing glaciers, polluted fresh water sources, sea erosion of land, nuclear waste, electronic waste, increasing deforestation, unplanned development, and more large scale, sudden onset disasters.

The economies of many countries are booming but the distribution of wealth is still unequal. Changing trends in consumption patterns, which directly affects the lifestyle of people, has also led to increasing health risks to people of all ages. Wherever in the world, environmental degradation is happening; it is always linked to questions of social justice, equity, rights, and people's quality of life in its widest sense. So far, for reaching sustainable development it could be concluded that some steps must be taken such as:

1. Developing nations must ally together to negotiate equally with the allied imperial centres.
2. There must be equal pay for equally productive work to provide roughly equal buying power relative to the talents and energy expended to all who are employed.
3. Sharing those productive jobs would melt the invisible economic borders, which currently guide the wealth into the hands of only the adequately paid. Each employable person now need work only two to three days per week.
4. Elimination of the subtle monopolizations of land, technology, finance capital, and information (Part IV), utilizing Henry George's principles of *conditional* title to nature's wealth, will restructure monopoly capitalism to *democratic-cooperative-(superefficient)-capitalism* and increase economic and social efficiency equal to the invention of money, the printing press, and electricity.
5. Addressing population issues and sustainable development will alert the citizenry that, through elimination of waste and then careful conservation, the earth has the capacity to provide resources for all and the environment to absorb wastes.

Interpreting the sustainable development is considered as an "operational definition of sustainable development," evidenced by the hierarchy of sustainable development principles. Sustainable development interpreting are applied, consists of:

1. Broad-based approaches that support sustainable development, such as integration and coordination, ecosystem-based management, environmental protection and sustainable use of natural resources, sustainable livelihood, and vulnerability/resiliency strengthening.

2. Operational strategies that create an effective governance framework, including: policy and institutional reforms, multi stakeholder participation, functional partnerships and networking, capacity development, information and knowledge management, financing arrangements, coastal strategy development and implementation, and monitoring and evaluation.

3. Operational tools that provide specific best practices, including: urban profiling, stakeholder analysis, governance review and coordinating arrangements, risk assessment, land use and urban planning, legal/regulatory, participatory tools, training and education, economic, and disaster preparedness/response covering manmade and natural hazards.

These are principles that set sustainable development interpreting apart from other management frameworks:

1. Adaptive management is based on the premise. The information and knowledge about resource systems and how to manage them are largely uncertain. This principle is a purpose and outcome-driven iterative process of planning, implementing, assessing, modifying, and/or redoing. The principle emphasizes that one must be ready to make appropriate administrative or management adaptations in response to unforeseeable forces, such as ecological uncertainties and changing political and management conditions that hamper the sustainable development initiative.

2. Integration and coordination are to ensure that:

a) Policies and management actions of relevant sectors within the sustainable development programme are consistent with one another; b) policy and management reforms to facilitate policy and functional integration are based on sound scientific advice; and c) various intersectional activities are closely coordinated and streamlined towards eventual scaling up of management practices.

3. Ecosystem-based management is focused on maintaining the integrity of ecosystems, which provide goods and services essential for human well-being. The principle maintains that effective ecosystem management means managing human interaction with the environment.

An understanding of each of the aspects is vital for the purpose of development and improvement, independent of the model which is applied to introduce sustainable development criteria. Below, a brief explanation is given for each of these aspects:

Environmental aspect:

Earth and the environment on it (natural environment, in general; built environment, in specific), as the habitat of all live creatures (human being, animals, and plants), is of great significance since protecting and maintaining it has a direct relationship with saving those creature's lives. Nowadays, human faces numerous challenges to save the environment. Some of the most important challenges and the factors observed in the Environmental aspect are:

- The use of natural resources, e.g. soil, water, etc.

- Knowing the Earth, its rules, and geo technology
- Climate and weather changes
- energy
- Threats to the environment, e.g. greenhouse gases, global warming, ozone layer hole
- The role of natural and green areas in human life
- Saving animal and plant species

Economic aspect:

Economics is a tool for the proper use of resources (natural, human, etc.) to manage and distribute products and incomes in human societies. Considering the economic aspect (human's economic needs) and developments has a major effect on escalating the quality of life and people's satisfaction. Economic development, problems, and crisis range from microeconomics level (family economy) to macroeconomics level (international economy). Some of the most important factors observed in the Economic aspect are:

- Life Cycle Cost (LCC)
- GDP (Gross Domestic Product) and GVA (Gross Value Added)
- Globalization and national economy
- Average salary range and purchasing power
- Chances and choices for new jobs and job security

Social aspect:

All human activities such as work and educational activities, sports and entertainment, interpersonal relationships, and generally, the day-to-day life happen in a group called society. This leads to the significance of society and social relationships, as human life cannot be considered apart from its society. In other words, society and people have so much mutual influences on each other that for every single person, having a better life requires a healthier, livelier, and more active society. Consequently, issues which cause the weakness or strength of a society have to be taken into account. A number of the most important issues in the Social aspect are:

- Demographic changes
- Social cohesion
- Human rights
- Education
- Public health
- Diversity and multicultural
- Social equity
- Migration and integration
- Governance and structure
- Security (micro and macro)

According to the stated criteria, since the emergence of the concept of sustainable development, two subjects have always been underlined in parallel:

- The definition of criteria which includes all the main aspects of human life (with attention to the 3 primary criteria, Environmental, Economic, and Social).

- Adopting proper strategies and policies (short-term, medium-term, and long-term) to realize sustainable development criteria.

Accordingly, countries' measures to realize predefined plans in order to reach sustainable development are annually assessed at national and international levels.

The adopted strategies must include all three principal aspects of sustainable development. Generally speaking, in sustainable development system, not only are the triple criteria not separated, but they also affect one another constantly. Therefore, any policy which is adopted to develop countries has to be measured against sustainability criterion to be consistent with all three criteria.

2.8 Summary

To sum up, as a benchmark and main plan, sustainability influences all human activities, from the way people live their everyday life to long-term international projects and policies, and it shows the outlook for progress and development in present and future life.

Finally it could conclude by having studied the different definitions of sustainable urban development and having identified the role of cities in their residents' lives, the chief goals of sustainable urban development can be categorized as follows:

- Creating equal life opportunities for all citizens and providing minimum needs for everyone
- Improvement and development of environmental, economic, and social aspects, and thus better life quality
- Maintaining the existence and liveliness of cities for present and future generations.

In order to have sustainable development, attention to these goals is necessary. Table 2 shows some of the features and advantages of sustainable development. In addition, the challenges development might encounter and a number of problems caused by unsustainable development have been included for comparison. Also it can be concluded that the important point is that a tool is required to evaluate the objectives and strategies of sustainable urban development. This need has resulted in the emergence and spread of certification systems, which will be reviewed in next chapter.

According to the features of sustainable development mentioned in table 2, two principal subjects are introduced in urban management and development:

- Appropriate strategies to achieve sustainable urban development

- Proper political decisions to execute strategies

Table 2 : The features and advantages of sustainable development

	Problems & Challenges of development	Benefits of Sustainable development
Economic aspects	- Energy crisis and increasing energy prices - Economic dependence on non-renewable energies and resources - Economic crisis - Cost of mobility and transportation	- Life cycle cost managing and saving - Stronger local business - A variety of dwelling types & prices - More chances and choices in employment
Ecological aspects	- Climate change - Greenhouse gases - Co_2 and global warming - Use natural resources - Air pollution - Water deficit	- Efficient land use - Protection of environment & climate - Renewable energies
Sociocultural aspects	- Demographic change - Noise pollution - Low quality of public services - Social disintegration and discrimination - Despair of the future	- More accessibility - Active and healthy Community - Social cohesion - More security for neighbourhoods - More chances and choices in education

Source: own analysis

3. Certification systems

3.1 Introduction

Today, sustainability has become an influential concept in economic, environment, social, and other policies of developed countries. In addition, cities and city districts (as the base of sustainable development) have such a stronger role in the advancement of sustainable urban development that sustainable development in districts is the precondition for the realization of sustainable development at higher levels. The main question is whether it is possible to develop specific strategies for sustainable development.

The important point is that a tool is required to evaluate the objectives and strategies of sustainable urban development. This need has resulted in the emergence and spread of certification systems.

Considering the variety of objectives, strategies and practical approaches of sustainable development at different levels and in different areas, it can be stated that "certification systems" are a tool to assess these objectives and approaches. In other words, they are a quantitative standard to measure the concept of sustainable development in each area.

These systems can be employed in buildings that have different occupancies and in sustainable urban development projects. However, these certificates are different from building codes of practice. The codes show the minimum requirements for development and construction, whereas certificates rate buildings and projects according to quality and predefined criteria, and they can show the maximums.

3.2 Definition and purposes

The following items can be pointed out in the definition of certification systems:

- Define criteria and indicators: this is the main element in these systems.
    - Criterion: states the main specifications and details of the determined objectives (i.e. objectives and aspects of sustainable urban development). (Cf. DV. Kommission Zertifizierung in der Stadtentwicklung. p.15)
    - Indicator: states the quantitative and measurable description of the criteria. Each criterion might be evaluated by a number of indicators. (Cf. DV. Kommission Zertifizierung in der Stadtentwicklung Nr. 37)

- Rating system: shows the specific boundaries of classification. In addition, the evaluation method (quantitative or qualitative) for indicators measurement, the criteria importance factor, and the minimum level of requirement must be carefully identified in this part. Finally, the result of evaluation must be shown simply and specifically.
- Certification process: decides the necessary measures and the steps to award the certificate. Assessment and rating usually takes place in a number of building (or city quarter) life cycle phases (e.g. design and planning, construction, etc.). It has to be taken into account that the assessment process and what is observed in which phase must be explained in detail.

- Besides, the assessing people or organizations, the applied instruments and standards, and the documents required for assessment must be specified.

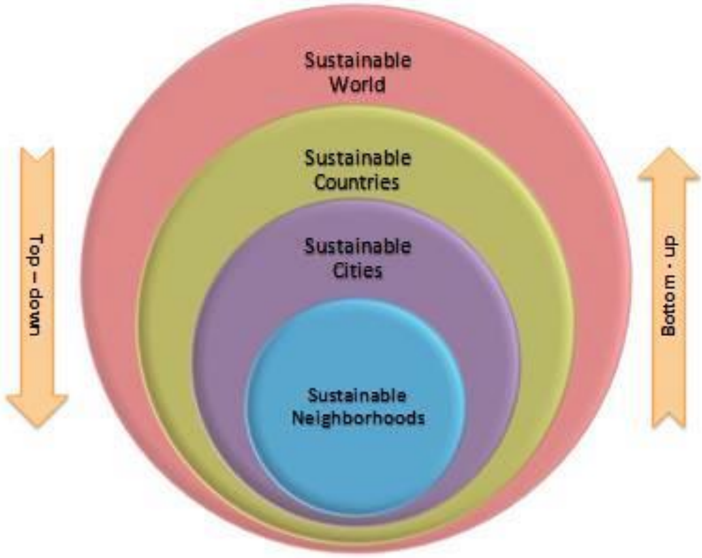


Figure 9 : Top-down, bottom-up method for sustainable urban development
Source: Cf. Rat für nachhaltiges entwicklung (2010) p.12, Cf. OECD (2001).

In the figure above, a mutual relationship can be seen between the first level and the final level. This relationship can be explained as:

- determining the general objectives and main aspects of sustainable development at national and international levels; and details and small objectives at regional and urban levels (TOP-DOWN)
- determining functional strategies and executive projects at regional and local levels; supporting and monitoring at national and international levels (BOTTOM-UP)

Certification systems are categorized based on the evaluation subject (house building, office building, neighbourhood, etc.). They first appeared with the aim of sustainability assessment in buildings, yet in recent years a lot of attention has been given to sustainability assessment in neighbourhoods. More and more attention to the importance and influence of cities and districts, climate changes, demographic changes, and economic crisis can be one of the reasons. Moreover, neighbourhood, as the level between city and building, is the smallest detail that contains all the aspects and criteria for sustainable urban development. As a result, the realization of sustainable development in neighbourhoods is the initial step towards sustainable development at higher levels. (Cf. Lützkendorf, p.7)

Therefore, it can be stated that the use of certification systems and the results of sustainability assessment is significant for all the people and groups in an urban zone. The following image introduces these groups (so-called community stakeholders):

Figure 10 : Urban development stakeholders
Source: Own evaluation based on Lützkendorf, p. 7

The advantages and importance of certification systems for each of these groups are studied below:

- National and local governments: city managers and decision makers at local government levels can use certification systems for the following purposes:
  - Examining the benchmarks specified by certification systems in order to understand the strengths and weaknesses of cities.
  - Monitoring the determined objectives, adopted policies, and improving urban development strategies.
- At higher levels, national governments use certification systems for the following purposes:
  - Monitor and track local government performance.(Bhada (2009)
  - Sustainability is assessment in different cities and policy adoption and investment for integrated urban development.
  - As an instrument to measure and monitor the degree of achievement in predefined national objectives and realization of international programs.
- User, visitor, and public: the greatest merit of certification systems for people (building buyers and tenants, users of public places in neighbourhoods, public transportation users, etc.) is their confidence in the existence of sustainability criteria in certificate-holding districts. In fact, these certificates play the role of a guarantee or a reliable brand for buildings and districts. So, the users can make sure of the high quality of living in a particular building or district and benefit their advantages, such as:
  - Clean air, green area, healthy water, etc.
  - Reduction in maintenance and marginal costs of buildings in the course of time, compared with conventional buildings.
  - Reduction in water and energy consumption in sustainable buildings (energy saving potential: 30% compared with conventional buildings).(Deutsche Bank Research (2010))

  - Reduction costs in urban services and transportation.
  - In general, benefit from economic, social, and environmental advantages in the district of residence.
- Owner, investor, and project developer: the importance and merits of certification systems for this group can be classified as follows:
  - Greater market attractiveness.
  - Lower risk of building vacancy in the district.
  - Higher value of the district and the buildings (the rents and purchase prices are at least 5% higher than conventional buildings).
  - Saving in construction costs and infrastructure-related activities.
  - Certainty of construction quality.
  - Saving in construction costs and time,
- Bank and insurance company: certification systems can play the role of advisor for credit organizations and insurance companies:
  - Reliable investment and certainty of the success of certificate-holding projects.
  - Helping banks and insurance companies to value buildings and districts.
  - Insuring buildings and urban development projects according to their rating and merit in risk management.
- Planner, engineer, and builder: construction companies can use certification systems for the following purposes:
  - Improving project optimization according to the results of assessment in different phases.
  - Help to present more useful plans with the use of experience and information gained from previously certified projects.
  - Using better building materials and new technologies during construction process.

On the other hand, certification systems have disadvantages, too; some are:

- The problem of gathering data and preparing the documents required for assessment.
- Financial and time costs of certificate imposed specially on small or old projects.
- Creating a new bureaucracy in projects execution
- The existing districts loss (uncertified) compared to new and certified districts (due to this incorrect belief that uncertified buildings or districts are necessarily unsustainable).
- Limiting local governments in the design and execution of urban projects because of the inflexibility of certificates (special conditions and needs of districts, financial and technical facilities of project executives, managers’ and the public opinion are all influential).

In general, the advantages of certification system outweigh the disadvantages. Besides, some of the disadvantages will be resolved with the development of certification systems in the end.

Selecting the criteria and indicators is one of the most important subjects in certificates, which is also the main distinction between them.

Criteria must have the following characteristics (Cf. Bhada (2009)):

- They must be precise and complete as well as transparent and simple (intelligible).
- They must be defined absolutely (not dependent on other factors, time, or place).
- They must be measurable and classifiable.
- They must be useful and effective so that their results can be used to improve implementation plans.
- They must include all aspects of sustainable urban development (so they can measure sustainability as a unified set in a specific area).
- They must be defined according to the objectives and strategies of sustainable urban development so that the achievement of standards leads to the creation of sustainable cities.

Certification systems might assess different criteria based on target groups (local governments, planner and builder, etc.) although there is not a definite delimitation. The programs that are prepared at local government level generally include more indexes that are extensive and can be considered as urban development plans. Two examples of such programs are as follows:

STAR Community Index (STAR Community Index internet portal): US national program to create more liveable, sustainable communities. This program is followed by USGBC, US Green Building Council, and ICLEI (USA) Centre of American Progress and National League of Cities and will enter pilot phase in 2012. This program presents more than 80 indicators in three main categories:

- Environment: include three subcategories of natural systems, planning and design, and energy and climate.
- Economy: include two subcategories of economic prosperity and employment and workforce training.
- Society: include three subcategories of education and arts and affordability and social equity, community, and health and safety.

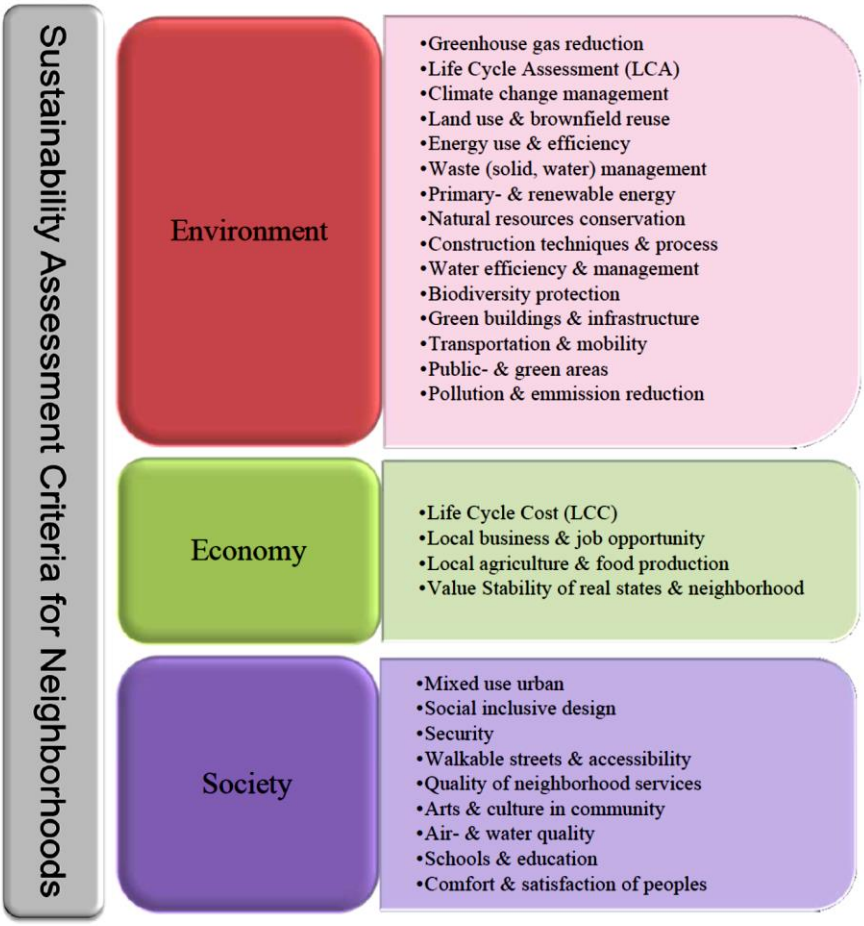


Figure 11 : Sustainability assessment criteria for neighbourhoods

Source: own analysis based on BRE Global (2011) BREEAM Communities: Stage2, Technical guidance manual - USGBC (2011) LEED 2009 for Neighborhood Development - DGNB (2011) Neubau Stadtquartiere (NSQ), Kriterium - ICLEI (USA), (2010) STAR Community Index. Sustainability Goals & Guiding Principles - Enterprise community partners (2011) Enterprise green communities' criteria - University of Toronto. Global city indicators program, Summary report of global indicators- IBEC (2007) CASBEE for Urban Development, Technical manual 2007 edition- GBC Australia, Green Star Communities, National Framework

The Global City Indicators Program (Cf. Bhada, 2009): is one of the programs that help different cities for city performance assessment at international levels. Organization such as UN, the World Bank Habitat, OECD, and ICLEI collaborate in this program. Twenty-eight themes are categorized in this program:

- City services including themes like education, safety, transportation, health, etc.
- Quality of life including themes likes economy, social equity, environment, etc.
- GCIP indices including themes like governance, total energy use, urban accessibility,

Indicators in this program are standardized by ISO. However, certification systems are generally for the purpose of sustainability assessment in buildings or neighbourhoods, and indexes mainly focus on construction issues (related to civil engineering). Therefore, they cannot replace comprehensive urban management programs. After studying different certification systems, the main subjects that are important in assessment are shown in the figure 11.

3.3 National / International Certification Systems

In this section, three important certification systems, which have been offered for sustainability assessment in neighbourhoods, will be introduced. The selected certification systems are:

- BREEAM – Communities: the understanding of this is important; as this is the oldest and one of the most used certification tools.
- LEED – ND: the understanding of this is important; as this is the most famous and widely applicable.
- DGNB – NSQ: the understanding of this is important; as this are one of the newest certificates and the first one from Germany (the most industrial European country and the most active in the construction and development of sustainable cities). The information about each certification system is categorized in table 3.

It is worth to mention, that there are some other certification tools besides these three certification systems, as seen in the following table:

Table 3 : The famous certification tools

Certification Tool	Year	Country	Certification for urban communities
BREEAM	1990	UK	BREEAM - Communities
HQE	1996	France	HQE - Aménagement
LEED	1998	USA	LEED - ND
CASBEE	2001	Japan	CASBEE - UD
Green Star	2002	Australia	Green Star - Communities
DGNB	2009	Germany	DGNB - NSQ

Source: own analysis

3.3.1 A comparison between certification systems

This section is dedicated to the comparison and evaluation of certification tools. For this purpose, the following certification systems (which were introduced and studied in the previous chapters) will be compared: BREEAM Communities, LEED-ND, and DGNB-NSQ. It is worth mentioning that this comparison does not mean to select the best certification system or recommend one of these three to be applied as a global standard; on the contrary, it intends to study and compare the features of these certification tools in order to indicate the advantages, disadvantages, and the unique features of each. The table 4 shows the overall characteristics of these three certification systems. Various factors can be applied to compare certification systems. Here, certification tools are compared and evaluated based on rating system, certification process, and criteria.

3.3.1.1 Rating system

As far as rating system is concerned, three major differences can be noticed between certification systems. The first difference is related to the weight that each criterion has for scoring. In DGNB, this weight, which is indicative of the significance of each criterion, is considered 1 to 3 for each criterion. Each main group also has a weight (DGNB has 5 main groups); for the existing main groups, this weight equals 22.5% (except the process quality which has the weight of 10%). In BEEAM, not only are the weights of criteria different, they also vary based on different locations - the nine English Regions (in general, the weight is considered between 0.5 and 1.0). Apart from this, the main groups don't have a specific weight (BREEAM has 8 main groups). LEED rating system is mostly similar to BREEAM in that the criteria have different weights based on their importance. However, main groups don't have specific weights individually; in fact, the number and weight of the existing criteria in each group determine its weight. In the figure 12, the main groups and their importance are shown for each certification system.

The second difference is in the "minimum gained score". This issue is defined as pre-requirements in LEED, and as mandatory credits in BREEAM; it means that some of the criteria are mandatory and gaining the minimum score in them is necessary in all projects. This ensures the existence of some fundamental elements in the project. There are no mandatory criteria in DGNB; the minimum gained score is considered in each main group. The final rating of the project depends on the final gained score as well as this factor (see the tab. 14). As a result, a minimum quality level is guaranteed for all the elements of the project.

The third and last difference in rating systems of the certification tools is related to different rating levels. The following image shows the rating levels for BREEAM, LEED, and DGNB:

Figure 12 : A comparison between BREEAM, LEED, and DGNB rating levels

Source: DGNB (2011) NSQ10-C00 Allgemeine grundlagen BRE Global (2011) BREEAM Communities: LEED 2009 for Neighborhood Development

According to the image, DGNB is generally the strictest about certifying projects, and then comes LEED and finally BREEAM. However, BREEAM uses the most labels for certification; and ranking highest (outstanding for which special requirements are presented) in it is much more difficult than ranking highest in other certification systems (gold for DGNB; platinum for LEED). Overall, LEED utilizes a simpler rating system than the other two certification systems; BREEAM stands in the middle and finally DGNB has the most complex and strict rating system.

Table 4 : An Overview of three certification systems

	BREEAM Communities	LEED - ND	DGNB – NSQ
Title	Building Research Establishment Environmental Assessment Method (for) Communities	Leadership in Energy and Environment Design - Neighbourhood Development	**German Sustainable Building Council - New City Districts** **(Deutsche Gesellschaft für Nachhaltiges Bauen - Neubau Stadtquartiere)**
Logo			
Developer	Building Research Establishment (BRE)	U.S. Green Building Council (USGBC)	**German Sustainable Building Council (DGNB)**
Country of origin	United Kingdom	United States of America	**Germany**
Release	2009	2009	**2011**
Groups of Criteria	- Climate & Energy - Resources - Place Shaping - Transport & Movement - Community - Ecology & Biodiversity - Business & Economy - Buildings	- Smart Location & Linkage - Neighbourhoods Pattern & Design - Green Infrastructure & Buildings - Innovation & Design Process - Regional Priority Credits	**- Ecological Quality** **- Economical Quality** **- Sociocultural & Functional Quality** **- Technical Quality** **- Process Quality**
Rating System	Outstanding Excellent Very Good Good Pass	Platinum Gold Silver Bronze	**Gold** **Silver** **Bronze**

Certification phases	- Planning - Project completion	- Planning - Construction - Project completion	**- Planning** **- Construction** **- Project completion**
Certification Institute	Building Research Establishment (BRE) Global	Green Building Certification Institute (GBCI)	**German Sustainable Building Council (DGNB)**
Assessment Method	Third-party, Education and Accreditation through BRE Global	Third-party, Education and Accreditation through GBCI	**Third-party, Education and Accreditation through DGNB**
Certified Projects	-	100 registered, 2 certified (2011.08.30)	**-**
Website	www.breeam.org	www.usgbc.org	**www.dgnb.de**

Sources: Internet portals of: BREEAM (http://www.breeam.org/), LEED (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19), DGNB (http://www.dgnb.de/_de/). Also Cf. Heyder, Monika and Koch, Andreas (2011) Nachhaltigkeitszertifizierung von Stadtquartieren als Beitrag zur Nachhaltigen Entwicklung

3.3.2 Certification process

In this section, the most important benchmarks for comparison are essential steps for certification and different certification phases. In general, in the steps required for certification there are no fundamental differences between the three-certification tools. In short, the rating process begins with registering the project. The documents required for assessment are completed and submitted to the corresponding certification institute. After criteria examination and rating, the certificate is issued. The assessment method, which is in the form of third-party assessment, is similar in these three systems; the only mentionable difference is in LEED, which does not necessitate a trained professional for completing, examining, and submitting the documents. On the other hand, the use of LEED Accredited Professional (AP) is considered a merit for the project.

Certification phases have been previously explained; however, they are briefly shown for each of these certification systems in the following table:

Table 5 : A comparison between BREEAM, LEED, and DGNB certification process

BREEAM Communities	LEED-ND	DGNB-NSQ
- Interim Certificate (optional) : planning stage **- Final Certificate : post construction stage**	- Conditional Approval of Plan - Pre Certificate - Certificate : post construction stage	- Pre Certificate : Planning - Certificate : Exploitation - Certificate : Quarter, Post construction

Source: Cf. DGNB (2011) NSQ10-C00 Allgemeine grundlagen
Cf. BRE Global (2011) BREEAM Communities: Stage2, Technical guidance manual
Cf. USGBC (2011) LEED 2009 for Neighbourhood Development

3.3.3 Criteria

The criteria in each certification system have been explained in figure 13, in general, and in corresponding section, in detail. However, similar benchmarks and subjects should be used for the comparison between certification systems. Therefore, the criteria and existing groups in BREEAM Communities, LEED-ND, and DGNB-NSQ along with the figure 14 (main criteria of sustainability assessment for neighbourhoods) have been studied and 13 main groups as well as 42 benchmarks for the comparison of these three certification systems are identified. The result is shown in the following figure 15 and table 6.

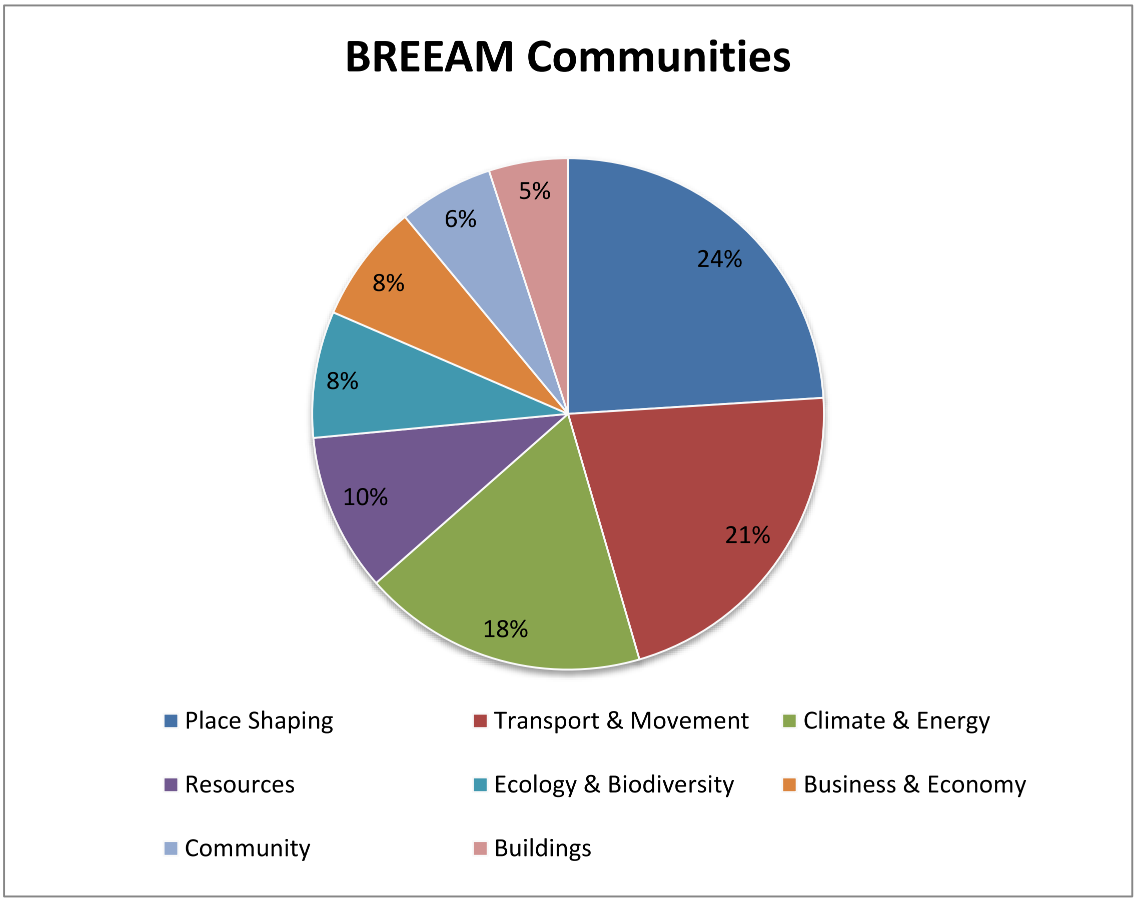
According to the figure 12, some of the subjects receive more attention in one more than in the other two. These subjects are as follows:

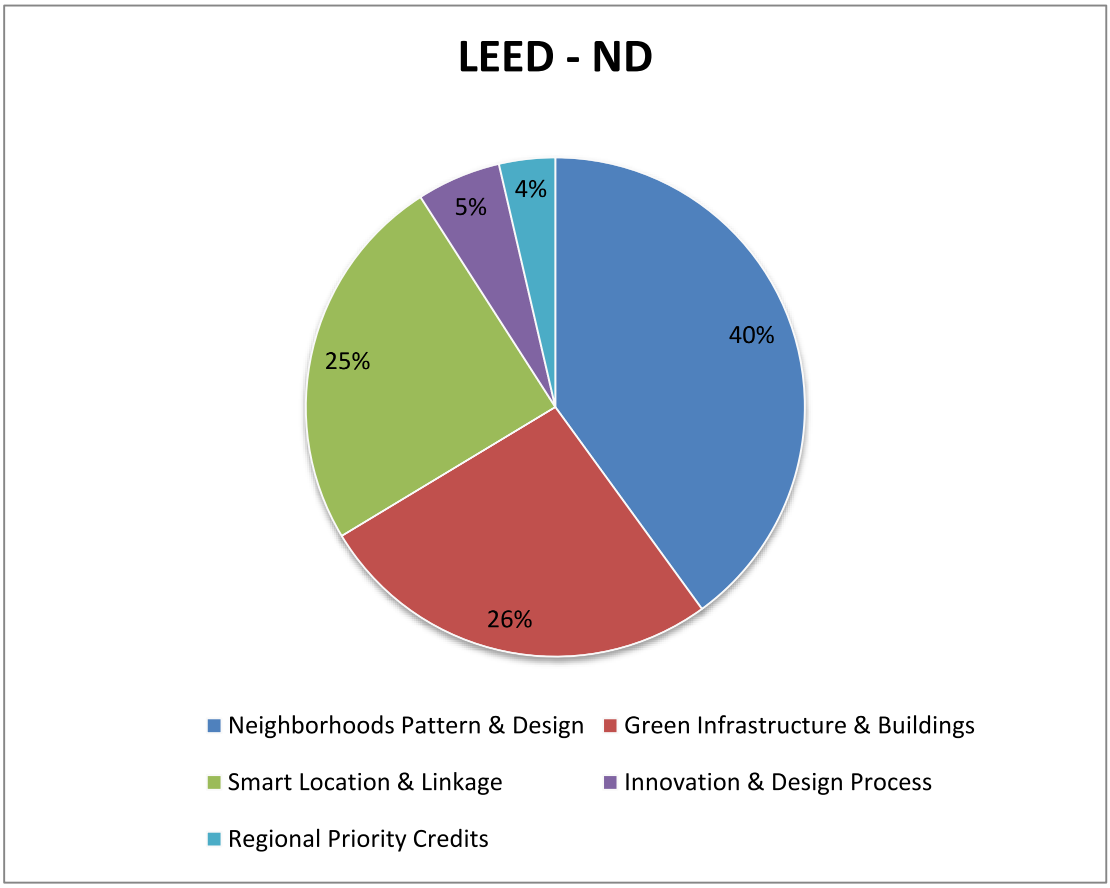
- BREEAM Communities : Transportation, Resources efficient use
- LEED-ND : Location of new community & existing communities, Design & planning
- DGNB-NSQ : Business & economy, Process- & construction management

Overall, studying the criteria and indicators in each certification system results in the following key points:

- DGNB pays more attention to the cohesion of sustainable development aspects (environmental, economic, and social) than the other two-certification tools.
- LEED criteria are most compatible with the common plans and elements of urban planning and criteria assessment in projects is simply possible in practice.
- BREEAM pays the most attention and is yet most dependent on the environmental conditions and characteristics of each project.

Source: own analysis based on BRE Global (2011) BREEAM Communities: Stage2, Technical guidance manual - USGBC (2011)





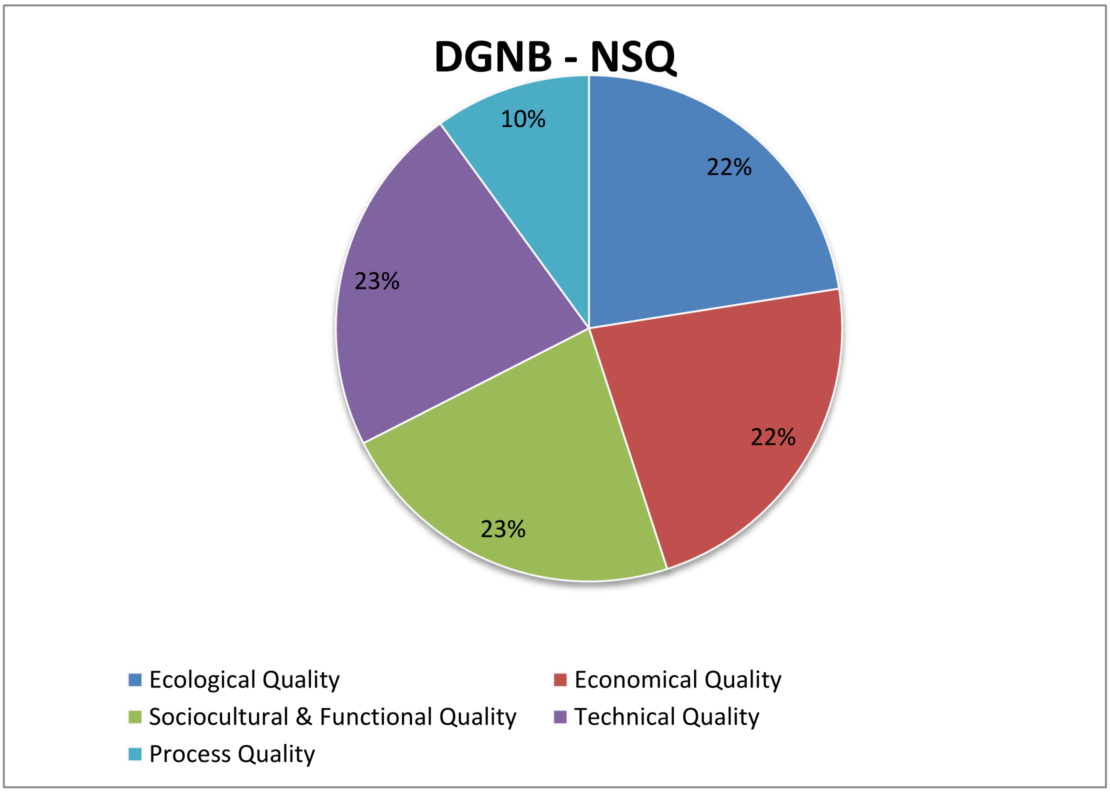


Figure 13 : BREEAM, LEED, and DGNB main groups of criteria

Source: own analysis LEED 2009 for Neighborhood Development - DGNB (2011) Neubau Stadtquartiere (NSQ), Kriterium - ICLEI (USA),

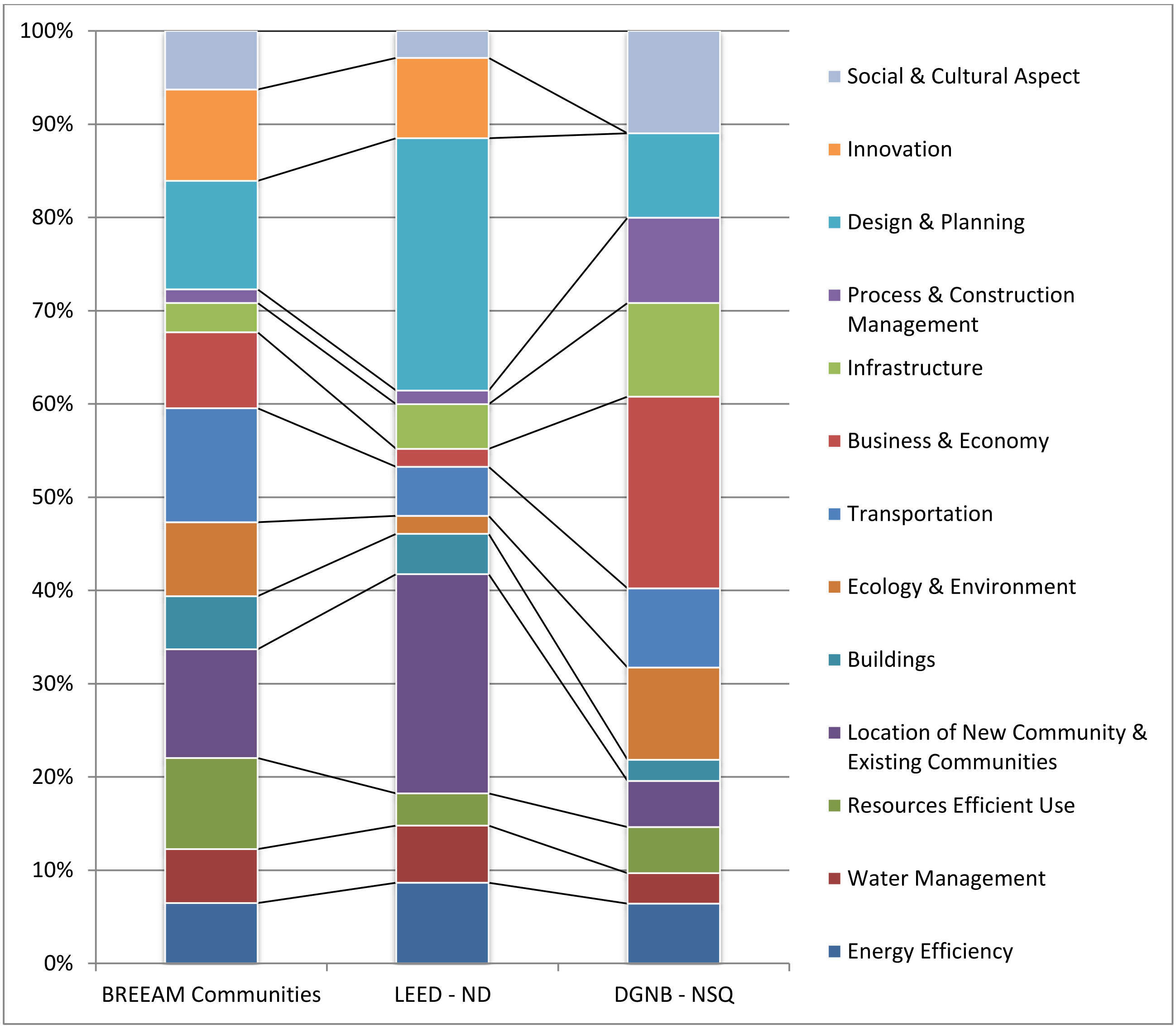


Figure 14 : A comparison between BREEAM, LEED, and DGNB criteria

Source: own analysis based on Internet portals of: BREEAM (http://www.breeam.org/), LEED (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19), and DGNB (http://www.dgnb.de/_de/). Cf. Heyder, Monika and Koch, Andreas (2011) Nachhaltigkeitszertifizierung von Stadtquartieren als Beitrag zur Nachhaltigen Entwicklung

Table 6 : A comparison between BREEAM, LEED, and DGNB criteria (in details)

Main Group	Criteria	BREEAM Communities	LEED - ND	DGNB - NSQ
Energy	Energy Efficiency	●	●	●
	Renewable Energy	●	●	●
Water	Water Management	●	●	●
	Water Efficiency	●	●	●
	Water Recycling	○	○	●
Resources	Local Materials	●	●	●
	Land - Use	●	◐	●
	Water Source	●	●	◐
	Local Food	○	●	●
Location of Project	Accessibility	●	●	●
	Smart Location	◐	●	○
	Brownfield Use	●	●	●
Buildings	Sustainable Building	●	●	◐
Ecology	Biodiversity	●	●	●
	Life Cycle Assessment	◐	◐	●
	Climate Change	●	○	●
	Environment Protection	●	◐	●
	Heat Island Reduction	●	●	○
	Emission and Pollution	◐	●	◐
Transportation	Public Transportation	◐	◐	●
	Street Network	●	●	◐
	Facilities	●	●	●
	Parking	◐	●	○
	Bicycle Network	○	●	●
Economy	Life Cycle Cost	◐	○	●
	Local Business	●	○	◐
	Value Stability	○	◐	●

Infrastructure	Water Management	●	●	●
	Waste Management	●	●	●
	IT and Communication	○	○	●
Process Management	Participation	◐	◐	●
	Construction Management	○	○	●
	Marketing	○	○	●
Design	Walkable Streets	●	●	◐
	Integral Planning	●	●	●
	Mixed - Use	○	●	◐
	Public Spaces	◐	◐	●
Sociocultural	Comfort of People	○	◐	●
	Security	●	○	●
	Inclusive Community	●	●	◐
	Education	○	●	○
Innovation	Innovation	●	●	○

● = Certification system is included directly the criterion
◐ = Certification system is included indirectly the criterion
○ = Certification system is not included the criterion

Source: own analysis based on based on Internet portals of: BREEAM (http://www.breeam.org/), LEED (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19), DGNB (http://www.dgnb.de/_de/). Cf. Heyder, Monika and Koch, Andreas (2011) Nachhaltigkeitszertifizierung von Stadtquartieren als Beitrag zur Nachhaltigen Entwicklung

3.4 The importance and goals of certification system for Sustainable Transportation Criteria

The concept of sustainable development has become a main issue in science and industry. However, various definitions and objectives are presented for it and different strategies are adopted to achieve that. This concept can be explained from three aspects: environmental, economic, and social. Sustainable development can specifically be studied and examined in building industry and urban planning. Considering the growth of urban life, attractions, and the potential of cities for economic, educational, and social successes, on one hand, and challenges cities face, on the other hand, show the importance and need for sustainable urban development. As a result, identifying clear objectives for sustainable urban development and adopting proper strategies to achieve those objectives are of great significance. Due to the variety of objectives, studying conferences and national and international activities in this field is a practical step to understanding them. At international levels, the UN conferences; the most famous ones held in 1987, 1992, and 2002; are some of the examples. At lower levels, EU programs (e.g. Europe 2020) and US programs (EPA, HUD, DOT partnership) can be mentioned. One of the issues considered in certification systems is how they are adapted and developed. The fact that countries; developing ones, in particular; pay attention to sustainability assessment and need certification systems, on the one hand, and the appeal of other countries' markets and the possibility of certification tools development at international levels for certification system developers and relevant organizations, on the other hand, shows the importance of this issue better.

In general, countries that lack a certification system have a number of options to achieve that:

- Use the existing international certification tools (LEED, BREEAM, and DGNB). Different types of these certification systems are used in other countries these days.
- Adaption and localization of international certification tools. Here, existing certification tools are altered (e.g. in criteria) and adapted to the regional needs and conditions. The international version of certification systems (e.g. BREEAM International) has also been released with some changes to be used in other countries.
- Compiling a national certification system based on existing certification systems. HQE (the French standard based on BREEAM), CASBEE (the Japanese standard based on BREEAM and LEED), Steadman (or pearl certification system, the UAE standard based on BREEAM and LEED) are some of the examples.

On balance, the second option is the best and the most practical. Here are the advantages of this option, which can be used to explain this selection:

- Using the experience, knowledge, and brand of international organizations (e.g. BRE, USGBC, and DGNB).
- Comparison and quality control of projects in different countries and helping advance international programs.
- Best practice sharing.
- Saving up on the time and cost of national certification system preparation.
- More transparency and competence in regional markets (e.g. the Middle East and Europe).
- Creating a certification system appropriate to local ecology and climate, infrastructure, construction technologies, specific conditions, etc.
- Creating a certification system compatible with national (or regional) building codes and standards.
- Available in the regional language.

Adaption and development of certification systems must be studied from two aspects:

- Actions and measures taken by certification systems developers and relevant organizations to export certification tools.

- Actions and measures taken by national and local governmental or non-governmental organizations to import certification tools.

It is worth mentioning that another organization, world green building council (WGBC), as a partner for the two stated organizations plays an important role in the introduction and development of certification systems. It has branches in many countries (GBC).

Next, actions taken to transfer and develop certification tools in BREEAM, LEED, and DGNB will be studied:

BREEAM:

BREEAM is known as the most active certification system worldwide. BRE (along with GBC) co-operates with a lot of countries in the adaption of a certification system. BREEAM NL (for Netherlands), BREEAM NOR (for Norway), BREEAM ES (for Spain), and BREEAM SE (for Sweden) are some of the certification tools which have been designed for other countries (under BRE Global license).

BRE has also presented a number of certification systems for global level, e.g. BREEAM Europe commercial, BREEAM Gulf (for countries in Persian gulf region), and BREEAM international. Adapting criteria and their importance factor to regional conditions is what distinguishes these certifications, for example, the criterion “water” in BREEAM Gulf and “energy” in BREEAM Europe have certain weights.

In particular, BREEAM Communities is normally heavily dependent on regional specifications (specifically England’s 9 regions), but it can be applied to projects outside England with use the international bespoke in sustainable development framework. Under these circumstances, the steps of certification process are briefly as follows: the criteria and rating tool have to be prepared by BRE, specifically for the project. For this purpose, the project team and BREEAM international assessor, and a local consultant if necessary, prepare the information and characteristics of the project, criteria, and relevant local codes and standards, and submit them to BRE. After the documents are approved, the process will continue like BREEAM Communities certification process (further information is available in the chapter about BREEAM).

LEED:

LEED is one of the active certification tools at global levels, which is highly capable of adaption and use in other countries due to its unique features. LEED Canada, LEED India, and LEED Brazil are among the most well-known certification tools which have been designed for other countries with the co-operation of USGBC and national GBC.

LEED pays special attention to local and regional conditions by using the criterion “regional priority credits” as one of the criteria main groups for project assessment.

USGBC has also offered LEED international for non-U.S. projects. In LEED-ND, some prerequisites make it possible to be applied to non-U.S. projects. These prerequisites can be studied as follows: generally, rating system, certification process, and list of criteria for non-U.S. projects are not different from the ones for U.S. projects. The only challenge is in the assessment and examination of some of the criteria. For this purpose, USGBC is requesting feedback from international projects to determine if the certification system encourages regionally appropriate and culturally sensitive planning and design decisions outside of the U.S. There are three methods of feedback:

1. The international questionnaire, which must be submitted to USGBC before the registered projects submits for the SLL Prerequisite Review or the first stage of certification.

2. A detailed survey about thresholds, metrics, and standards in the rating system, which can be submitted before or after certification review.

3. Participation in at least one interactive feedback session.

DGNB:

Although it has been less than three years since the first DGNB certification tools were presented, this organization co-operates with various countries, specially neighboring countries (Germany), in certification system adaption. This co-operation has resulted in DGNB Switzerland (SGNI), DGNB Austria (ÖGNI), and DGNB Bulgaria.

Today, DGNB is known as one of the international certification systems, especially in Europe. As DGNB-NSQ version is still young, it has not been specifically presented for international use.

3.4.1 Essential circumstance steps must be taken for adaption and development to prepare a certification system

All things considered, certification systems are of great significance at international levels and play a key role in the whole development of sustainability and for defining Sustainable Transportation Criteria. This raises a basic question as to what essential steps must be taken for adaption and development, and more generally, to prepare a certification system. To answer this question, adaption process of certification systems, along with national Green Building Council's experiences have been studied. The result, which is in the form of a 10-step process, is as follows:

1. **Understanding the current condition:** this step includes the study and examination in order to identify a general sustainability schema (including a general understanding of environmental, economic, and social aspects, infrastructures, construction technologies, etc.), specifying weaknesses, strengths, and priorities of region.
2. **Establishing local organizations and governmental or non-governmental departments:** these organizations, with the help of certification systems developers (such as BREEAM, LEED, etc.), are responsible for the examination of different certification systems, selecting one or some of them, and then development and adaption of the certification system for region. GBC is known as one of such organizations. Research organizations, consulting organizations (including experts

and stakeholders), and human organizations (for public participation) are also among them.

3. **Developing legal mechanisms:** rules and regulations related to co-operation with foreign and international organizations, and specifically relevant organizations of certification systems are established in this step. The authority and responsibility of organizations are defined and legal permits are obtained, if necessary.
4. **Completing and improving standards:** identifying local standards and building codes, updating and completing them, and applying international standards, if necessary. These standards are used in relevance to certification system structure and criteria.
5. **Acknowledgement and training:** includes specialized understanding of strategies for sustainable development and certification systems, co-operation with international scientific organizations for experience and information sharing, international assessors training, and public training and informing about certification systems.
6. **Creating or completing databases:** these databases are used as instruments for criteria assessment. Building materials database is an example of this type of instruments.
7. **Preparing technical documentation:** includes relevant local codes, local criteria and priorities, and other essential documents for adaption of a certification system. These documents are prepared by local organizations (with the help of consultants and assessors) based on the existing certification systems, and are submitted to the corresponding organization (relevant organization of certification tool).
8. **Offering an adapted certification system:** the main core is usually preserved in this certification tool. However, any of the system elements, including rating system (includes rating levels and criteria weightings) and list of criteria, might change according to the documents submitted by local organizations and certification institute (e.g. BRE or USGBC) examination.
9. **Pilot phase:** in this test phase, some projects (selected by relevant organizations) are certified. Some or all of the criteria might be selected for assessment.
10. **Monitoring system:** is a system to control certification tool and quality management. Any of certification system elements might be corrected. Technical guidelines and other documents might also be corrected or completed.

3.5 Summary

It is obvious that meeting the objectives, which are identified in this chapter, is not possible without having proper strategies. On the other hand, differences in the objectives, regional conditions, facilities, and needs result in different strategies. Therefore, considering these difference, the main question is whether it is possible to develop specific strategies for sustainable development. The answer is that if the general objectives and fundamental aspects of sustainable development are identified at international and national levels, the details are considered at regional and urban levels; practical strategies and projects are devised at regional levels, and supported and monitored at national and international levels, reaching common strategies for sustainable development becomes possible. Strategies required for sustainable urban development and Sustainable Transportation Criteria can then be categorized as follows:

- Create a plan for sustainable development
- Support local and regional governance (decentralization)
- Create a strong local partnership (between different groups in each city quarter)
- Investment on knowledge- R&D
- Support regional cooperation (between neighbourhood city quarters)
- Cohesive urban development
- Monitoring and reporting the progress

Applying these strategies and devising and developing projects can lead to the realization of and Sustainable Transportation Criteria objectives, from the lowest level (city districts) to an international level. It has to be taken into account that the projects and regional activities must be constantly controlled and the objectives and strategies must be updated, if necessary. Certification systems are the tools that have been established and developed for this purpose. In other words, they are a quantitative standard to measure the concept of sustainable development in any region. By defining a set of criteria and a rating system to score them, these systems assess projects during a specific process. The result of this assessment can be useful for different groups, e.g. national and local governments, users, planners, builders, owners, investors, etc. BREEAM, LEED, and DGNB are some of the most well-known international certification systems.

According to the role and importance of city districts as the foundation of sustainable development, BREEAM Communities-, LEED-ND, and DGNB-NSQ certification tools have been developed specifically to assess sustainability in urban communities.

As countries, developing ones in particular, pay more and more attention to certification systems, applying these systems proper to regional conditions and needs has become their aim. Therefore, studying international certification systems (such as BREEAM, LEED, and DGNB), identifying their weaknesses and strengths, and creating a clear process to adapt them to regional conditions are essential to achieve the stated objective.

It can be concluded that identifying comprehensive objectives, adopting proper strategies to realize those objectives, applying certification systems to control the performed activities, and correcting the objectives, and strategies guarantee sustainable development achievement. Additionally this methods and process can be used for measuring and monitoring sustainable transportation and based on each area, the suitable certification system can be chosen.

4. The Transportation Planning

4.1 Introduction

Transportation helps shape an area's economic health and quality of life. Not only does the transportation system provide for the mobility of people and goods, it also influences patterns of growth and economic activity by providing access to land. In this chapter, the performance of the system affects public policy concerns like air quality, environmental resource consumption, social equity, land use; urban growth, economic development, safety, and security are reviewed. Additionally Transportation planning recognizes the critical links between transportation and other societal goals. The planning process is more than merely listing highway and transit capital projects. It requires developing strategies for operating, managing, maintaining, and financing the area's transportation system in such a way as to advance the area's long-term goals.

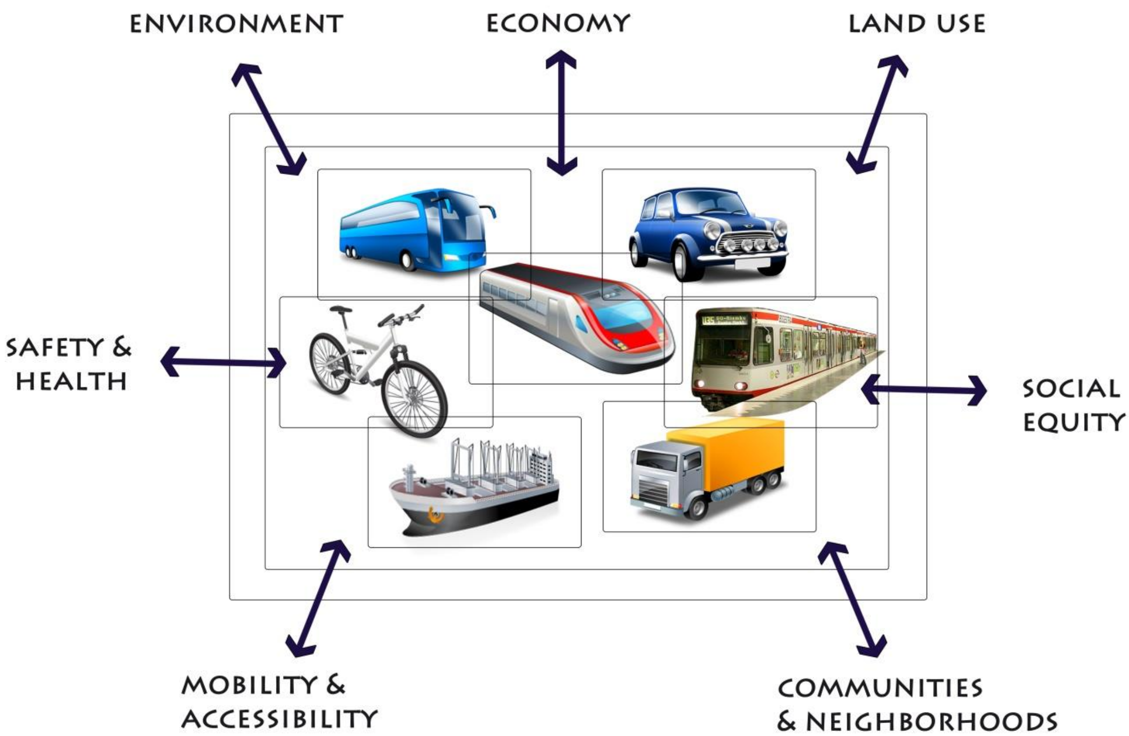


Figure 15 : Links between Transportation and Societal Goals
Source: own evaluation

Transportation planning is a cooperative process designed to foster involvement by all users of the system, such as the business community, community groups, environmental organizations, the traveling public, freight operators, and the general public, through a proactive public participation process conducted by the Metropolitan Planning Organization (MPO), state Department of Transportation (state DOT), and transit operators. This chapter aims to cast light on these issues by providing an integration of literature relevant to the area. This is followed by a brief review the transportation planning and different aspects of sustainable transportation.

4.2 Transportation planning process

Transportation planning includes a number of steps:

- Monitoring existing conditions;
- Forecasting future population and employment growth, including assessing projected land uses in the region and identifying major growth corridors;
- Identifying current and projected future transportation problems and needs and analysing, through detailed planning studies, various transportation improvement strategies to address those needs;
- Developing long-range plans and short-range programs of alternative capital improvement and operational strategies for moving people and goods;
- Estimating the impact of recommended future improvements to the transportation system on environmental features, including air quality;
- Developing a financial plan for securing sufficient revenues to cover the costs of implementing strategies, Figure 16 illustrates the transportation planning process.

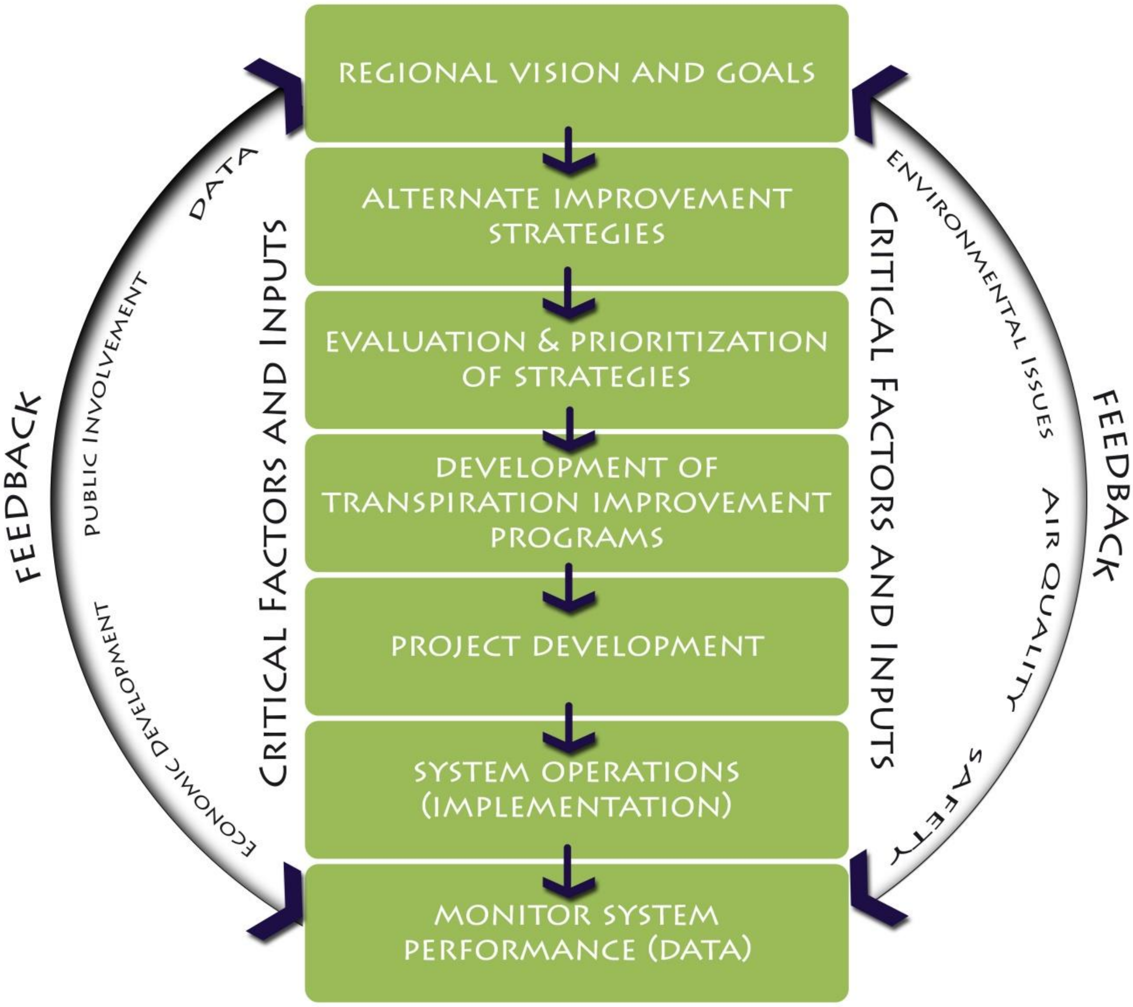


Figure 16 : The transportation planning process

Source: own representation based on The Transportation Planning Process Key Issues, 2007

Figure 16 shows the basic steps in the transportation planning process. While each step in the process depends on all the other steps before it, the "feedback" arrows demonstrate that the process is continuous and flexible. The planning process accommodates changes that influence the transportation system and related decision making processes.

Transportation planning is more than listing highway and transit projects. It requires developing strategies for operating, managing, maintaining, and financing the area's transportation system to achieve the community's long-term transportation goals. It looks for ways to solve current transportation problems while anticipating and addressing issues likely to occur in the future. The planning process:

- Links transportation goals to the goals of land use, cultural preservation, social, economic, environmental, and quality of life for the area covered by the plan;
- Uses data to examine current transportation operations and identify future transportation needs;
- Helps planners and Tribal governments make well-informed decisions on how to spend money set aside for transportation projects;
- Involves Tribal communities, Federal government agencies, State and local governments, metropolitan and regional planning organizations, special interest groups, and others;
- Results in workable strategies to achieve transportation investment goals over both the long term (20 years or more) and the short term (three to five years);

4.3 Public Participation in the Planning Process

Since planners have the professional background and experience in planning, there is often a belief that they would be able to consider and decide the best option that can meet people real needs and satisfy them. However, even though a planner has the experience in planning, it is not possible for them to know the specific transport needs of a locality. This is why public participation is very important in any type of planning process. For example increases the likelihoods that actions that are taken or services that are provided by public agencies more adequately reflect the needs of the public. (United Nations Economic and Social Commission for Asia and the Pacific) A Guidebook is the Application of Public Participation in Planning and Policy Formulation towards Sustainable Transportation. There are three main reasons of public participation. First, the involvement of all stakeholders including the public is needed to bring qualitative improvement in planning and decision-making.

Second, public participation in planning can deal with the various issues of crosscutting nature. Third, the main element of any transport system is its users. Involving the public in the decision making process provides a better chance of determining the needs of the public especially the disadvantaged group. If these groups are not involved then an important of social equity may remain ignored.

Benefits of Public Participation

The benefits of public participation have made public participation a part of the planning process. In some countries, it is even required by law. A study by TRANSPLUS identifies the following benefits of active public participation:

- Clearer identification of problems.
- Improving the quality of the resulting plans.
- Developing a common basis for action program.
- Raising awareness and encouraging changes in behaviour.
- Overcoming conflicts and streamlining implementation.
- Initiating social empowerment of participants

4.3.1 Transportation Planning in the Comprehensive Plan

A comprehensive plan is a long-term plan, which outlines the vision, goals and objectives and the approaches that a city can take to have that vision come true. As transportation service is a key component related to quality of life, it is not possible to improve the quality of life without improving the transportation system. (United Nations Economic and Social Commission for Asia and the Pacific and CITYNET, 2012)

The comprehensive plan should consider transportation planning adequately. It should mention the direction in which the transportation system should be developed. It should identify the future transportation demands and based on that consider sustainable transportation development plans (short-term, medium-term and long-term) that the city may implement to meet those demands. If transportation planning is not well covered in the comprehensive plan then it generally means that the city has no concrete plans for the transportation system and that in the end the transportation system will most likely be developed without any overall guiding direction. In this case the suggested actions and policy considerations are:

- Identification of future transportation demands of the city using demographic and other economic and social data on a regular basis
- Provisions to include sustainable transportation development in the comprehensive plan such as public transit, network of pedestrian sidewalk and bike lanes

Transportation planning indicators are some of the most valuable tools investors can place in relationship between using demographic and other economic and social data. The suggested for indicators are (United Nations Economic and Social Commission for Asia and the Pacific and CITYNET, 2012):

- Adequate consideration of future strategic directions of transportation development in the comprehensive plan
- Sustainable transportation development plans, policies and projects exist in the comprehensive plan

4.4 Sustainable Transportation

4.4.1 Defining sustainable transportation

An important task of sustainable transportation research and policy is reaching an agreed-upon definition of ‘‘sustainable transportation’’. Without such a definition, we simply do not know where to start, let alone to persuade others into pursuing sustainable transportation. Specifically, if decision- makers do not know clearly what they mean by ‘‘sustainable transportation’’, it is almost impossible for them to promote it, as it will be a moving target and policies and programs based on it would not be consistent and decisive.(Zhou, Jiangping,2012)

About 18 years ago, OECD (1996) commented that there had been extensive research on defining and setting conditions for sustainable development but comparatively little on sustainable transportation. With respect to ‘‘sustainable development’’ the most influential definition is probably the one given in The Brundt land Report named as Our Common Future, a publication by the World Commission on Environment and Development of the United Nations. In this research, sustainable development is defined as development that ‘‘meets the needs of the present without compromising the ability of future generations to meet theirs’’ (The World Commission on Environment and Development, 1987). Many entities have simply adopted the above sustainable development definition as theirs, as indicated in Sustainable Development Commission (2011), Black (2005), and Transport Canada (1997). In academia, voluminous research has been done on "how sustainable development is constituted and how to approach it", for instance, Eichler (1995), Benton (1996), Castro (2004), and Rogers et al. (2008) all provide a review of existing research and efforts, using different ways to categorize a large body of materials they identified. Partially built on the research on sustainable development, the past 10 years or so have seen several reviews of different definitions of sustainable transportation (e.g., Black, 2005; Hall, 2006; Litman and Burwell, 2006; Jeon et al., 2007; FHWA, 2011; Oregon Department of Transportation, 2006, 2008). In each of the reviews, authors were able to identify many definitions of ‘‘sustainable transportation’’. The lack of discussion on definitions of ‘‘sustainable transportation’’ argued by OECD (1996) thus now is no longer the case. To substantiate, table 6 highlights some sustainable transportation definitions since 2002.

Most authors believe that ‘‘sustainable transportation’’ is derived from the idea of sustainable development (OECD, 1996, 2002, 2002; Hall, 2002, 2006). In its totality, sustainable transportation has three equally weighted considerations: environment, economy, and equity (society) (e.g., Litman and Burwell, 2006; Hall, 2006; Deakin, 2002; Lee et al., 2002). This argument is consistent with those by governmental or intergovernmental entities such as Transport Canada (1997) and ECMT (2002).

‘‘Although there is no single, commonly held definition of sustainable transportation, for the department the concept means that the transportation system, and transportation activity

Table 7 : Selected of defining and indicating ''sustainable transportation''.

	Inter-Governmental Entities	Governmental Agencies	Academic/ Professional Associations & NGOs	Individual(s)
Before 2002	M, E 3 - OCED	△ R - Transport Canada		□ -Van Veen-Croot & Nijkamp M E 3 -Kenworthy & Newman
2003	△- OCED	T - FHWA		△ I - Lee ei al E 2 E 3 G - Hirschi ei al
2004				□ - Deakin △ T - Castells T C - Litman
2005			E 2 E 3 M - GEC & EAAD	△ ICT - Black & Nijkamp
2006	△- GEF & UNDPG △- ECMT	△ - Transport Canada △ - ODOT	T - TRS	I R - Black △ R - Jeon et al.
2007				△ G CR - Hall △ R - Litman & Burwell
2008		△ - ODOT		△ I - Macario △ I - Litman △ I R- Jeon et al.
2009				G C - Polk △ I M- Gudmun-dsson C T- Bueler et al.
2010 and after	△ I G - SUMP(2013)	I - EPA (2011) T- FHWA (2011)	T - EF (2012)	△ I- Ramani et al.

Economic Consideration	E 1	Governance	G	Economic, Equality, Environment & Many Others Institutional	□
Equility/Societal Consideration	E 2	Information, Communication & TelcommuteOECDM	ICT	Economic, Equility and Environment	△
Environmental Consideration	E 3	Mode-specific Objectives	M	Indicator and Measurement	I
Review of other definitions	R	Rethinking about Current Way of Living, Traveling, Doing Business, etc	T	Institutional Capacity Building	C

Source: own representation based on (US Environmental Protection Agency (EPA) (2011);FHWA (2001); GEF and United Nations Development Program (UNDP) (2006); General Exhibitions Corporation (GEC) and the Environmental Agency in Abu Dhabi (EAAD) (2005); Hirschi et al. (2002); Newman and Kenworthy (1999); Polk (2007); Ramani et al. (2009).

In general, must be sustainable on three counts, economic, environmental and social'' (Transport Canada, 1997). To ECMT, ''sustainable urban travel'' is providing mobility with little or no harmful impact on health and environment and is providing mobility that ensures economic prosperity at no danger of depleting limited natural resources.

In discussing sustainable transportation, the early focus has been on environmental degradation caused by automobile and resource depletion because of petroleum usage (Deakin, 2002; Black and Sato, 2007). In recent years, authors have gone beyond the focus and have attempted to define and to approach sustainable transportation in more dimensions. These dimensions include: seeking an ''integrated solution'' to sustainable transportation (Litman and Burwell, 2006), building institutional capacity and reforming existing institutions (Hall, 2006), benchmarking transportation sustainability (Black, 2005), operationalizing the definition of sustainable transportation at the regional level (Jeon et al., 2007) and integrate sustainability into routine transportation planning processes at the local and state levels (FHWA, 2011). Arguing that sustainable transportation has both a ''narrow definition'' and a ''broader definition'', Litman and Burwell (2006) contend that the latter enables people to think more comprehensively about all the impacts of transportation. Narrowly defined sustainable transportation focuses on resource depletion and air pollution, while broadly defined sustainable transportation considers not only the a for mentioned but also ''economic and social welfare, equity, human health and ecological integrity''. The latter facilitates people to search for ''opportunities for coordinated solutions'', which encompass ''improved travel choices'', ''economic incentives'', ''institutional reforms'', and ''technological innovation''. It would also contribute to an ''integrated solution'' to sustainable transportation. Built on OECD (1996), Hall (2002), Litman and Burwell (2006), Victoria Transport Policy Institute (VTPI) (2005), and Hall (2006) argue that sustainable transportation needs to look at these elements: environment, economy, equity, and governance. He contends that the most existing definitions of sustainable transportation are lack of ''system-/sector-centric views that tend to be less cognizant of the wider issues (p. 478)''. He advocates a comprehensive definition for sustainable transportation which ''include[s] the transportation sector's interconnections with other sectors'' (p. 478). This definition would help address the lack of an integrated approach to decision-making within the US federal system, which is a major obstacle to progress towards sustainable development and sustainable transportation (Hall and Sussman, 2007). Commissioned by the Transportation Research Board (2005) and Black (2005) conducts a systematic review of existing definitions on sustainable transportation. He argues that there are multiple ways to define and indicate sustainable transportation but all the ways are ''moving toward measurement at some point (p. 37)''. Sustainable transportation should consider measurement of these phenomena related to, or impacts of the transportation sector:

- Diminishing petroleum reserves
- Global atmospheric impacts;
- Fatalities and injuries;
- Local air quality impacts;
- Congestion;

- Noise;
- Biological impacts;
- Equality;

In the same vein, Black and Sato (2007) argue that sustainable transportation results from people's widespread concern over global warming, which is a component in the sustainable development (Deakin, 2002). According to Black and Sato (2007), sustainable transportation could be best defined by the factors that make transport unsustainable and by what can be done about such ‘‘negative externalities’’ of transportation.

Interested in measuring sustainable transportation and the progresses made in Atlanta, GA, Jeon and Amekudzi (2005) and Jeon et al. (2007) explore working definitions of sustainable transportation used by different government agencies professional and academic entities. Their work indicates that multiple governmental agencies, academic/professional entities, NGOs, and international organizations had been pursuing ‘‘sustainable transportation’’, no matter they had defined sustainable transportation or not at the outset. The US Department of Transportation (USDOT) and 14 State DOTs had listed the sustainability-related objectives in their respective mission statements as of 2007. Despite this, many of them did not even define what ‘‘sustainable transportation’’. Outside the US, according to Jeon and Amekudzi (2005) and Jeon et al. (2007), institutions in Canada, for instance, VTPI and the Centre for Sustainable Transportation (CST) had working definitions for sustainable transportation in place since 2003 and 2005, respectively. VTPI's definition emphasizes social and equity aspects of transportation systems ‘‘attentive to basic human needs’’. CST's definition encompasses economic, environmental, and social aspects of transportation. Per the CST definition, sustainable transportation should account for multiple objectives simultaneously: access needs of individuals, safety, transportation system, operation efficiency, environmental protection, and economic vitality. Putting all the above work on defining ‘‘sustainable transportation’’ together, we can see that there is still not a universally accepted definition of ‘‘sustainable transportation’’. Collectively, the definitions identified still show that:

1. The idea of ‘‘sustainable transportation’’ derives from the concept of sustainable development.
2. Sustainable transportation is about a balanced pursuit of multiple objectives. At the minimum, sustainable transportation should equally account for the transportation sector's impacts on local society, economy, and the environment.
3. To better define or pursue sustainable transportation, it is necessary to somehow measure how ‘‘sustainable’’ or ‘‘unsustainable’’ existing or planned transportation systems are. This also means that when pursuing sustainable transportation, there should be a task about establishing a measurement or accounting system for transportation.
4. Sustainable transportation is not just, about how transportation systems are performs or measured. It is also about institutional capacity building, institutional reform,

governance, interconnections between the transportation sector and other sectors, among others.

5. Lack of a working definition of ‘‘sustainable transportation does not prevent people from promoting ‘‘sustainable transportation’’;

Bearing the above findings in mind, the following discussion on goals, visions, and strategies of sustainable transportation adopt a broad rather than narrow perspective. This allows us to look at various goals, visions, and strategies directly or indirectly related to ‘‘broadly defined’’ rather than ‘‘narrowly defined’’ sustainable transportation, which ‘‘dominates nearly all research in transport’’ (Black and Sato, 2007).

4.4.2 Goals, visions, and strategies by individuals

No matter how they defined ‘‘sustainable transportation’’, individuals and entities have proposed different goals, visions and strategies of ‘‘sustainable transportation’’.

At some risk of oversimplifying, we have summarized existing goals, visions and strategies by individuals into the following groups, according to what people think sustainable transportation is all about, how they trace the root of sustainable transportation, and how they think sustainable transportation ideas can be materialized.

4.4.2.1 Sustainable transportation is about measurement

If one does not know how sustainable or unsustainable the current transportation system is, she or he probably does not know exactly what to do next about the system (Black, 2005). Table 2 summarizes the indicators and measurements for ‘‘sustainable transportation’’ proposed by different authors. On the one hand, the indicators and measurements quantify impacts of different transportation systems; on the other hand, they partially represented the directions where the authors want ‘‘sustainable transportation’’ to go, and which areas ‘‘sustainable transportation’’ strategies/goals should focus on.

4.4.2.2 Sustainable transportation is about changes

With a thought that ‘‘sustainable development is the code word for the most important social debate of our time’’, Castells (2002) questions the current ways of consumption and transportation. Castells argues that sustainable development and sustainable transportation are both about changes in general and about changes in large cities. In particular general and about changes in large cities ‘‘it is in large cities where we generate most of the CO_2 emissions that attack the ozone layers’’ and ‘‘[it] is our urban model of consumption and transportation that constitutes the main cause of the process of global warming and can irreversibly damage the condition of livelihood’’.

Similarly, Litman (2003) asks for ‘‘rethinking’’ about the end, focus, and decision- making process in transportation planning ‘‘sustainability requires rethinking how we measure transportation’’. Vehicle movement should not be ‘‘an end in itself’’ and transportation planners should consider ‘‘access’’ and ‘‘comprehensive decision-making’’. To him, better planned ‘‘access’’ reduces the needs for travel while not compromising quality of life.

‘‘Comprehensive decision-making’’ requires people look at both ‘‘direct’’ and ‘‘indirect’’ impacts of transportation.

4.4.2.3 Sustainable transportation as a part of sustainable development

Deakin (2002) argues that sustainable development is an outcome of people’s increased concerns about environmental quality, social equally, economic vitality, and the threat of global climate change. The strategies for increasing transportation sustainability, a ‘‘principal component’’ of sustain- able development, include demand management, operation management, pricing policies, vehicle technologies, clean fuels, and integrated land use and transportation planning (pp. 5–6). In the same vein, Benfield and Replogle (2002) maintained that sustainable transportation is an essential component of sustainable development as transportation is a ‘‘prerequisite to development in general’’ and ‘‘contributes substantially to a wide range of environmental problems, including energy waste, global warming, degradation of air and water, noise, ecosystem loss and fragmentation, and decentralization of landscape’’.

They point out that ‘‘legal and political framework for sustainability in American transportation has been improved’’ since 1992 but the US federal government had not addressed ‘‘matters related to fuel efficiency and emissions control through vehicle technology’’. Their proposed federal-level strategies for sustainable transportation are:

- Establish and work towards goals for energy conservation and equity;
- Recognize ‘‘induced demand’’ in transportation planning and management;
- Provide subsidy for less polluting transportation modes;
- Encourage use-based car insurance;
- Improve and expand pedestrian and bicycle facilities;
- Expand incentives for affordable housing near jobs and transit;
- Improve motor vehicle fuel economy with stronger CAFE standards.

4.4.2.4 Sustainable transportation is beyond transportation

Instead of focusing on specific strategies or visions for sustain- able transportation, Hall (2006) focuses on a decision-support framework and a ‘‘road map for developing policy that will move the transportation system towards sustainability’’. Hall argues that sustainable transportation is not just about the transportation sector, and that there is a lack of integrated decision-making mechanism for promoting sustainable development within the US federal political system. According to him, federal agencies, especially USDOT should be ‘‘enlightened’’ and lead efforts towards sustainable transportation. Hall identifies major challenges faced by the US for promoting sustainable transportation as the ‘‘problems of horizontal, vertical, spatial, and temporal integration’’. He asserts that in the current political setting, USDOT is relatively weak given the ‘‘division of transportation functions across Congressional committees, powerful policy networks that promote modal interests without necessarily being concerned about the wider system impacts (p. 667)’’. In addition, despite there were ‘‘a number of federal initiatives that support the progress of specific aspects of sustainable transportation’’, ‘‘the effectiveness of these initiatives is likely to be reduced by the fact that there is no federal mechanism to coordinate or integrate these activities (p.

687)''. Thus, Hall (2006) recommends that different elements (i.e., economic, social, and environmental objectives) of sustainable transportation be pursued separately. ''Given the lack of Congressional interest in sustainable development, a better approach than pushing the ST (Sustainable Transportation) framework in a unified manner might be to repackage and promote the various elements of the framework individually (p. 631)''.

4.4.3 Goals, visions, and strategies by high- profile entities

Since the publication of Our Common Future in 1987, the concept of sustainable development has been increasingly accepted by NGOs, governmental and intergovernmental agencies, professional associations, academic organizations, among others. As an important element of the concept, sustainable transportation has also been increasingly attended to. Many high-profile entities have articulated their specific visions, goals, and strategies for sustainable transportation. Unlike what was discussed in academia, opinions or positions explicitly expressed by these entities that are closer to public policies and actions. The following subsections discuss the visions, goals, and/or strategies for sustainable transportation by these entities.

4.4.4 Entities with a global perspective

Other than the United Nations, the World Bank is another influential entity which has a global presence and which is interested in promoting sustainability. The World Bank started addressing the issue of sustainable transportation in its publication in 1996. It argued that then there were three challenges facing the transportation sector in different countries

- Increasing responsiveness to customer needs;
- Adjusting to global trade patterns;
- Coping with rapid motorization;

To cope with these challenges, it recommends nations reform transportation policy, incorporating the idea of ''sustainability''. It interprets ''sustainability'' as a three- fold concept: economic and financial sustainability, environmental and ecological sustainability, and social sustain- ability. Economic and financial sustainability means that ''resources be used efficiently and that assets be maintained properly''. Environmental and ecological sustainability indicates that ''the external effects of transport be taken into account fully when public or private decisions are made that determine future development''. Social sustain- ability requires that ''the benefits of improved transport reach all sections of the community'' (World Bank, 1996). The above concept has long-standing impacts on how other entities define sustainable transportation and deal with related issues. For instance, in a background dissertation pre- pared for the World Resources Institute (WRI), Lagan and McKenzie (2004) recommend that the WRI refer to the concept. In 2011, a sustainable transportation guidebook by the Federal Highway Administration (FHWA) (FHWA, 2011) also adopts the above concept.

The WRI Centre for Sustainable Trans- port, which ''fosters government-business-civil society partnerships whose members are committed to finding solutions to the transportation-related problems in their cities (EMBARQ, 2012)''. Similar to EMBARQ, several other

NGOs with an international presence have worked on transportation system sustainability across nations. Most of these entities do not have an explicit definition of ‘‘sustainable transportation’’ but are very active in areas such Bus Rapid Transit (BRT), clean fuel, green freight trucks, and urban design. Good examples of these entities are the Institute of Transportation and Development Policy (ITDP), The Energy Foundation (EF), and Clean Air Initiative for Asian Cities (CAI- AC). More specifically, ITDP helped deliver the Guangzhou BRT project. Working with Cal Thorpe Associates, EF published a guide for low-carbon neighbourhood design. In this document, innovative street design is used to promote transit and non-motorized modes of transportation (The Energy Foundation, 2011). CAI-AC has completed several ‘‘green trucks’’ projects in Guangzhou and Manila.

In recent years, Brookings, an influential think tank in the US has also shown an interest in sustainable transportation. In 2009, it sponsored a report on Germany's sustainable transportation experience. In this research, the authors argue that density and income do not explain the differences in car dependence in the US and in Germany. They recommend the following strategies for the US based what Germany did and achieve in sustainable transportation:

- Using pricing to encourage the use of less polluting cars, driving at non-peak hours and more use of public transit;
- Fully coordinate and integrate transportation-land use planning;
- Increase public awareness of sustainability;
- Implement policies in stages with a long-term perspective (Buehler et al., 2009).

4.4.5 Entities in Europe

ECMT is one of the first intergovernmental organizations that articulated policy tools for ‘‘sustainable urban travel’’, an alternative name for sustainable transportation (Black, 2005). As early as 1995, the ECMT released a report titled ‘‘Urban Travel and Sustainable Development’’. In this research, the ECMT emphasizes the following policy tools:

- Economic incentives and disincentives;
- Land-use planning;
- Traffic management schemes;

In 2000, the ECMT further elaborated the above tools to cover the following sustainable transportation policy goals:

- Improved decision making incorporating best practice in cost benefit analysis and environmental assessment;
- Efficient and coherent pricing and financing of infrastructure;
- Reducing CO2 emissions from road transport;
- Promoting the use of low emission trucks;
- Improving the competitiveness of road alternatives – rail and inland shipping – and removing barriers to international development of their markets;
- Improving road safety;

- Resolving conflicts between transport and sustainable development in urban environments (ECMT, 2000)

In another document focusing on urban transportation sustainability, ECMT (2002, p. 12) believe that cities could reduce car travel to ‘‘achieve sustainable urban development’’. For member national governments pursuing sustain- able transportation, ECMT is recommended strategies be:

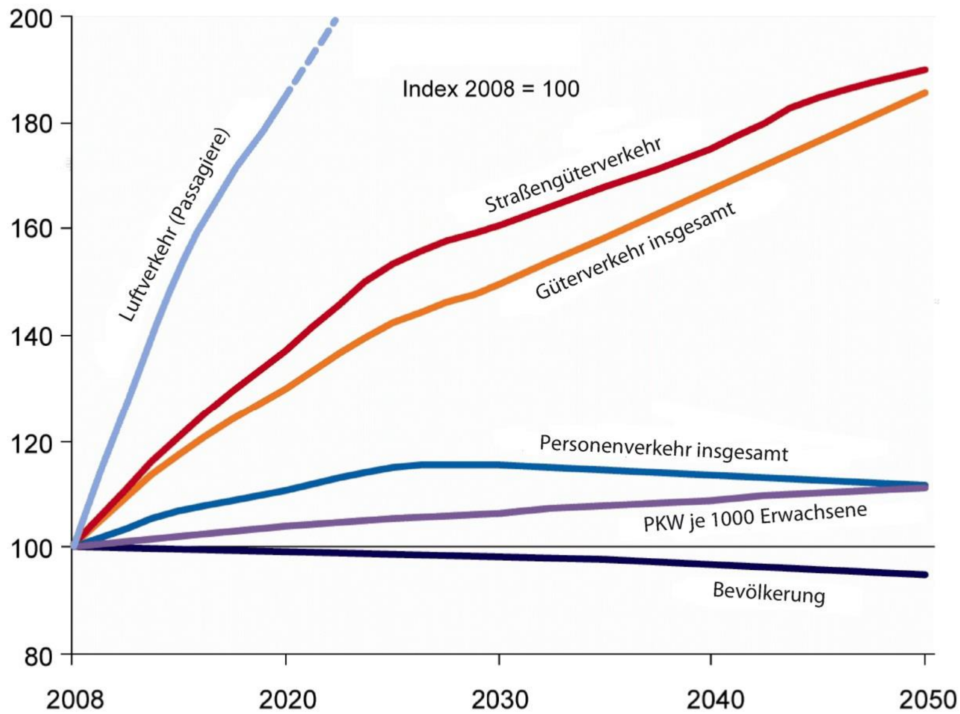
- Establish supportive national policy frameworks;
- Improve institutional co-ordination and co-operation;
- Encourage effective public participation, partnerships and communication;
- Provide a supportive legal and regulatory framework;
- Ensure a comprehensive pricing and fiscal structure;
- Rationalize financing and investment stream;
- Improve data collection, monitoring, research.

In 2003, the European Council of Town Planners (ECTP) released The New Charter of Athens 2003, which details ECTP members’ shared visions on the future of European cities. In the document, ECTP emphasizes that European cities of future should provide their citizens with ‘‘a varied choice of transportation modes’’ and ‘‘accessible and responsible information networks’’. ECTP points out that sustainable transportation should cover the movement of ‘‘persons’’, ‘‘materials’’, as well as ‘‘information flows’’. At different ‘‘scales’’, ECTP puts forward different strategies and goals for sustainable transportation. At the strategic scale, ECTP treats sustainability as one of the four goals for the future EU transportation network. At the city level, ECTP regards ‘‘ease of movement and access’’ and ‘‘greater choice in the mode of transportation’’ as ‘‘critical element[s] of city living’’. Within the city transportation net- work, ECTP attaches great importance to interchange facilities and separation of residences and rapid transportation networks. At the travel demand management scale, ECTP advocates for ‘‘full integration of transportation and town planning’’, ‘‘imaginative urban design’’, and ‘‘easier information access’’ (ECTP, 2003). In the UK, one of the most notable steps towards sustainable transportation is on-line information sharing and marketing. To increase public awareness of the UK’s sustainable development strategy, for instance, the UK government launched a gateway website in 2005 (The Sustainable Development Unit, 2007). This website is not specifically dedicated to sustainable transportation, however, transportation was mentioned as a component of ‘‘sustainable communities’’, one the four key priority areas in the UK’s sustainable development strategy. Per the strategy, a sustainable community should be ‘‘well connected—with good transport services and communication linking people to jobs, schools, health and other services’’. The strategy also lays out 68 indicators to evaluate the sustainability at the national level. Of these indicators, many are transportation-related, such as GHG emissions, road transport connectivity, and efficiency, accessibility, and road accidents.

The UK Department for Transport (DfT), following the UK government's footstep, has published a series of on-line research s covering in-depth the following topics that are related to sustainable transportation:

- Alternatives to travel: how employees can reduce trips while do not compromise productivities;
- How GHG emissions can be measured and reported according to the Dft requirements (DfT, 2011a);
- Information about bio fuels (DfT, 2011b);
- How to consider sustainable transportation in new development (DfT, 2008);
- How 15 local governments in the UK had simultaneously addressed the sustainable transportation and housing growth issues (DfT, 2010);
- How different individuals can use travel plans to make more green trips (DfT, 2011c);
- Guides for local governments about how to deliver sustainable, low carbon, travel (DfT, 2009).

Trend development in the transport systems of Germany- 2008-2050. (Klaus Beckmann and Udo Becker) Transport Economics and Policy assume that the traffic to incalculably long can expand time and continue to be, both in passenger and in Freight transport, both on land and in the air or in the global ship traffic, contributes 80% of world trade. The status quo assessments typically go (still) believe that the current trend is more or less perpetuate, from the postulate of affordable mobility to be released (Hinkel 2009: 15p.).



Source: Postfossile Mobilität und Raumentwicklung, Klaus Beckmann and Udo Becker

Condition of the unchanged " upward " trend curves is a development model which is based firstly on the assumption that the petroleum resource remains sufficient and relatively cheaply available , as it was in the past,and for the further development of only moderate price increases of 1 % p . others (such asin the integration Forecast 2025 ; Hinkel your 2009: 14) assumed. On the other assumed that the reaction of car traffic demand from private households (Fuel price elasticity) " relatively inelastic " short-term " approximately between -0.2 and-0.4 " Long term " will be -0.6 to -0.8 " (IVT et al 2004: . 191).

Specifically, however , these values mean that the car traffic demand in the short decreases by 20 to 40 % and long term by 60 to 80% when the price of gasoline is doubled. Moreover, this interpretation of the empirical findings in the long run not permitted.

More extreme price spikes , such as in 2008 are not yet included. It is questionable whether these elasticities are valid even with fast and strong price surges ." There is some evidence that the actual changes in behavior of households in the Case of drastic price increases could be more pronounced than in model calculations and simulations based on the historical data " (IVT , et al 2004 . 190).

The Federal Transport Infrastructure planning is still based , for example, on the assumption abundant and cheaply available oil . The consulting firm McKinsey (2009) goes in baseline scenario 2008 by oil prices (price-adjusted) of $ 59 per barrel in 2020 and From $ 70 in 2030 , but the case of highly volatile scarcity prices and the necessary Development costs of new high -risk investments significantly be exceeded. The McKinsey assumption makes sense only if one of unchanged abundantly available oil runs out . On the basis of the Federal Ministry of Transport, Building and Urban Development (BMVBS) given for the review of federal transport infrastructure planning in order Predictions based on the master plans airports and freight and logistics are obtained for the sectors of passengers, goods and air transport following trend curves modal:

passenger road transport : The transport capacity , is the actual distance Distances transported persons , increases in motorized Individual traffic after BMVBS - interlacing forecast (ITP , BVU 2007) due to the fast-growing long-distance traffic and increasing journey lengths even more strongly, by a total of 19.4 % from 2004 to 2025. Empirical experiences , what adaptations of steeply rising Fuel prices are chosen are , not yet available. Under the current Conditions have private households theoretically a number of different Options to rising fuel prices - if this because in the high volatility (fluctuation) are recognized as a warning signal – to react (Gertz , Altenburg 2009: 786 f.) They range from short-term actionable Behavioral changes in everyday mobility on the restriction of Activities up to medium actionable changes in the choice of traffic sources and objectives , ie of living, working , training , supply and Recreational sites , leading to a gradual reorganization of inner cities and regions through intra-regional mobility in the course of market-based adjustment processes leads . A trend is possibly due to the high gasoline prices during the survey period in 2008 as part of mobility in Germany (MiD 2008) already : the public transport (PT) and the so-called non-motorized individual transport gain in importance.

Freight transport by road: The vast disproportionately rising freight perspective made clear. After the interdependence forecast 2025 in road transport, an increase of 79%, in Road freight transport even of 84% of the market power related to 2004 expected (ITP, BVU 2007). For a large part of the company play the Currently transport cost shares no major role, mostly are the cost shares with 1 to 4% of the total. At the same time, after the shipping forecast in the German seaports by 2025 with a doubling of the freight turnover and a tripling of container handling expected (PLANCO 2007). Accordingly noticeable Impact on the harbor relevant transport routes and nodes on the hinterland connections (Roads and railways) is expected. Given the projected high growth rates is the question of the future post-fossil mobility of goods more than a challenge . will regional economic cycles establish stronger again? How strong are the effects Given the globalized distance or intensive supply chains , transport distances ,Storage and handling of the principle of " just- in-time " and so on Its location patterns ? The medium can be found currently no incentives for transport avoidance, Optimization of the tour by freight and vehicle exchanges ,other than truck - optimized sites for industrial and busines Logistics centers , and no growing awareness regarding sidings industrial parks and logistics parks . Decoupling of Economic and Traffic performance growth is evident not take place.

Aviation: The master plan for the development of airport infrastructure is in (uncongested) baseline scenario for the whole of Germany for the year 2020, a riseof 307 million passengers and 6.78 million tons of air cargo andAirmail expected. This represents an increase of 82 % in passengers and even 117 % for freight and mail over the reference year 2005 and means average annual growth rates of 4.1 % in passenger traffic and 5.3 % in Fracht-/Postverkehr 2020 (initiative " Air Transport Germany " 2006). It is based on the philosophy that the air traffic has been doubled every 15 years , so this also in the next Will be 15 years of case (Ohler 2011). On the other hand, the Lufthansa pursues the Target , with the admixture of biofuel by 2050 , CO_2 emissions in air transport compared to 2005 to reduce by 50 %, which alone for reasons of land use and other environmental drawbacks of biofuel production would be problematic.

Currently, the public debate remains in anxious - defensive attitude to fossil Age arrested , a trend reversal is not recognizable. A simple trend extension the traffic expansion - and not the from the period before 2008 already – is however, no longer possible, the non- sustainable transport (Held 2007) decelerates to themselves, and so result in a foreseeable significant increase in energy prices in particular by high fuel costs with new challenges , the transport users and today's space structures are not prepared. The end of cheap oil allows spatial disparities and socio- economic implications affecting expect on mobility and participation opportunities and problems - of ecological Conflicts to social exclusion - threatening grow . Against this Background may status quo scenarios as a " modernized " Business-as in our technologically - optimized fossil driven world no future-proof basis for planning represent . With the current trend of primarily fossil transportation expansion neither the energy nor the turn of climate protection goals of the Federal Government to reach.

4.4.6 Entities in the US

In the US, TRB leads the nation is brainstorming of sustain- able transportation. By default, TRB is not a government agency and is only an entity that is to ‘‘promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, TRB facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provide expert advice on transportation policy and programs; and disseminates research results broadly and encouraged their implementation (TRB, 2012)’’.

In 2003, a Sustainable Transportation Symposium was held in the TRB’s annual meeting in Washington D.C. Experts were invited to present their ideas about sustainable transportation theories and practices at various scales. A year later, TRB organized another meeting on sustainable transportation in the US. In the subsequent publication, 70+ participating experts provide their shared vision of sustain- able transportation. Along the original concept of ‘‘sustain- able development’’, this vision highlights that ‘‘a sustainable transportation system is one that meets the transportation and other needs of the present without compromising the ability of future generations to meet their needs’’ (TRB, 2005, p. 3). Regarding the characteristics of a sustainable transportation system, the vision emphasizes:

- The role of transportation planners;
- The nurturance of sustainable transportation culture;
- Provision of transportation funding;
- Accountability;
- Feedback loop of planning activities;
- The role of flexibility and innovation has in the transportation system.

The authors argue that transportation planners and providers should realize that there are multiple goals when sustainability comes into the field of transportation and they have to ‘‘struggle with’’ the trade-offs among those goals. Sustainable transportation culture is one that ‘‘not only sees sustainability as desirable but also accepts the inclusion of sustainability concepts (p. 3)’’. ‘‘Adequate and reliable transportation funding consistent with fiscal constraints’’ is a necessity to promote the sustainable transportation culture (p. 3). Learning from the past and from real-time feedback of ongoing planning processes would enable people to make informed and better decisions about sustainable transportation. After the above warming-up conferences, TRB has recently started working on indicators for sustainable transportation planning. In 2007 and 2008, two papers on such indicators were published by an individual who had participated in the TRB-sponsored efforts to develop the indicators (Litman, 2007, 2008).

At a much higher advisory position for the US government than TRB, the US National Academies (USNA) has embedded sustainable transportation into a much wider picture of sustainable development rather than treating the topic in- depth separately. In its projects since 2003, USNA has focused on general topics such as using scientific knowledge in policy and program decisions in developing countries, urban environmental sustainability in the developing world, pollution prevention and abatement handbook, biofuels, and ecosystem services. Sustainable transportation, if ever mentioned, was mostly considered as a subtopic within a broader backdrop of general sustainability within an international context.

4.4.6.1 Governmental entities

Federal-level unlike its counterparts in the UK and Canada, the US federal government did not have a gateway website for sustainable development or sustainable transportation as of 2011. Climate change, an important topic related to sustainable development or transportation; however, has garnered increased attention since about the 1990s (Black and Sato, 2007). For instance, there have been the US Climate Change Science/Technology Programs under the Office of President, White House, since 2002. If there were any specific federal-level visions, mission statements, or organizational goals about sustainable development and/ or sustainable transportation, they are scattered across websites and/or documents of different agencies or their branches. Using key words such as ‘‘sustainability’’, ‘‘clean air’’, ‘‘climate change’’, and ‘‘biofuels’’ to search across different federal agencies' official websites, the author was able to identify sustainability-related goals or mission statements of four agencies. The author also found four five-year (2006–2011) strategic plans of these agencies. These plans were mandated by the Government Performance andResultsActof1993. EPA: In the US Environmental Protection Agency (EPA)'s Strategic Plan, five long-term goals are proposed:

- Goal 1: Clean air and global climate change;
- Goal 2: Clean and safe water;
- Goal 3: Land preservation and restoration;
- Goal 4: Healthy communities and ecosystems;
- Goal 5: Compliance and environmental stewardship;

Relative to the notion of ‘‘sustainable transportation’’ as defined by individual authors mentioned above, Goals 1, 3, 4 and 5 are directly related to sustainable transportation. EPA has also set up some sub-objectives under these goals for the transportation sector. EPA emphasizes that reduction of emissions from the transportation sector should be a sub-objective. To achieve this sub-objective, EPA regards vehicle fuel-efficiency, alternative fuel, innovative technology, and international collaboration as major strategies (US Environmental Protection Agency (EPA) (2007)).

USDOT: In the strategic plan of USDOT, sustainability is only implicitly mentioned. USDOT puts forward six goals in the plan: safety, reduced congestion, environmental stewardship, security, preparedness and response, and organizational excellence (USDOT, 2006). The word ‘‘sustainability’’ is not explicitly used in any of the goals. However, if one uses the definitions sustainable transportation mentioned above, one can still find that some elements of sustainable transportation in the plan, for instance, safety, decreased accidents, reduction of GHG emissions, and environmental protection. Partially encouraged by this fact, some branches of USDOT have undertaken much explicit efforts towards sustainability. In 2011, for instance, FHWA (2011) published a report titled ‘‘Transportation Planning for Sustainability Guidebook’’ for agencies working on sustainable transportation planning. This research reviews existing definitions of sustainable transportation. It also discusses how sustainability issues are addressed in different processes or subareas of transportation planning:

- Strategic planning;
- Fiscally-constraint planning;
- Performance measurement and performance-based planning;
- Climate change and transportation;
- Freight planning;
- Social sustainability in transportation

In addition, the research summarizes domestic as well as international practices in sustainable transportation planning. In 2001, FHWA once sent a delegation to West Europe to study the sustainable transportation there. The delegation summarizes its findings as:

- Many sustainable transportation strategies and measures being implemented in West Europe had also been implemented in the US;
- The implementation saw different consequences in West Europe and in the US;
- The above differences caused by: (a) West Europe had started integrating sustainability into the planning process while the US was still focusing on mitigating the negative impacts of transportation; (b) Transportation agencies in West Europe had been given more authority over sustainability.

HUD: Similar to USDOT, the US Department of Housing and Urban Development (HUD) also implicitly covers sustainability in its strategic plan. Of the six goals in the HUD plan, the words of ‘‘sustainability’’ or ‘‘sustainable’’ are rarely used. Only Goal C, ‘‘Strengthen Communities,’’ calls for sustainability: ‘‘enhance sustainability of communities by expanding economic opportunities’’ (HUD, 2006). Thus, despite the fact that HUD is the lead agency at the federal level responsible for urban development, urban sustainability, and related elements such as sustainable urban transportation and land use are not explicitly pursued in its strategic plan. This might indicate that, like the USDOT’s pursuit of sustain- ability, HUD also faced barriers such as ‘‘uncertainties about the problem and the best ways to address it, uncertainties about public support, and lack of a clear mandate for action’’ (Deakin, 2002, p. 1). In addition, internal culture of sustainability may not be there yet as the plan was draft (cf, TRB, 2005).
Interdepartmental partnership: To better address sustain- ability issues across the administrative boundary, HUD, EPA and USDOT launched a joint program called ‘‘Partnership for Sustainable Communities (PfSC)’’ in 2009. The mission of the program is ‘‘to help improve access to affordable housing, more transportation options, and lower transportation costs while protecting the environment in communities nationwide. Through a set of guiding liveability principles and a partnership agreement that will guide the agencies’ efforts, this partner- ship will coordinate federal housing, transportation, and other

infrastructure investments to protect the environment, pro- mote equitable development, and help to address the challenges of climate change The liveability principles are:

- Provide more transportation choices: Develop safe, reliable, and economical transportation choices to decrease household transportation costs, reduce our nation's dependence on foreign oil, improve air quality, reduce greenhouse gas emissions, and promote public health.
- Promote equitable, affordable housing: Expand location- and energy-efficient housing choices for people of all ages, incomes, races, and ethnicities to increase mobility and lower the combined cost of housing and transportation.
- Enhance economic competitiveness: Improve economic competitiveness through reliable and timely access to employment centres, educational opportunities, services and other basic needs by workers, as well as expanded business access to markets.
- Support existing communities: Target federal funding toward existing communities through strategies like transit oriented, mixed-use development, and land recycling—to increase community revitalization and the efficiency of public works investments and safeguard rural landscapes.
- Coordinate and leverage federal policies and investment: Align federal policies and funding to remove barriers to collaboration, leverage funding, and increase the accountability and effectiveness of all levels of government to plan for future growth, including making smart energy choices such as locally generated renewable energy.
- Value communities and neighbourhoods: Enhance the unique characteristics of all communities by investing in healthy, safe, and walkable neighbourhoods rural, urban, or suburban (EPA, 2011).

So in its mission statement or interpretation of ''liveability principles'', PfSC avoids using the word of ''sustainability''. In the PfSC written agreement, there are not any performance measures or indicators to for the participating agencies to evaluate their respective progresses made towards liveability (EPA, 2009).

Besides EPA, USDOT, and HUD, the US Department of Energy (DOE) has some interest in sustainable transportation as well. This interest is reflected in the DOE's aims specified in the programs it operated or sponsored. In its vehicle technologies program, for instance, DOE stresses that it is ''developing more energy efficient and environmentally friendly highway transportation technologies … the long-term aim is to develop 'leap frog' technologies that will provide Americans with greater freedom of mobility and energy security, while lowering costs and reducing impacts on the environment'' (DOE, 2007a). At the city level, DOE has the Clean Cities program, which aims to ''develop public/private partnerships to promote alternative fuels and advanced vehicles, fuel blends, fuel economy, hybrid vehicles, and idle reduction'' (DOE, 2007b). In DOE's 2006–2011 strategic plan, sustainability is not specifically mentioned either. In the plan, ''security'' rather than ''sustainability'' is the code word. The plan describes DOE's vision as ''to achieve results in our lifetime ensuring: Energy Security; Nuclear Security; Science-Driven Technology Revolutions; and One Department of Energy—Keeping our Commitments'' (DOE, 2006). DOE's emphasis on sustainability is tied to economic development. For example, the DOE argues that taking actions specified in the plan ensure that ‘‘we are enhancing America’s energy security and sustaining our economic vitality (DOE, 2006).

4.4.6.2 State and local levels

Compared to the US federal government, several states in the US are much more active in promoting sustainable transportation. The state-level sustainable transportation planning is not the focus of this dissertation. Interested readers can refer to FHWA (2011), Oregon Department of Transportation (2008), and Mineta Transportation Institute (2002). They all contain a review of relevant efforts and documents. According to the above references, in addition to Washington D.C., there were five states in the US has a specific sustainable transportation plan and/or program in place: Oregon, Massachusetts, California, Washington, and Pennsylvania. At the local level, there have been more substantial efforts to be linked sustainable transportation planning process. (e.g., Lee et al., 2002; Jeon et al., 2007; Portney, 2002, 2003).

In addition to the above, two state-level legislations in California are notable: AB 32 and SB 375. AB 32, the Global Warming Solutions Act of 2006 sets the 2020 GHG emission reduction goal into California’s law. AB 375, Sustainable Communities, and Climate Protection Act of 2008 enhance California’s ability to reach its AB 32 goals by promoting good planning with the goal of more sustainable communities. These two laws become precedents for the US. Despite both laws do not deal with transportation sustainability per sec, they do require significant reduction of GHG emissions from California’s transportation sector.

4.4.7 Sustainable Transportation Principles and Goals

Principles and goals of sustainable transportation can be defined as follow:

Principle 1: Access

People are entitled to reasonable access to other people, places, goods, and services.

Principle 2: Equity

Nation states and the transportation community must strive to ensure social, interregional, and inter-generational equity, meeting the basic transportation-related needs of all people including women, the poor, the rural, and the disabled. Littman (2013)

Principle 3: Health and Safety

Transportation systems should be designed and operated in a way that protects the health (physical, mental, and social well-being) and safety of all people, and enhances the quality of life in communities.

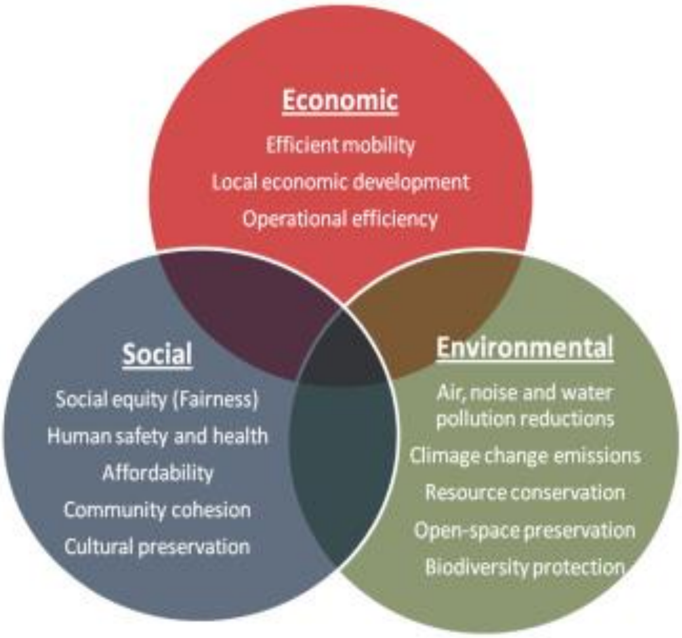


Figure 17 : Sustainable Transport Goals
Source: Victoria Transport Policy Institute

Principle 4: Individual Responsibility

All individuals have a responsibility to act as stewards of the natural environment, undertaking to make sustainable choices with regard to personal movement and consumption.

Principle 5: Integrated Planning

Transportation decision makers have a responsibility to pursue more integrated approaches to planning.

Principle 6: Pollution Prevention

Transportation needs must be met without generating emissions that threaten public health, global climate, biological diversity or the integrity of essential ecological processes.

Principle 7: Land and Resource Use

Transportation systems must make efficient use of land and other natural resources while ensuring the preservation of vital habitats and other requirements for maintaining biodiversity.

Principle 8: Fuller Cost Accounting

Transportation decision makers must move as expeditiously as possible toward fuller cost accounting, reflecting the true social, economic, and environmental costs, in order to ensure users pay an equitable share of costs. OECD international Conference (1996)

Table 8: Sustainable transportation principles

Sustainable transportation principles	
1.Access	5.Integarted planning
2.Equity	6.Pollution Prevention
3.Health and Safety	7.Land and Resource Use
4.Individual Responsibility	8.Fuller Cost Accounting

Source: OECD international Conference (1996)

4.5 Summary

To sum up, there are three strands led to a lively discussion about sustainable transportation and many excellent efforts to describe, characterize or define it since the 1990s:

1. Concerns about transportation's burdens and the counter productivity of much conventional highway-oriented planning began to emerge around the planet from the 1970s onward as pollution increased and the often-destructive effects of highway expansion upon cities attracted more attention (Stringer and Wenzel, 1976; Gakenheimer, 1978; Newman and Kenworthy, 1989).

2. The recognition in some places that reducing traffic in cities through traffic calming (deliberately slowing personal motor vehicles, or PMVs) and pedestrian (excluding PMVs from certain streets) had many benefits for mobility and the environment, including reductions in vehicular traffic pedestrians and bicyclists, and increases in the numbers of people walking, bicycling and using public transportation.

3. The growth of sustainability awareness, especially following on the Brundtland commissions report (WCED, 1987) on sustainable development as 'development which meets the needs of current generations without compromising the ability of future generations to meet their own needs'.

Therefore, while all efforts to define a field as complex as sustainable transportation are fraught with difficulty, one of the more useful definitions is that of the university of Winnipeg's Centre for Sustainable Transportation. A sustainable transportation system is one that:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
- is affordable, operates efficiently, offers choice of transport mode and supports a vibrant economy;
- limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources

to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise

It can be concluded, Common threads in various efforts examining sustainable transportation emphasize that sustainability with regard to passenger transportation should:

- Meet basic access and mobility needs in ways that do not degrade the environment;
- Not deplete the resource base upon which it is dependent;
- Serve multiple economic and environmental goals;
- Maximize efficiency in overall resource utilization;
- Improve or maintain access to employment, goods and services while shortening trip lengths and/or reducing the need to travel; and
- Enhance the liveability and human qualities of urban regions (Schiller and Kenworthy, 1999, 2003). L.Schiller (2010)

5. Sustainable Transportation Indicator

5.1 Introduction

In all metropolitan regions in the world today, the problem of the automobile and its environmental impact is a major issue. Also growth of urbanization and use of automobile increases environmental problems in the future. Transportation has significant economic, social, and environmental impacts, and is an important factor in sustainability (Litman, 2008). How do we know if our transportation systems are becoming more or less sustainable, and how do we know if our transportation policies are helping to achieve the goals they are meant to serve? Such questions have increased the demand for indicators to measure the performance of transportation systems and policies. Agenda 21 emphasizes the role of sustainable development indicators to help decision-making (United Nations, 1992). Sustainable transport indicators should be developed and be used to monitor transport sustainability. Some attempts have been made to develop sustainable transport indicators, which are listed as sustainable transport indicators. A few studies actually use sustainable transport indicators to compare and analyse sustainability between two cities. For the research, the most important global urban transportation database reviewed such as "UITP Millennium cities database for sustainable mobility" or MCDST (UITP, 2001) Environmentally Sustainable Transport, World Business Council Sustainable Mobility Indicators, TERM, had the aims to study:

- How performance-planning requirements in the case study are working in general, and with respect to transportation and sustainability policymaking.
- To what extent performance planning serves as an instrument to integrate sustainability goals in transportation decision making,
- Which kind of indicators is used to measure the environmental, economic, and social performance and sustainability of transportation in the two cities of Dortmund and Portland?

Therefore, to find out proper criteria for measuring the sustainability of urban transportation the transportation planning and different aspects of sustainable transportation and role of indicators on defining and characterizing sustainable transport are reviewed.

5.2 Data base

Sustainable development has become a major concern for policymakers and planners in both developed and developing countries since the publication of "Our Common Future on Brundtland World Commission on Environment and Development, 1987" (Quaddus and Siddique, 2001). The Brundtland commission defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, (WCED, 1987). Sustainable development is composed of three main aspects: environmental, economic, and social (Quaddus and Siddique, 2001; Krajnc and Glavi ˇ c, 2005; Litman, 2008; Tanguay et al., 2010).

Transportation systems provide access, mobility and other benefits, while at the same time putting pressures on the human and natural environment. Making progress towards more sustainable transportation systems and mobility patterns, simultaneously increasing the economic prosperity and quality of life, are policy aims shared by countries. Nevertheless, how do we know if our transportation systems are in fact becoming more or less sustainable, and how do we know if the transportation strategies are helping to achieve the goals they are meant to serve? Such questions have increased the demand for indicators to measure the performance of transportation systems and strategies.

The definition of an indicator, the various ways in which it may be developed, the different functions it may perform, and the criteria upon which its ability to meet policy requirements are best assessed may at first sight seem rather obvious and simplistic issues. However, it is, in practice, impossible to separate the definition of indicators from a discussion of the functions they perform. Indicators are quantities that give a schematic and informative representation of the 'reality' of complex systems. There are many different definitions of indicators. The Organisation for Economic Cooperation and Development (OECD), proposes the following '*a parameter or a value derived from parameters, which provides information about a particular phenomenon*'.

It has been noticed that there is often a tension between the different types of providers, users, applications and functions of sustainable development indicators (OECD, 1993):

- Technical indicators: aiming at a technical or science-based representation and modelling of complex human-environmental systems
- Policy indicators: aiming at a policy or management-focused information with direct linkages into the stages of the decision-making process
- social indicators: aiming at a more general use for citizens, consumers, non-governmental organizations and other bodies, where the practical application is more in awareness-raising and agenda-setting.

An 'ideal indicator' would fulfil all these functions (see Figure 18).Accordingly, ideal indicators should be comprehensive, rather than measuring a single aspect, independently of others; sustainability indicators should illustrate the linkages between and among systems. For instance, an indicator programme, which is traditional, might rely on a single factor. An indicator programme of comparable sustainability would gauge the overall economic condition of the community and review other factors such as income distribution, size of businesses, pollution levels and so on. Sustainability indicators are also distinguishable from traditional measures of progress by their measure of an aspect, which is non-traditional of 'quality of life'.

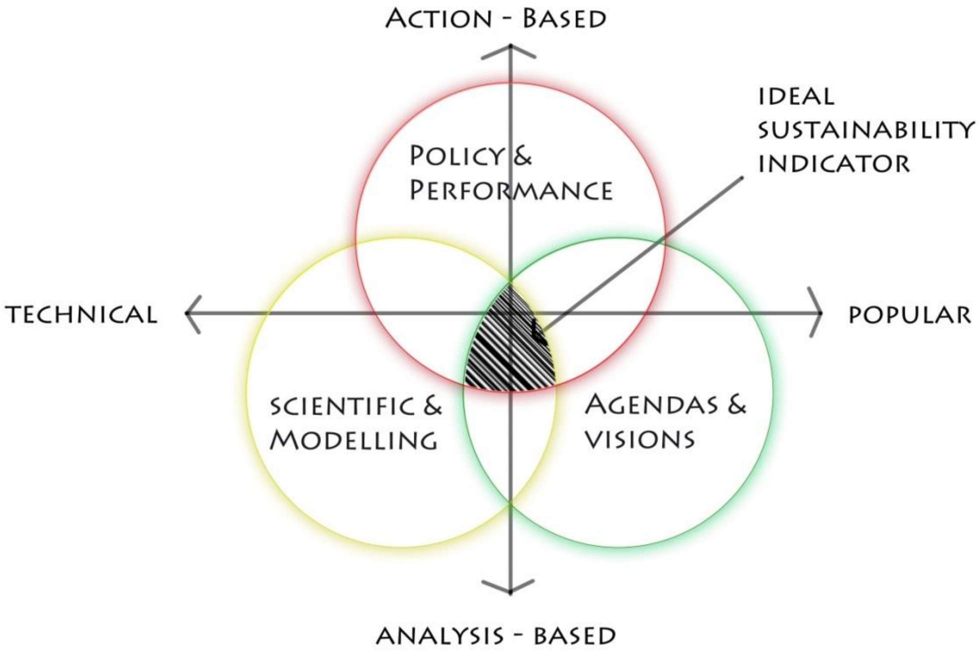


Figure 18 : Ideal indicator
Source: own representation based on The Organisation for Economic Cooperation and Development, 1993

Sustainability indicators can rarely be considered as independent from each other; indicators designed to measure improvement in one capital asset often have simultaneous positive and negative impacts on other capital assets. For example, building new or modernising existing transport infrastructure will inevitably improve physical capital of local region, but will have a negative impact, which is potential on human health and the environment (i.e. natural capital). Schemes where indicators are used to measure various aspects of sustainability independently are therefore questionable.

Indicators are quantities that give a schematic and informative representation of the reality of complex systems. There are many different definitions of indicators. OECD, 1993, uses the following “a parameter or a value derived from a parameter, which gives information with regard to a particular phenomenon” (OECD, 1993).
Indicators are useful every time the performance of a system, the evolution of a process or the results of a particular action on a complex system. For more details the sustainable transportation, needs to be evaluated; in all these events, an instrument is needed able to extract comprehensible and an informative content which is reliable from a huge amount of data and information. When this informative content has to be used to infer a choice criterion between different options, the instrument must also be able to inform about feedbacks of a system to a perturbation.

Indicators are thus instruments that give synthetic information by means of several representations of a complex and wide phenomenon, thereby making clear a situation or a characteristic that is not directly perceivable. They represent an empirical model of the reality, implicitly assuming that a complex phenomenon could be represented by a limited number of variables (Musu et al., 1998).

The most important purposes of the indicators are (OECD, 1993):

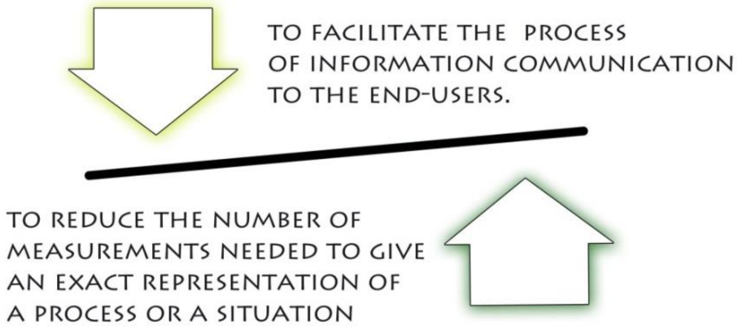


Figure 19 : The most purpose of indicators
Source: Own representation based on (OECD, 1993)

Every indicator should also correspond to the following characteristics:

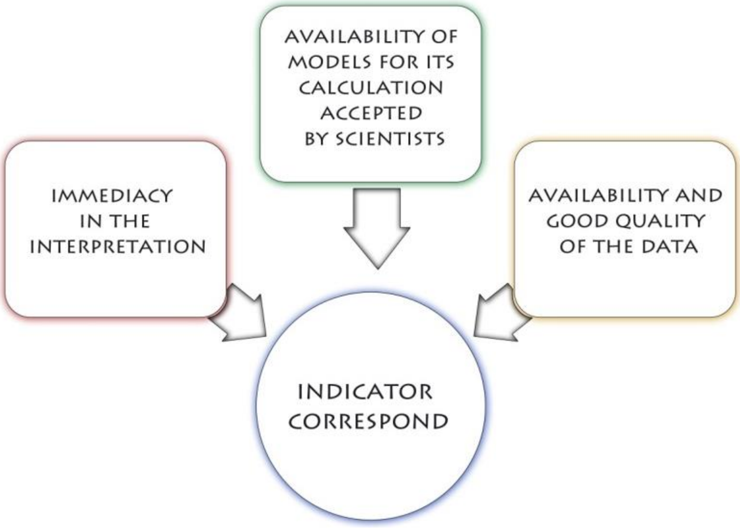


Figure 20 : Indicator correspond/cxd to the necessary characteristics
Source: own analysis based on OECD, 1993

There are a few comprehensive databanks available covering world urban transportation. There are also some other transportation data which are at the country level and not at urban (World Bank, 2002), some studies have collected urban data only about a give country or a specific region of the world (Appleton and Davies, 2008; Hezri and Hasan, 2004). Other studies or databases have collected world cities information but do not have enough quantitative data about urban transportation impacts (United Nations Habitat, 2004; Jane’s, 2006).

Kenworthy and Newman have collected three important databases that are useful for sustainable transport global comparison. The first of them is an international sourcebook of automobile dependence in cities that contains some transport indicator for period of 1960-1990 for 47 world cities (Newman and Kenworthy, 1999). In addition, they have collected

two important databases with UITP cooperation. UITP, International Association of Public Transport, has developed two important databases about urban transportation:
MCDST, Millennium cities database for sustainable mobility (UITP, 2001) and MCD, Mobility in cities database (UITP, 2006).
MCDST has collected more than 230 indicators about 100 world cities distributed in all world regions in 1995. In MCD, there is transportation information of 50 cities in 2001 which most of them are in Europe. The numbers of world regional cities in UITP database are in Table 9.

Table 9 : The numbers of world regional cities in UITP database

Region	**MCDST**	**MCD**
Africa	8	1
North America	15	1
Latin America	10	1
Asian Developed	5	2
Asian Developing	16	1
Europa	41	46
Oceania	5	1
Sum	100	52

Source: UITP, 2006

5.2.1 Towards sustainable transportation - The Vancouver Conference

The conference entitled Towards Sustainable Transportation was held in Vancouver during the period March 24-27, 1996. It was organised in response to the concerns of governments that transportation, poses severe challenges for sustainable development.

The environmental and health effects of motorised transport are well known. They include global warming and depletion of the ozone layer; spread of toxic organic and inorganic substances, notably tropospheric ozone; depletion of oil and other natural resources; and damage to landscape and soil. Improvements in pollution control and fuel efficiency during the past three decades have been directed towards reducing the impacts of transportation on environment and health. The improvements have mostly been more than offset by increases in the ownership, use, and power of motor vehicles. The number of motorised road vehicles, now over 800 million worldwide, is growing almost everywhere at higher rates than both human population and GDP; road traffic—freight and passengers—may be growing even more quickly. Air transport grows the most rapidly of all. Movement of people by rail and bus, which is generally more environmentally benign, is declining in many countries. In short, transportation is unsustainable and is becoming more unsustainable.

The stated objectives of the Vancouver conference were these:

- To provide for dialogue among disciplines, among levels of government, and among economic sectors as to how to move towards environmentally sustainable transportation;
- To explore perspectives on environmentally sustainable transportation;
- To attempt to reconcile goals for transportation, environment, energy, and development;
- To contribute to the development of principles that will guide nations in implementing environmentally responsible transportation programs;
- To identify policies and measures that should be adapted to achieve sustainable transportation.(OECD Proceedings towards sustainable transportation, 1996);

The OECD paper set out six criteria for the attainment of EST in the target year of 2030:

- Transport-related emissions of nitrogen oxides (NOx) have been reduced to the extent that the objectives for ambient nitrogen dioxide and for ozone levels as well as for nitrogen deposition are achieved.
- Emissions of volatile organic compounds (VOCs) have been reduced to the extent that excessive ozone levels are avoided, and emissions of carcinogenic VOCs from all movement of all vehicles have been reduced to meet acceptable risk levels.
- Climate change is being prevented by achieving per-capita carbon dioxide emissions from fossil fuel use for transportation consistent with the global protection goals for the atmosphere.
- Emissions of particulates have been reduced to the extent that harmful ambient air levels are avoided.
- Land surface in urban areas is used for the movement, maintenance, and storage of motorised vehicles, including public transport vehicles such that the objectives for ecosystem protection are met.
- Noise caused by transportation should not result in outdoor noise levels that present a health concern or serious nuisance.

Sustainability, whether applied to transportation or to other human activities, is seen as having three components. First is economic sustainability, which involves creating incentives for efficient response to needs. Second is environmental sustainability, which involves promoting more liveable settlements and reducing adverse external effects. Third is social sustainability, which focuses on the reduction of poverty.

Visions of sustainable transportation

The conference explored three visions of sustainable transportation: A high-technology and a low-activity vision, and what might loosely be called the automobile industry vision.

The high-technology vision centred around the notion of the “hyper car,” an ultralight and ultra-slippery vehicle, moulded from advanced composites, with a hybrid-electric propulsion system, 5-20 times more fuel efficient than present cars, and yet “safer, sportier, probably cheaper, and more comfortable, durable, and beautiful.” Such an automobile, it was claimed, would meet public-policy goals of economy, environment, and security. It would also mean, "We would run out of roads and patience rather than air and oil." Hyperactive cars, it was proposed, would buy time for and increase the need for fundamental reforms in urban form and land use.

The high-technology vision was taken further by another participant. who invited the imagination; of "cars powered by pollution-free perpetual motion engines, and built with materials that are cheap, and recyclable without imposing any burden on the environment. Wide-bodied supersonic are passenger aircraft with science fiction engines that make no noise and consume negligible amounts of energy high-speed maglev trains powered by pollution-free electricity. The consequences of such a state of affairs, it was said, would be a socially polarised world that would be one continuous suburb peopled by a spatial community of interest, with no opportunity to travel to unusual places, no fragile ecosystems, no street life, Orwellian law enforcement, remote political authority, and little in the way of democracy.

Although the conference to a degree reflected the prevailing preoccupation with technological solutions to transportation problems, there was sympathy with the view that technical fixes can result in more problems than they resolve. Mention was made of the Jevons principle: named for a British economist who argued correctly in the 1860s that making coal burning more efficient would increase rather than reduce the use of coal, because there would be more economic uses of coal.

Presentation of the low-activity vision began with the proposition that the central issue is "automobile dependence." It can be interpreted to refer on the one hand to an innate disposition of humans to engage in motorised travel and on the other hand to a condition of reliance on automobile use for essential activities such as may be found in a rural area or a low-density suburb. Attainment of sustainable transportation, the argument continues, will require reductions in the use of motorised transport to be achieved by making it less desirable or less necessary than non-motorised transport, or both, or at least substitution of more benign forms of motorised transport such as buses and trains for less benign forms such as personal automobiles and aeroplanes.

The changes will involve giving non-auto infrastructure higher priority than auto infrastructure, developing land-use patterns that minimise the need for travel, and placing greater emphasis on community rather than individual values and on urban rather than suburban and exurban living conditions.

The automobile industry vision extolled the central place of private transportation in modern industrialised society, and noted the accomplishments of automobile manufacturers in absorbing new technologies and adapting them to the needs of their customers. The improvements in pollution control and cost effectiveness will continue, even people with the lowest incomes will prefer the private automobile, and even though public transport will be "kept afloat" with large subsidies. Information technologies will make vehicles more efficient and replace some travel. Working hours will fall, resulting in increases in leisure time that people will choose not to spend in trains and buses. Road traffic, according to the automobile industry, has an important contribution to make towards achieving the increases in productivity necessary for environmental and social sustainability.

The Vancouver conference can be considered as having several outputs. One is the set of principles and strategic directions appended to this review. Another comprises conclusions derived from the presentations and discussions at the meeting. A preliminary set of such conclusions was presented at the meeting and accepted by the participants. It has been elaborated into the conclusions that follow:

1. Sustainable transportation had achieved when needs for access to people, services, and goods met without producing permanent harm to the global environment, damage to local environments, and social inequity. This implies rates of use of non-renewable resources that do not exceed the rates at which renewable substitutes are developed, and rates of emission and of concentration of substances that do not exceed the assimilative capacity of the environment.
2. Systems of transportation used in OECD and some other countries are unsustainable. Substantial improvements in technology was been made, but their impact has been more than offset by growth in individual mobility and in the movement of freight. In most countries, current trends point away from sustainability.
3. Achievement of sustainable transportation will likely involve improvements in vehicles, fuels, and infrastructure, on the one hand, and reductions in personal mobility and in the movement of goods, on the other hand. It is possible that some improvements will be counterproductive, and even that things may have to get worse before they get better; environmental catastrophe may be the only sufficiently strong motivator for change in transport practices.
4. Present thinking focuses on measures concerning the use of vehicles— as opposed to ownership—designed to secure progress towards sustainable transportation. However, a focus on ownership may also be required, notwithstanding the political difficulties inherent in limiting ownership. Successful restrictions on use or ownership will require the development of satisfactory alternatives.
5. Moves towards life-cycle analysis, full-cost accounting, and full-cost pricing are desirable components of strategies for achieving sustainable transportation. However, full-cost pricing may not be enough to secure sustainability; even higher prices may have to be imposed or other measures.
6. Other key components of strategies for moving towards sustainable transportation are measures to increase urban and suburban densities of land use and the setting and enforcing of targets that represent required changes in environmental and other indicators concerning transportation.
7. More work needs to be done on the identification and removal of barriers to securing progress towards sustainable transportation, including societal attitudes and trends, government and corporate practices, and the prospect of economic adversity. Work is required also, on how the economic benefits associated with moves towards sustainable transportation might enhanced.

8. Two other areas requiring further work with respect to the attainment of sustainable transportation are aviation generally and the inter-city movement of people and freight and aviation generally. Both areas been somewhat neglected in the series of OECD meetings, in part because there are relatively few relevant data.

5.3 Sustainable transportation indicators development

An indicator is a variable based on some measurements, representing as accurately as possible a phenomenon of interest (Joumard and Gudmundsson, 2010). Indicators are variables selected and defined to measure progress towards an objective (Litman, 2008). Chapter 40 of Agenda 21 states that "indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulatory sustainability of integrated environment and development systems" (United Nations, 1992). OECD defined sustainable transportation indicators as statistical measures that give an indication of the sustainability of social, environmental, and economic development (Joumard and Gudmundsson, 2010).

Table 10 : Information related to 17 studies, which list Sustainable transportation Indicator

No	References	Authors (Year)	Urban SDI	Urban STI
1	Sustainability and cities: overcoming automobile dependence	Newman and Kenworthy (1999)	44	22
2	Towards sustainable mobility indicators application to the Lyons conurbation	Nicolas et al. (2003)	-	18
3	Sustainable transportation performance indicators (STPI)	Gilbert et al. (2003)	-	14
4	Management framework for sustainable development indicators in the State of Selangor, Malaysia	Hezri and Hasan (2004)	30	3
5	Addressing sustainability in transportation systems: definitions, indicators, and metrics	Jeon and Amekudzi (2005)	-	30
6	Sustainable transport indicators and assessment methodologies	Zegras (2006)	25	18
7	Sustainable transportation in Halifax regional municipality, GPI (Genuine Progress Index) for Atlantic Canada	Savelson and Colman (2008)	-	14

8	Practical appraisal of sustainable development, methodologies for sustainability measurement at settlement level	Moles et al. (2008)	40	11
9	Sustainable transportation indicators, Subcommittee of the Transportation Research Board	Litman (2008)	30	12
10	SMART transportation ranking report (27 Canadian cities)	Appleton and Davies (2008)	-	12
11	Measurement indicators and an evaluation approach for assessing urban stainable development: (China's Jining City)	Li et al. (2009)	52	3
12	Sustainable transportation indicator data quality and availability	Litman (2009a)	-	35
13	Well measured developing indicators for comprehensive and sustainable transport Planning	Litman (2009b)	-	42
14	ELASTIC – a methodological framework for identifying and selecting sustainable transport indicators	Castillo and Pitfield (2009)	-	20
15	Evaluation of the Q-method as a method of public participation in the selection of sustainable development indicators	Doody et al. (2009)	37	5
16	Measuring the sustainability of cities: an analysis of the use of local indicators (23 study)	Tanguay et al. (2010)	233	63
17	The role of common local indicators in regional sustainability assessment	Mascarenhas et al. (2010)	55	5

Source: Own evaluation based on urban sustainable transportation indicators for global comparison, Haghshenas, Vaziri, 2012

There are some efforts to define indicators to quantify urban sustainable transportation. Table 10 shows 17 studies that list urban sustainable transportation indicators, STI. In some cases, STI's have been used and selected from urban sustainable development indicator set. In this research, indicators from several past studies were collected and summarized. Indicators are categorized in three main groups:

- Transportation environmental impact indicator,
- Transportation economic impact indicator,
- Transportation social impact indicator and transportation indicator;

Transportation indicators are those, which show urban transportation state and cannot be place in other groups. Indicators in the first three groups are named as sustainable transportation indicators. Table 11 shows categories of sustainable transportation indicators.

Table 11 : Categories of urban STIs extracted from various studies.

Sector	Number of indicator	Frequency of use
Categories of Transport Environmental Impact indicator	33	90
Air pollution	5	30
Energy consumption	3	11
Renewable energy type	4	8
Efficient vehicle	6	7
Noise pollution	4	13
Land consumption	1	9
Environment management	2	2
Transport facility environment impact	2	2
Wild life	2	3
Other resource	4	5
Categories of Transport Economical Impact indicator	25	48
Local government cost and benefit	9	16
Consumer direct cost and benefit	6	16
Consumer indirect cost and benefits	6	12

Transport price	2	2
Commercial transport	2	2
Categories of Transportation Social Impact indicator	27	59
Safety	4	17
Satisfaction	4	7
Access	6	16
Transport for disable	1	4
Equity	6	8
Citizen participation in transportation decision	6	7
Security	1	1
Sum	85	197

Source: Urban sustainable transportation indicators for global comparison, Haghshenas, Vaziri, 2012

Several authors note that indicator selection should primarily be driven by the questions that the indicators are supposed to answer (Joumard and Gudmundsson, 2010; Zhang and Guindon, 2006; Li et al., 2009; Litman, 2009 a,b). Indicator should be easily understandable, reasonable, measurable, possible to quantify, accessible, comprehensive, reflect various aspect of study, sensitive to changes over time, independent, standardized for comparison, clearly defined and capture long-term processes (Zhang and Guindon, 2006; Nourry, 2008; Li et al., 2009; Litman, 2009a,b).
Also Joumard et al. in chapter 4 of their recent research, introduce 10 criteria for indicator selection that were categorized in three main groups (Joumard and Gudmundsson, 2010):

- Representation: validity, reliability, sensitivity
- Operation: measurability, data availability, ethical concerns
- Policy application: transparency, interpretability, target relevance, action ability;

According to the aim of this research for sustainable transportation evaluation, the main criteria as shown in figure 21 were identified selected for comparative assessment. Table 12 shows indicators with more than three frequency of use in various past studies in each sector. The last column of the table shows indicators, which are measurable by MCDST. The nine indicators with most frequency of use in various studies are measurable from MCDST.
These 12 indicators were selected initially for current research while taking into consideration; subsequently some of them were edited or redefined to satisfy indicator

criteria. In the followings, the modified or changed indicators are presented and the reasons for these changes are explained:

a. Transportation environmental impact indicator, TEII, TEII's in MCDST is about urban transportation local emission, energy use and land consumption. Transportation sector energies use indicator according to its primary definition from reviewed studies as is shown in Table 12, land consumption indicators have been subjected to changes.

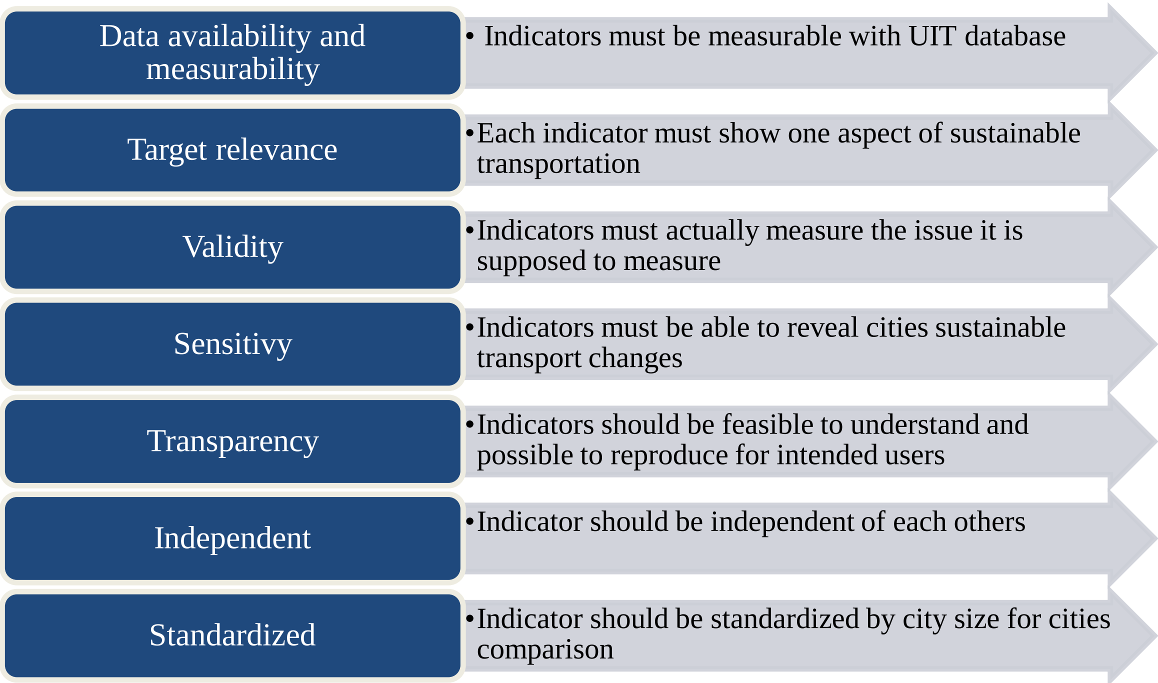


Figure 21 : Criteria for indicator assessment

Source: Own analysis based on Joumard and Gudmundsson, 2010; Zhang and Guindon, 2006; Li et al., 2009; Litman, 2009 a,b

b. Transportation economic impact indicator, TCII Initially TCII' s definitions extracted from reviewed studies was taken in this research without any important changes. Economic indicators, local government budget in transportation sector and time spent in traffic remained unchanged but indicator about household expenditures on transport was changed because of information in database. Initially definition of economic indicator, household expenditure for transportation, was the share of transportation on total household's costs. While in MCDST database, this indicator is user cost over GDP per capita.

Some studies consider indirect cost like energy use and emission as economic indicators but here they have used as environmental indicators when indicators should be independent.

c. Transportation social impact indicator, the greatest changes occurred in TSII's definition was related to transportation accessibility and variety of transportation option. Other social indicators are such as transportation death, remained unchanged, and standardized on per capita basis.

Table 12 : Sustainable transportation indicators, which are measurable by MCDST

Sustainable Transportation Indicator	**Frequency of use**	**Measurable from MCDST**
Transportation Environmental Impact Indicator (TEII)		
Emissions of local air pollutants (CO, VOC, NO x, etc.) per capita	12	√
GHG emissions from transport (CO2–CH4 tons) per capita	12	
Transport energy use per capita	9	√
Land consumption for transport infrastructure (roads, parking,)	9	√
Population exposed to noise >55 dB (A)	9	
Total consumption of renewable energy per capita per year	4	
Transportation Economical Impact Indicator (TCII)		
Household expenditure allocated to transport (%budget)	10	√
Expenditures on transportation for local government (annual, per GDP)	6	√
Total time spent in traffic	5	√
Transportation Social Impact Indicator (TSII)		
Fatality and injured of traffic accidents per capita	14	√
Access to public transport (population served by public transit near around a train station, subway, bus stop)	11	√
Satisfaction of citizens and variety and quality of transport options	4	√
Quality of transport for disadvantaged, disabled, children, non-driver	4	√

Source: H. Haghshenas, M. Vaziri / Ecological Indicators 15 (2012) 115–121

5.4 Introducing proper indicator for measuring urban sustainable transportation

The purpose of the Sustainable Transportation Indicators is to develop a set of indicators that can be used to monitor the progress of transport systems towards (or away from) sustainability. In this section on dissertation will be described in a little more detail.

The introducing proper indicator for measuring urban sustainable transportation proceeds in three steps:

The first step included a review of 15 international sources of sustainable transportation related indicator sets (For more information about 15 international sources of sustainable transportation related indicator please sees the appendix A). The 160 indicators in those sets were evaluated and rated for their relevance for measuring progress towards sustainable transportation, and a preliminary list of candidate indicators for further work was identified. Step 1 was completed with a brief explanation in section 5.3.

The second step of the finding proper sustainable indicator is conducted as the result of section 6. The aim is to enable the selection of two or three indicator sets with a limited number of indicators (expected 3-5 and 10-12 indicators) from the long list of 'candidate' indicators. Major elements in this step include a statistical analysis of database collection of two different cities (Dortmund, Portland). The third step will aim to complete the actual sets of indicators.

The third step is innovative approach of the proper indicator for measuring urban sustainable transportation is to base the selection and construction of sustainable transportation indicators on an explicit definition of sustainable transportation. According to the definition (Gilbert & Tangauy 2000) a sustainable transportation system is one that:

• Allows the basic access needs of individuals to be met safely and in a manner consistent with human and ecosystem health, and within equity within and between generations.

• Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy

• Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits 37consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

The definition has been decomposed into (now) 12 elements within three dimensions or 'domains'. Each element represents some key concern of sustainable transportation. Each concern should therefore somehow be reflected in the indicators if they are to show progress towards a sustainable transportation system, as defined. The elements are shown in the Table below:

Environmental domain

- limiting emissions
- limiting waste
- minimizing consumption of non-renewable energy
- reusing and recyling of componeds
- minimizing land use
- minimizing noise

Economic domain

- affordable
- efficient operation
- choose of transport mode
- support for vibrant economy

Social domain

- meeting access needs of individual
- meeting access needs of society
- access needs are met consistent with human health
- access needs are met safely
- access needs are met with quality within this generation
- access needs are met with equity across generations

Source: own analysis based on Gilbert & Tangauy 2000

The idea with using the approach based on a definition is to build on a logical and comprehensive framework from which indicators can be identified. The elements of the definition are used to search for and group candidate indicators from various sources, and point to areas where new indicators have to be defined.

All 160+ indicators have been reviewed for their relevance as indicators for the 12 elements of the definition. The quality of the indicator was rated on a scale from A to C, based on certain criteria.

‘A’ means that an indicator is provides a strong quantified indication of progress for one or more element(s) of the definition of ‘sustainable transportation’. For example, for the first definition element (limiting emissions) this could be measure of how far current transportation emissions are from a level that will respect the absorption capacity of the atmosphere or ecosystems.

‘B’ means that the indicator provides a quantified assessment of relevance to some element(s) of the definition, without being able to indicate the degree of progress. Again, for emissions this could be a 38 quantitative figure for the transportation emissions (in tons) without a specified target.

‘C’ means that the indicator is only loosely related to any element(s). For emissions, this could be an estimate of total (not transport) emissions. The main result of the analysis is that only 4 of the 160 indicators currently in use or proposed in the 13 sources receives an ‘A’ grade for any element in the definition.

For some elements in the definition, few or no relevant indicators were found among the 160 candidate indicators in the literature. Issues with limited indicator coverage are e.g. ‘Noise minimization’; ‘Meeting access need consistent with ecosystem and human health and safety'; 'Meeting access needs consistent with equity within generations'; 'Support for a vibrant economy'; Waste limitation'; 'Reuse and recycling" and 'Access needs met with equity across generations'.

The introduction of a core set helps to keep the indicator set manageable, whereas the larger set allows the inclusion of additional indicators that enable countries to do a more comprehensive and differentiated assessment of sustainable development. Core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that is either readily available or could be made available within reasonable time and costs. Conversely, indicators that are not part of the core are either relevant only for a smaller set of countries, provide complementary information to core indicators or are not easily available for most countries.

According to appendix, some indicators had lack performance standards for evaluation. For example, there may be no suitable performance standards for population management or universal design. In that case, they may be evaluated based on how well best population management and universal design practices are included in the planning process.

Indicators can be disaggregated by demographic (income, employment, gender, age, physical ability, minority status, etc.) and geographic factors (urban, suburban, rural, etc.), time (peak and off-peak, day and night), and by mode (walking, cycling, transit, etc.) and trip (commercial, commuting, tourism, shopping, etc.). For equity analysis, special consideration should be given to transport service quality and cost burdens for disadvantaged people (people with disabilities, low incomes, children, etc.). For example, compare the portion of household income devoted to transport, and satisfaction with the transport system, between people with and without disabilities, the lowest, and the average income quintile, and young adults with other age groups. Similarly, special consideration can be applied to the quality of "basic access" (transport with high social value, such as access to for emergency and service vehicles, medical services, education, employment, etc.), by measuring how often people are unable to make such trips.

Comprehensive, lifecycle analysis should be used, taking into account all costs and resources used, including production, distribution, and disposal. The analysis should indicate if costs are shifted to other locations, times and groups.

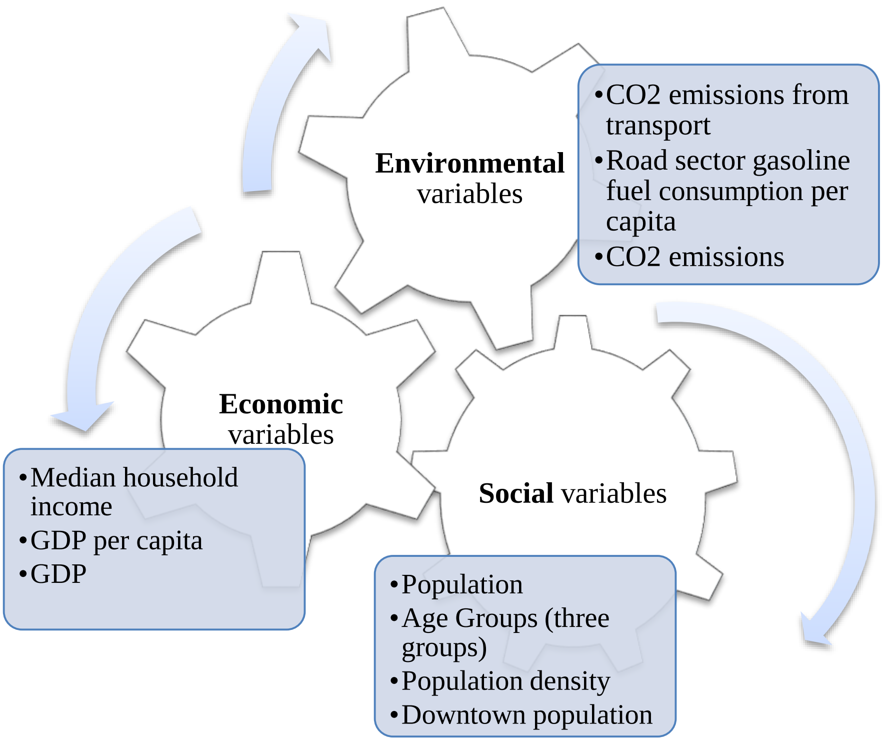
These data can be presented in various ways to show trends, differences between groups and areas, comparison with peer jurisdictions or agencies, and levels compared with recognized standards. Overall impacts should generally be evaluated *per capita*, rather than per unit of travel (e.g., per vehicle-mile) in order to take into account the effects of changes for travel that occurs.

These indicators can be used to establish specific performance targets and contingency-based plans (for example, a particularly emission reduction policy or program is to be implemented if pollution levels reach a specific threshold, or a community will receive a reward for achieving a particular rating or award if it achieves a particular mode shift).

It may be appropriate to use a limited set of indicators, which reflect the scale, resources, and responsibilities of a particular sector, jurisdiction, or agency. For example, a transportation agency might only measure transportation impacts involving the modes, clients and geographic area it serves. Special sustainability analysis and indicators may be applied to freight or aviation sectors.

It is important that users understand the perspectives, assumptions and limitations in different types of indicators and indicator data. Indicators should reflect different levels of impacts, from the decision-making processes; travel effects; intermediate impacts; and ultimate outcomes that affect people and the environment.

The candidate indicators are shown in the figure below. Sustainable transport indicators were considered, three indicators in each parts of environmental and economic, and six indictors in social. These sustainable transport indicators were selected from other researches and some new indicator were developed based on criteria's found in the literature. For approving the strength of a relationship between new approach of sustainable transportation indicator and candidate sustainable variables correlation and liner regression analysis is used. The methodology for using these techniques of analysis is implemented as the following steps. First step the correlations between sustainable transportation indicator and sustainable variable will be calculated and interpreted. In the next step, the regression analysis is used to prove that the usage of public transportation as criteria for sustainable transportation indicator is proper criteria as an indicator for transportation certificate system.



Source: own analysis

5.5 Summary

Indicators are things we measure to evaluate progress toward goals and objectives. Such indicators have many uses: they can help identify trends, predict problems, assess options, set performance targets, and evaluate a particular jurisdiction or organization. Indicators are equivalent to senses (sight, hearing, touch, smell, taste) – they determine how things are perceived and what receives attention. Which indicators are used can significantly affect planning decisions. An activity or option may seem good and desirable when evaluated using one set of indicators, but harmful when evaluated using another. It is therefore important to careful select indicators that reflect overall goals. It is also important to be realistic when selecting indicators, taking into account data availability, understand ability and usefulness in decision-making. (Developing Indicators for Comprehensive and Sustainable Transport Planning, 4 February 2008.)

Although there are many possible definitions of sustainability, sustainable development and sustainable transportation, experts increasingly agree that these should refer to a balance of economic, social, and environmental health. Comprehensive and sustainable transport planning therefore requires a balanced set of indicators reflecting appropriate economic, social, and environmental objectives. An indicator set that focuses too much on one impact category can result in suboptimal decisions. There is tension between convenience and comprehensiveness when selecting indicators. A smaller index using easily available data is more convenient to use, but may overlook important impacts and therefore distort planning decisions. A larger set can be more comprehensive but have unreasonable data collection costs and be difficult to interpret.

There are currently no standardized indicator sets for comprehensive and sustainable transport planning. Each jurisdiction or organization must develop its own set based on needs and abilities. It would be useful for major planning and professional organizations to establish recommended sustainable transportation indicator sets, data collection standards, and evaluation best practices in order to improve sustainability planning.

To sum up, in this research three indicators in each parts of environmental and economic, and six indictors in social. These sustainable transport indicators were selected from other researches and some new indicator were developed based on criteria's found in the literature. For approving the strength of a relationship between new approach of sustainable transportation indicator and candidate sustainable variables correlation and liner regression analysis is used. The methodology for using these techniques of analysis is implemented as the following steps. First step the correlations between sustainable transportation indicator and sustainable variable will be calculated and interpreted. In the next step, the regression analysis is used to prove that the indicators are suitable as criteria for sustainable transportation indicator.

6. Methods of Analytical Approach

6.1 Introduction

In this research the methods of the descriptive statistics, correlation, and regression analysis is used to find effects of independent variables on dependent variables, which can help us for monitoring, and measurement of sustainability in many different ways. Descriptive statistics are distinguished from inferential statistics, in that descriptive statistics aim to summarize a sample, rather than use the data to learn about the population that the sample of data is thought to represent. Correlation is a term that refers to the strength of a relationship between two variables. A strong, or high, correlation means that two or more variables have a strong relationship with each other while a weak, or low, correlation means that the variables are hardly related. In statistics, regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. . More specifically, regression analysis helps one understand how the typical value of the dependent variable (or 'Criterion Variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed.

6.2 Descriptive statistics

Descriptive statistics is the discipline of quantitatively describing the main features of a collection of information, or the quantitative description itself. Descriptive statistics are distinguished from inferential statistics (or inductive statistics), in that descriptive statistics aim to summarize a sample, rather than use the data to learn about the population that the sample of data is thought to represent. This generally means that descriptive statistics, unlike inferential statistics, are not developed based on probability theory. Even when a data analysis draws its main conclusions using inferential statistics, descriptive statistics are generally also presented. For example in a paper reporting on a study involving human subjects, there typically appears a table giving the overall sample size, sample sizes in important subgroups (e.g., for each treatment or exposure group), and demographic or clinical characteristics such as the average age, the proportion of subjects of each sex, and the proportion of subjects with related comorbidities.

Some measures that are commonly used to describe a data set are measures of central tendency and measures of variability or dispersion. Measures of central tendency include the mean, median and mode, while measures of variability include the standard deviation (or variance), the minimum and maximum values of the variables, kurtosis and skewness.

- **Scatter plot**

The first step in the investigation of the relationship between two continuous variables is a scatterplot. Create a scatterplot for the two variables and evaluate the quality of the relationship.

A scatter plot is used when a variable exists that is below the control of the experimenter. If a parameter exists that is systematically incremented and/or decremented by the other, it is called the control parameter or independent variable and is customarily plotted along the horizontal axis. The measured or dependent variable is customarily plotted along the vertical axis. If no dependent variable exists, either type of variable can be plotted on both axis and a scatter plot will illustrate only the degree of correlation (not causation) between two variables.

A scatter plot can suggest various kinds of correlations between variables with a certain confidence interval. For example, weight and height, weight would be on x axis and height would be on the y-axis. Correlations may be positive (rising), negative (falling), or null (uncorrelated). If the pattern of dots slopes from lower left to upper right, it suggests a positive correlation between the variables being studied. If the pattern of dots slopes from upper left to lower right, it suggests a negative correlation. A line of best fit (alternatively called 'trend line') can be drawn in order to study the correlation between the variables. An equation for the correlation between the variables can be determined by established best-fit procedures. For a linear correlation, the best-fit procedure is known as linear regression and is guaranteed to generate a correct solution in a finite time. No universal best-fit procedure is guaranteed to generate a correct solution for arbitrary relationships. A scatter plot is also very useful when we wish to see how two comparable data sets agree with each other. In this case, an identity line, i.e., $a\, y = x$ line, or a $1{:}\,1$ line, is often drawn as a reference. The more the two data sets agree, the more the scatters tend to concentrate approximately the identity line; if the two data sets are numerically identical, the scatters fall on the identity line exactly.

One of the most powerful aspects of a scatter plot, however, is its ability to show nonlinear relationships between variables. Furthermore, if the data is represented by a mixture model of simple relationships, these relationships will be visually evident as superimposed patterns.

6.3 Correlation and Regression Analysis

6.3.1 Correlation Analysis

Correlation is a term that refers to the strength of a relationship between two variables. A strong, or high, correlation means that two or more variables have a strong relationship with each other while a weak, or low, correlation means that the variables are hardly related. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 means that there is no relationship between the variables has being tested. The most widely used type of correlation coefficient is the Pearson r, which is also referred to as linear or product-moment correlation. This analysis assumes that the two variables being analysed are measured on at least interval scales. The coefficient is calculated by taking the covariance of the two variables and dividing it by the product of their standard deviations.

6.3.2 Interpreting the Correlation Coefficient

A value of $+1.00$ implies that the relationship between variables X and Y is perfectly linear, with all data points lying on a line for which Y increases and X increases. Conversely, a negative value of implies that all data points lie on a line for which Y decreases as X increases.

For example, let us suppose we were looking at variables age and income. If the correlation coefficient was$+0.80$, this means that as age increases, income increases as well.

6.3.3 Regression analysis

In statistics, regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. More specifically, regression analysis helps one understand how the typical value of the dependent variable (or 'Criterion Variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed. Most commonly, regression analysis estimates the conditional of the dependent variable given the independent variables – that is, the average value of the dependent variable when the independent variables are fixed. Less commonly, the focus is on a quintile, or other location parameter of the conditional distribution of the dependent variable given the independent variables. In all cases, the estimation target is a function of the independent variables called the regression function. In regression analysis, it is also of interest to characterize the variation of the dependent variable around the regression function, which can be described by a probability distribution.

Regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning. Regression analysis is also used to understand which among the independent variables are related to the dependent variable, and to explore the forms of these relationships. In restricted circumstances, regression analysis can be used to infer causal relationships between the independent and dependent variables. However, this can lead to illusions or false relationships, so caution is advisable; for example, correlation does not imply causation.

Many techniques for carrying out regression analysis have been developed. Familiar methods such as linear regression and squares regression are parametric, in that the regression function is defined in terms of a finite number of unknown parameters that are estimated from the data. Nonparametric regression refers to techniques that allow the regression function to lie in a specified set of functions, which may be infinite-dimensional.

The performance of regression analysis methods in practice depends on the form of the data generating process, and how it has relates to the regression approach being used. Since the true form of the data-generating process is generally not known, regression analysis often depends to some extent on making assumptions about this process. These assumptions are sometimes testable if a sufficient quantity of data is available. Regression models for prediction are often useful even when the assumptions are moderately violated, although they may not perform optimally. However, in many applications, especially with small effects or questions of causality based on observational data, regression methods can give misleading results.

Suppose there are n data points $\{yi,\ xi\}$, where$i\ =\ 1,\ 2 \ldots\ n$. The goal is to find the equation of the straight line

$$y\ =\ \alpha + \beta x$$

This would provide a “best” fit for the data points. Here the "best" will be understood as in the least-squares approach: such a line that minimizes the sum of squared residuals of the linear regression model. In other words, numbers α $(the\ y - intercept)\ and\ \beta\ (the\ slope)$ solve the following minimization problem:

Equation 1 :

$$\text{Find} \min_{\alpha,\beta} Q(\alpha,\beta),\ \ \text{where}\ Q(\alpha,\beta) = \sum_{i=1}^{n} \hat{\varepsilon}_i^2 = \sum_{i=1}^{n} (\,y_i - \alpha - \beta x_i)^2$$

By using either calculus, the geometry of inner product spaces or simply expanding to get a quadratic in α and β, it can be shown that the values of α and β that minimize the objective function are (Kenney, J. F. and Keeping, E. S. (1962) :

Equation 2 :

$$\hat{\beta} = \frac{\sum_{i=1}^{n}(\,x_i\ -\ \bar{x})(y_i\ - \bar{y})}{\sum_{i=1}^{n}(\,x_i\ -\ \bar{x})^2}$$

$$= \frac{\sum_{i=1}^{n} x_i\, y_j - \frac{1}{n}\sum_{i=1}^{n} x_i \sum_{j=1}^{n} y_j}{\sum_{i=1}^{n}(x_i^2) - \frac{1}{n}(\sum_{i=1}^{n} x_i)^2} = \frac{\overline{xy} - \bar{x}\bar{y}}{\overline{x^2} - \bar{x}^2} = \frac{\text{Cov}\,[x,y]}{\text{Var}\,[x]} = r_{xy}\frac{S_y}{S_x},$$

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x}$$

Where r_{xy} is the sample correlation coefficient between x and y, S_x is the standard deviation of x, and S_y is correspondingly the standard deviation of y, a horizontal bar over a quantity indicates the sample-average of that quantity. For example:

Equation 3 :

$$\overline{xy} = \frac{1}{n}\sum_{i=1}^{n} x_i y_i$$

Substituting the above expressions for $\hat{\alpha}$ and $\hat{\beta}$ into

$$y = \hat{\alpha} + \hat{\beta}x$$

Yields

$$\frac{y - \bar{y}}{S_y} = r_{xy}\frac{x - \bar{x}}{S_x}$$

This shows the role $\mathbf{r_{xy}}$ plays in the regression line of standardized data points. It is sometimes useful to calculate $\mathbf{r_{xy}}$ from the data independently using this equation:

Equation 4 :

$$\mathbf{r_{xy}} = \frac{\overline{\mathbf{xy}} - \bar{\mathbf{x}}\bar{\mathbf{y}}}{\sqrt{(\overline{\mathbf{x^2}} - \bar{\mathbf{x}}^2)(\overline{\mathbf{y^2}} - \bar{\mathbf{y}}^2)}}$$

The coefficient of determination (R squared) is equal to r_{xy}^2 when the model is linear with a single independent variable. See sample correlation coefficient for additional details.

Sometimes, people consider a simple linear regression model without the intercept term, $y = \beta x$. In such a case, the OLS estimator for β simplifies to equation 12:

Equation 5 :

$$\hat{\boldsymbol{\beta}} = \frac{(\overline{\mathbf{xy}})}{(\overline{\mathbf{x^2}})}$$

In addition, the sample correlation coefficient becomes

$$\mathbf{r_{xy}} = \frac{\overline{\mathbf{xy}}}{\sqrt{(\overline{\mathbf{x^2}})(\overline{\mathbf{y^2}})}}$$

6.3.4 Interpretation of regression

The sets in the Anscombe's quartet have the same linear regression line but are themselves very different.

A fitted linear regression model can be used to identify the relationship between a single predictor variable x_j and the response variable y when all the other predictor variables in the model are "held fixed." Specifically, the interpretation of βj is the expected change in y for a one-unit change in x_j when the other covariates are held fixed that is, the expected value of the partial derivative of y with respect to x_j variable. This is sometimes called the unique effect of x_j on y. In contrast, the marginal effect of x_j on y can be assessed using a correlation coefficient or regression model relating x_j to y; this effect is the total derivative of y with respect to x_j .

Care must be taken when interpreting regression results, as some of the regression may not allow for marginal changes (such as dummy variables, or the intercept term), while others cannot be held fixed.

It is possible that the unique effect can be nearly zero even when the marginal effect is large. This may imply that some other covariate captures all the information in x_j , so that once that variable is in the model, there is no contribution of x_j to the variation in y. Conversely, the unique effect of x_j can be large while its marginal effect is nearly zero. This would happen if the other covariates explained a great deal of the variation of y, but they mainly explain variation in a way that is complementary to what is captured by x_j . In this case, including the other variables in the model reduces the part of the variability of y that is unrelated to x_j , thereby strengthening the apparent relationship with x_j variable.

The meaning of the expression "held fixed" may depend on how the values of the predictor variables arise. If the experimenter directly sets the values of the predictor variables according to a study design, the comparisons of interest may literally correspond to comparisons among units whose predictor variables have been "held fixed" by the experimenter. Alternatively, the expression "held fixed" can refer to a selection that takes place in the context of data analysis. In this case, we "hold a variable fixed" by restricting our attention to the subsets of the data that happen to have a common value for the given predictor variable. This is the only interpretation of "held fixed" that can be used in an observational study.

The notion of a "unique effect" is appealing when studying a complex system where multiple interrelated components influence the response variable. In some cases, it can literally be interpreted as the causal effect of an intervention that is linked to the value of a predictor variable. However, it has been argued that in many cases multiple regression analysis fails to clarify the relationships between the predictor variables and the response variable when the predictors are correlated with each other and are not assigned following a study design.

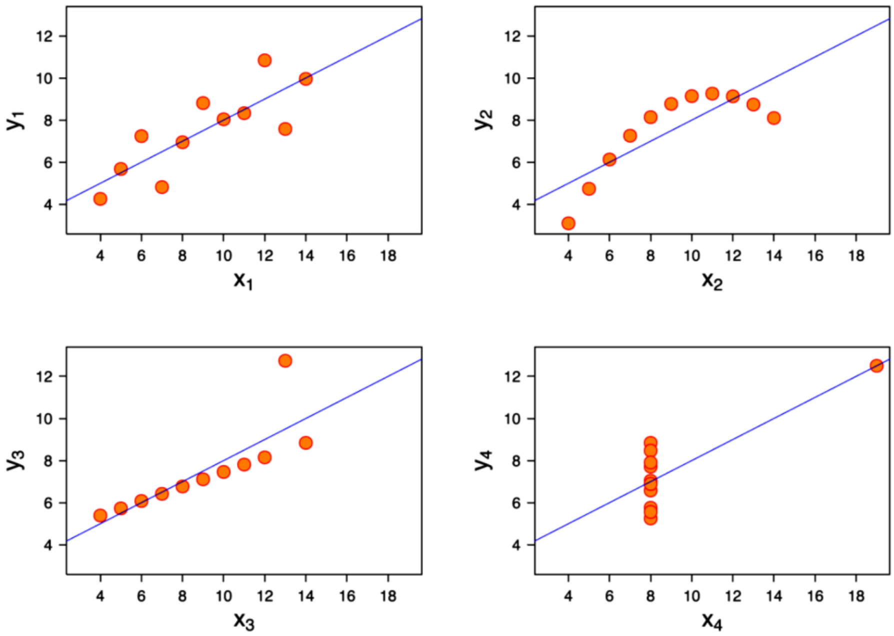


Figure 22 : Four sets of data with the same correlation of 0.816

Source: Anscombe, Francis J. (1973) Graphs in statistical analysis. American Statistician, 27, 17–2

6.4 Summary

It can be concluded, Descriptive statistics is the discipline of quantitatively describing the main features of a collection of information, or the quantitative description itself. Descriptive statistics are distinguished from inferential statistics, in that descriptive statistics aim to summarize a sample, rather than use the data to learn about the population that the sample of data is thought to represent.

Correlation is a term that refers to the strength of a relationship between two variables. A strong, or high, correlation means that two or more variables have a strong relationship with each other while a weak, or low, correlation means that the variables are hardly related.

Regression analysis is one of the most frequently used tools for analyzing. In its simplest form, regression analysis allows monitoring and analyzes relationships between one independent and one dependent variable. The key benefits of using regression analysis are that it can:

- Indicate if independent variables have a significant relationship with a dependent variable.
- Indicate the relative strength of different independent variables' effects on a dependent variable.
- Make predictions.

To sum up, the performance of regression analysis methods in practice depends on the form of the data generating process, and how it has relates to the regression approach being used. Since the true form of the data-generating process is generally not known, regression analysis often depends to some extent on making assumptions about this process. These assumptions are sometimes testable if a sufficient quantity of data is available. Regression models for prediction are often useful even when the assumptions are moderately violated, although they may not perform optimally. However, in many applications, especially with small effects or questions of causality based on observational data, regression methods can give misleading results.

7. Analysis of Sustainable transportation criteria

7.1 Introduction

The selection of explanatory variables was based on theoretical guidance and empirical availability in the two enriched datasets.

The hypotheses for the influence of the individual explanatory variables on sustainable transportation indicator variables were relatively straightforward. Expected differences between the cities were more difficult to hypothesize, as there were few prior multivariate studies comparing these influences between cities. Therefore, hypotheses regarding the differences of effects between the cities were based on logical assumptions, but empirical analysis still had to show if they held true. For each variable, an attempt was made to formulate expected effects for the overall sign of the coefficients and potential difference in their magnitude between the cities.

The main reason for choosing this two cities backs to similarity of structure and infrastructure of them which has been the most important and logical factor for comparing two different cities. (For more information about this, two cities please see the Appendix B,C)

7.2 Data collection

For the purpose of statistical analysis, 160 sustainable transportation indicators were collected from the comprehensive literature review, and finally 12 sustainable transport indicators were selected, three indicators in each parts of environmental and economic, and six indictors in social. These sustainable transport indicators were selected from other researches and some new indicator were developed based on criteria’s found in the literature. The final selections of important factors affecting urban transportation sustainability are based on correlation analyses.

For approving applicability of the new approach, the data for the variables are collected and given in table 13. The variables are divided according to sustainable dimensions known as social, economic, and environmental variables. It is worth to mention that because of lack of information for the variables of these two cities the data collection is limited in the period of 2002-2010. For collecting relevant data for each variable, different sources of available databases are reviewed and among them, the more accurate ones are selected.

Descriptive data analysis such as, summary statistics, time series plot and other useful techniques are used to explain the behaviour of variables. The software used for data analysis is IBM SPSS version 22.

The apply method of analysis, allows the inclusion of additional indicators that enable countries to do a more comprehensive and differentiated assessment of sustainable development. Core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that is either readily available or could be made available within reasonable time and costs. Conversely, indicators that are not part of the core are either relevant only for a smaller set of countries, provide complementary information to core indicators or are not easily available for most countries.

Table 13 : Data collection variables (social, economic, and environmental variables)

Sustinabale transporation Indicator	**Economic** variables	**Social** variables	**Environmental** variables
usage of public transporation	Median household income	Population	CO2 emissions from transport
	GDP per capita	Age (3 Groups)	Road sector gasoline fuel consumption per capita
	GDP	Population density	CO2 emissions
		Downtown population	

Source: own analysis

7.3 Descriptive Analysis of data in Dortmund

The main sources of data collected for Dortmund are: Stadt Dortmund, Fachbereich Statistik und Wahlen, Jahresbericht 2002-2012: Dortmunder Bevölkerung, Stadt Dortmund, Fachbereich Statistik und Wahlen, Jahresbericht 2002-2012: Wirtschaft, Stadt Dortmund, Fachbereich Statistik und Wahlen, Jahresbericht 2002-2012: Lebensraum Dortmund. 2014 The World Bank, dortmunderstatistik - statistisches jahrbuch 2013.
The results of descriptive analysis for the variables of Dortmund are given in the following sections.

7.3.1 Usage of Public Transportation (Sustainable Transportation Indicator)

All levels of government in Germany have a long tradition of providing subsidies for public transportation. In Germany and the U.S., transit companies were originally privately owned, but government subsidies started much earlier in Germany. In the U.S., the federal government has only subsidized public transportation since the 1970s, when most of the privately owned transit systems had already gone bankrupt and been disassembled. In 1991, the U.S. federal government renewed its funding priorities for public transportation. This policy shift in the U.S. marked a convergence of public transportation policies at the federal level in both countries.

In 2005, transit subsidies per passenger and passenger kilometre of transit use were lower in Germany than in the U.S. The share of government subsidies in transit operating budgets is almost 50 percent lower in Germany than in the U.S. Policies at the local and regional levels still differ in the two countries. As early as the 1960s, Germany's transit operators began coordinating their fares and timetables region-wide to provide inexpensive, convenient, and seamless public transportation service for their customers. In the U.S., some cooperation between transit operators exists as well, but overall customers still face fragmented timetables and fare structures. As it, mention in section 5, the usage of public transportation is used as an indicator for measuring sustainability of urban transportation, which can also be used in transportation certificate system. This variable is used as a response or independent variable in our research.

The summary statistics for the variable of percentage of public transportation is given in table 14.

Table 14 : Summary statistics for percentage of public transportation in Dortmund

Usage of Public Transportation	
Mean	22.3044
Median	22.2300
Std. Deviation	1.56694
Minimum	19.87
Maximum	24.84

Source: own analysis

The time series plot for percentage of public transportation is presented in figure 23.

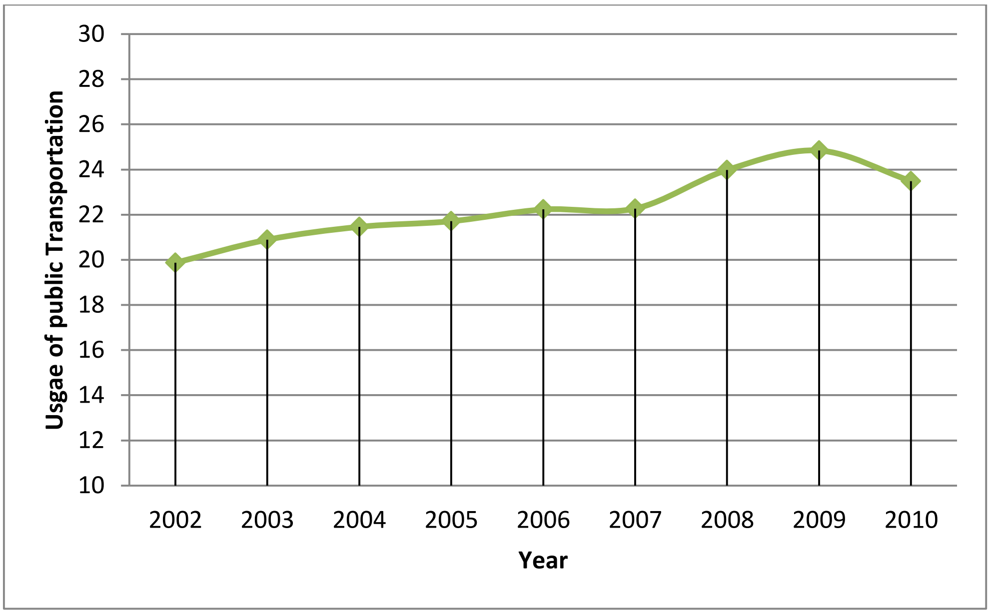


Figure 23: Time series plot of usage of public transportation

The results of descriptive analysis for percentage usage of public transportation for Dortmund show that the mean value in this period of study is 22.3% and the trend of usage is gradually increasing.

7.3.2 Social variables:

The summary statistics for the variable of population, different age groups, rural population, and population density is given in table 15.

Table 15 : Summary statistics for social variables in Dortmund

Summary Statistics	Population (* 10,000)	Rural Population*	Population Density **	Age 0-17 (%)	Age 18-64 (%)	Age 65+ (%)
Mean	58.3369	73.4699	2051,74	16.6675	63.2391	20.0934
Median	58.5045	73.4470	2054,20	16.6721	63.0490	20.4157
Std.Deviation	.43137	.22166	8.052	.42387	.33717	.65893
Minimum	57.67	73.18	2038	16.04	62.91	18.96
Maximum	58.76	73.82	2061	17.16	63.90	20.78

* Percentage of total population
** People per sq. km of land area
Source: own analysis

The time series plots of population, downtown population, and bar chart of mean percentage of different age groups are presented in figure 24, 25, 26, 27.

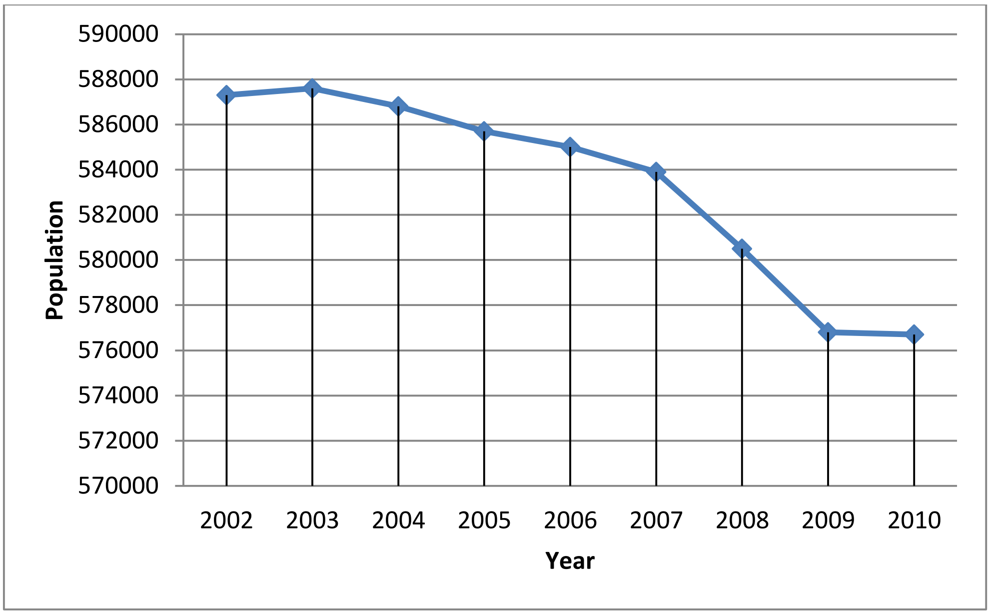


Figure 24: Time series plot of Population in Dortmund

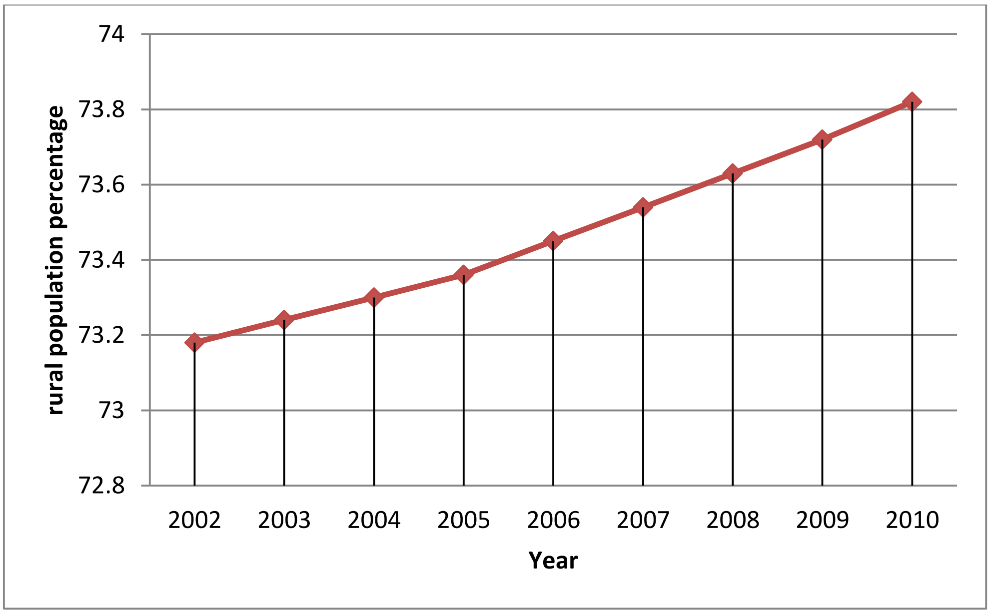


Figure 25: Time series plot of Rural Population Percentage in Dortmund

Sustainable transportation must take into account social factors as well as economic and environmental considerations. Social sustainability occurs when the formal and informal processes; systems; structures; and relationships actively support the capacity of current and future generations to create healthy and liveable communities. Socially sustainable communities are equitable, diverse, connected, and democratic and provide a good quality of life.

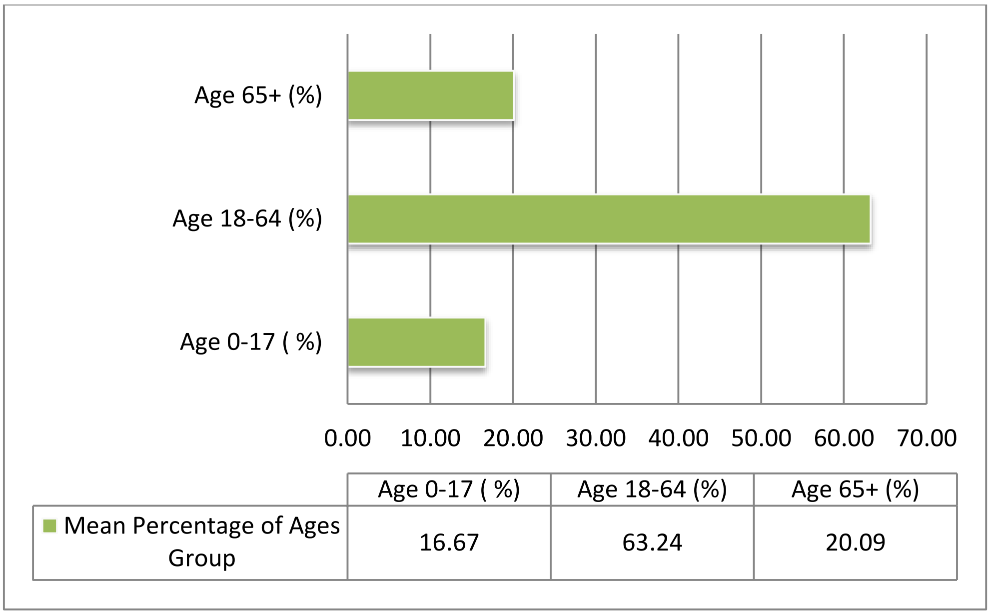


Figure 26: Bar Chart of Mean Percentage of age groups in Dortmund

The results of descriptive analysis for social variables for Dortmund show that the mean population in the period of study is 583369 and it is shown in figure 24 the trend of population is negative it means that the population of this city is decreasing.

Figure 25 shows that the mean percentage of downtown (Innenstadt) population of Dortmund is about 27% and the trend is negative it means that the population living rural (Außenstadt) is more than 70% and the trend is positive.

Figure 26 illustrates that the age of 64% of population belongs to age group of 18 to 64; also, the following figure shows that the trend of age group 0-17 is decreasing and age group 65+ is increasing.

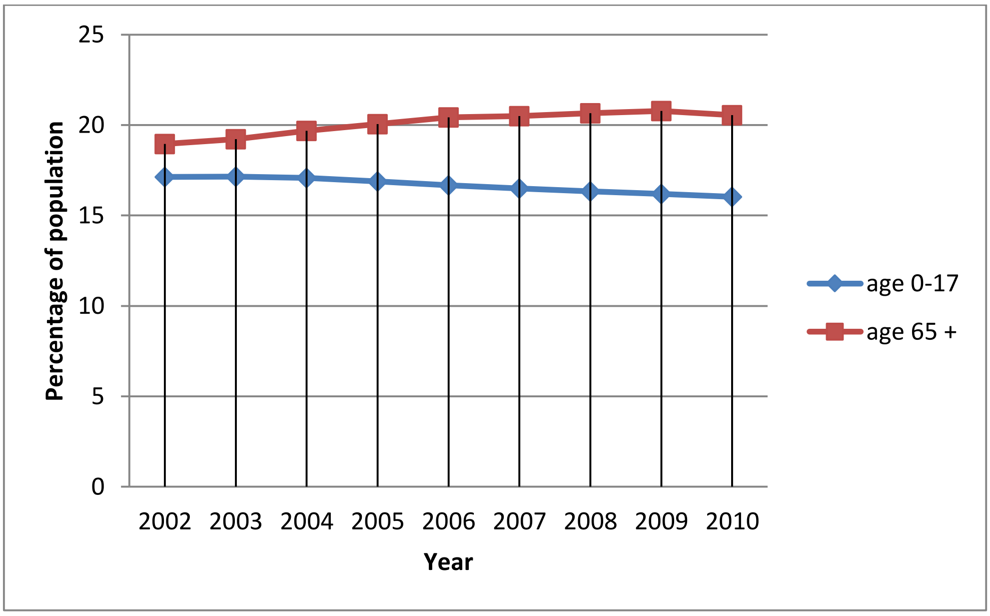


Figure 27 : Time series plot of age groups Population in Dortmund

It can be concluded from this part of study and analysis of Dortmund demography that whole population is decreasing and the age groups of 65+ is increasing; therefore as the population of Dortmund is getting smaller the population of older groups is getting bigger. It means that Dortmund will have more old population in the future we will use this fact in next section for sustainable transportation purpose.

7.3.3 Economic variables

The summary statistics for the economic variable of Income, GDP per capita, and GDP is given in table 16.

Table 16 : Summary statistics for economic variables in Dortmund

Summary Statistics	Income*	GDP per capita* (current US$)	GDP** (current US$)
Mean	16.7116	35.6098	2928.56
Median	16.8800	35.2380	2903.00
Std. Deviation	.79869	6.27911	509.355
Minimum	15.46	24.33	2007
Maximum	17.88	44.13	3624

*: income and GDP per capita ×1,000
**: GDP × 1,000,000,000
Source: own analysis

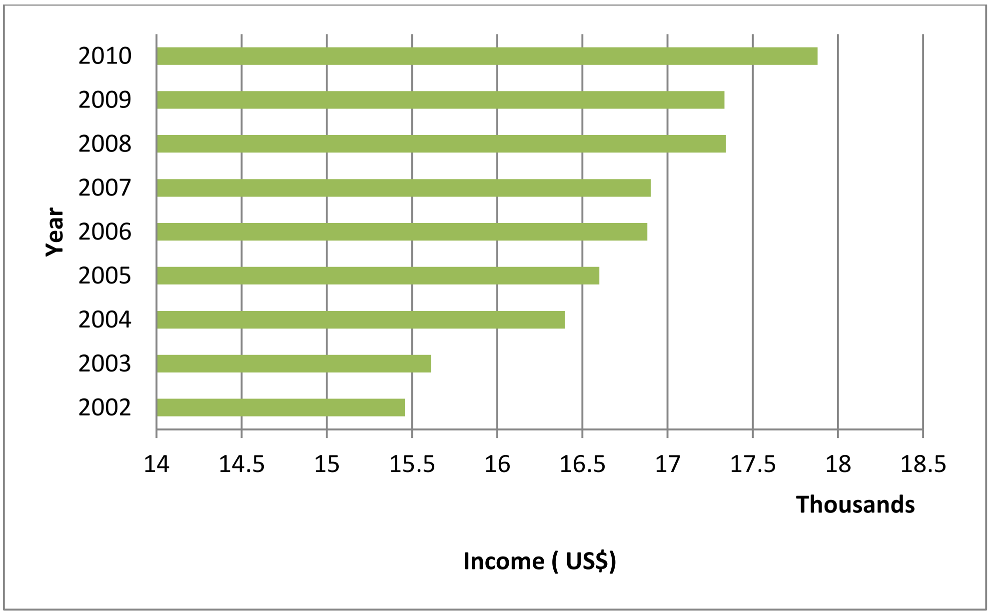


Figure 28 : Time series plot of Household Income in Dortmund

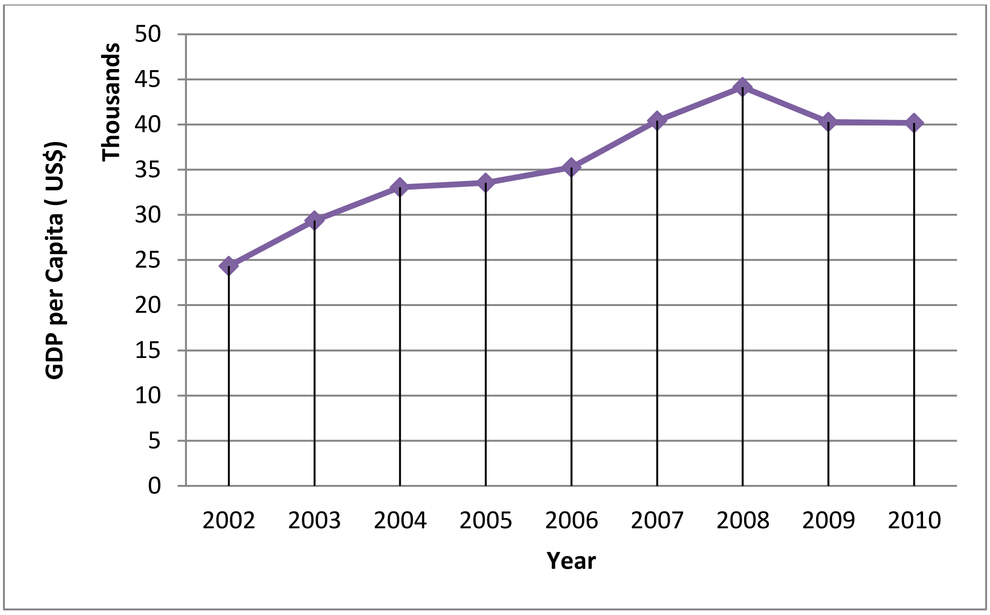


Figure 29 : Time series plot of GDP per Capita in Dortmund

The results of descriptive analysis for economic variables for Dortmund show that the mean household income (The combined gross income of all the members of a household who are 15 years old and older. Individuals do not have to be related in any way to be considered members of the same household. Alternatively, household income is the combined income of all members of a household who jointly apply for credit. Household income is an important risk measure used by lenders for underwriting loans.) In the period of research is 16711.6 (US $), and it is obvious from figure 28 the trend of household income is positive; also from figure 29 can be concluded that GDP per capita in Dortmund is increasing in the period of study.

Finally, the economic variable of GDP is measurement that helps to determine how an economy functions. GDP Growth Rate in Germany is reported by the Federal Statistical Office. GDP Growth Rate in Germany averaged 0.29 Percent from 1991 until 2013, reaching an all-time high of 2.10 Percent in the second quarter of 2010 and a record low of -3.70 Percent in the first quarter of 2009. Germany is the fourth largest economy in the world and the largest within the Euro Area.

The total GDP in Dortmund is increasing from 2000 billion US dollars in 2002 to 3200 billion US dollars in 2010.

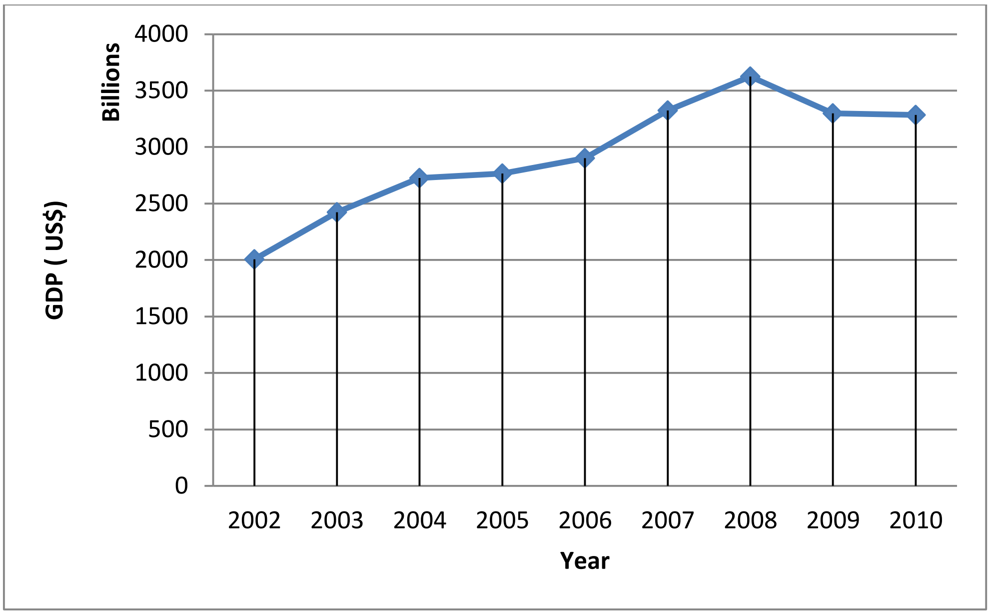


Figure 30 : Time series plot of GDP in Germany

7.3.4 Environmental variables

The summary statistics for the environmental variable of CO2 emissions, CO2 emissions from transport and road sectors gasoline fuel consumption per capita is given in table 17.

Table 17 : Summary statistics for environmental variables in Dortmund

Summary Statistics	CO2 emissions*	CO2 emissions from transport**	Road sector gasoline fuel consumption per capita
Mean	7.12311	131.78.56	270.4368
Median	7.25100	130.450.0	265.4521
Std. Deviation	.410390	7.59214	35.93592
Minimum	6.411	124.550	223.28
Maximum	7.567	144.980	326.95

***:** (metric tons per capita)
**:(million metric tons)
***:(kg of oil equivalent)
Source: own analysis

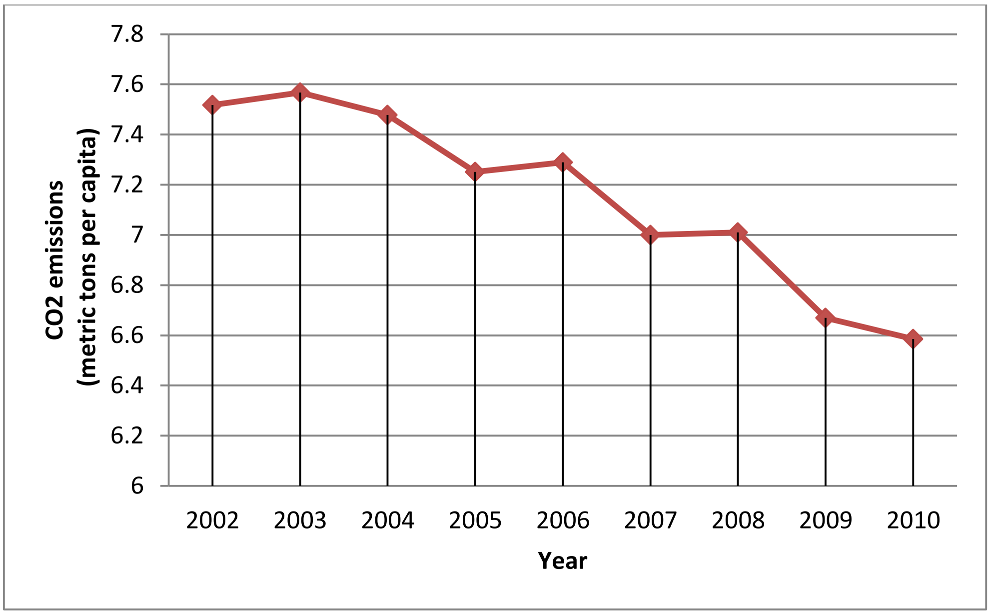


Figure 31 : Time series plot of CO2 emissions in Dortmund

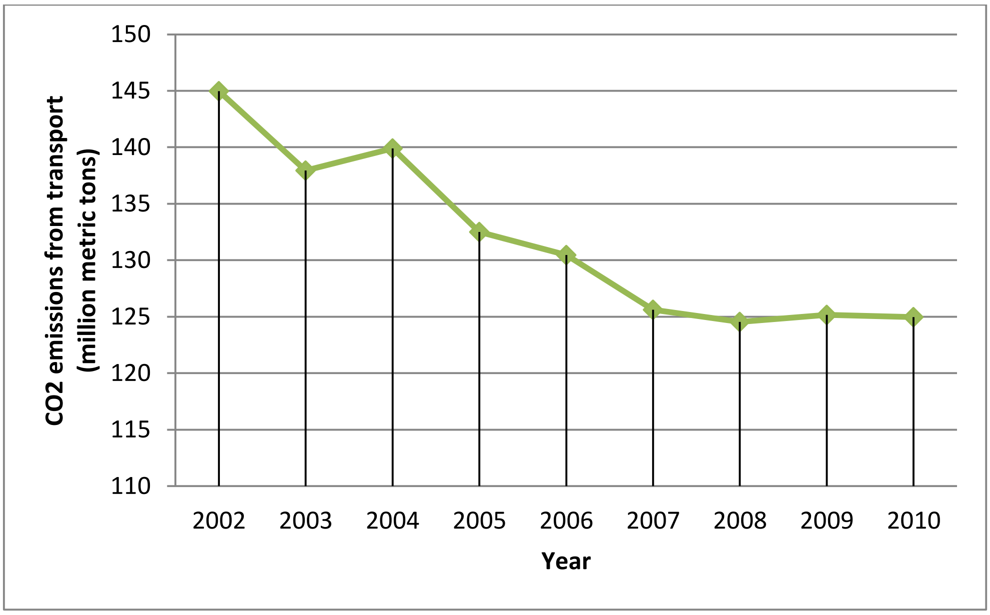


Figure 32 : Time series plot of CO2 emissions from transport sector in Dortmund

The essence of these figures demonstrates that there are statistically significant relationship between the CO2 emissions and CO2 emissions from transportation. Carbon dioxide (CO2) is colourless, odourless, and non-poisonous gas form by combustion of carbon and in the respiration of living organisms and is considered a greenhouse gas. An emission means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period. Figure 31 shows that the CO2 emission in Dortmund is decreasing about 1 metric ton per capita and CO2 emissions from transport is decreasing by nearly 20 million metric ton.

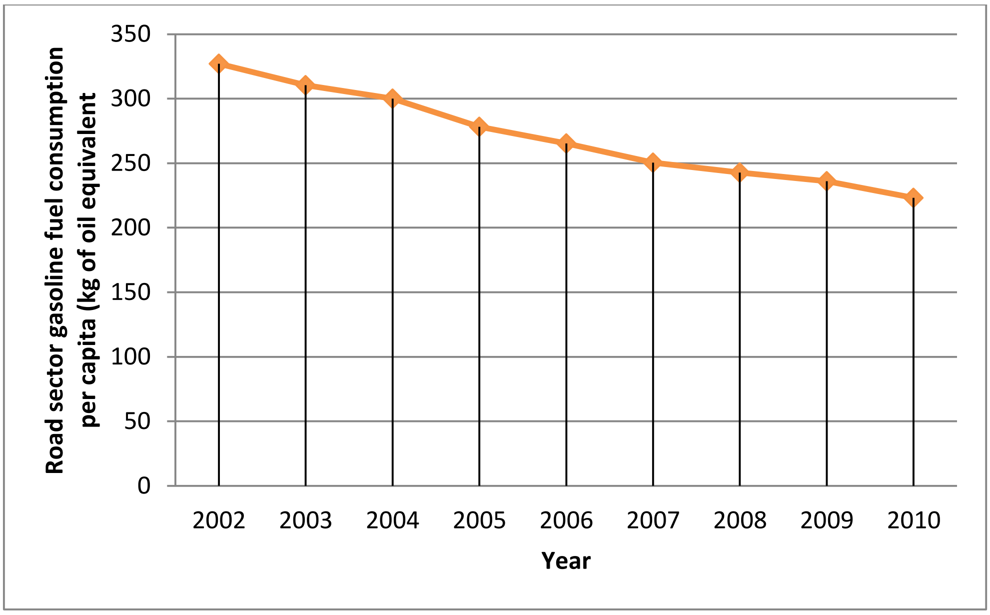


Figure 33 : Time series plot of Road sector gasoline fuel consumption per capita in Dortmund

Transport is responsible for around a quarter of EU greenhouse gas emissions making it the second biggest greenhouse gas-emitting sector after energy. Road transport alone contributes about one-fifth of the EU's total emissions of carbon dioxide (CO2), the main greenhouse gas. The value for road sector gasoline fuel consumption per capita (kg of oil equivalent) in Dortmund is 326 as of 2002. As the figure 33 shows, over the past 8 years this indicator reached a maximum value of 326 kg of oil equivalent in 2002 and a minimum value of 223 kg of oil equivalent in 2010.

7.4 Descriptive analysis of data in Portland

7.4.1 Usage of Public Transportation (Sustainable Transportation Indicator)

Public transportation, except for ferryboats, was not a part of everyday life until the 19th century, since home, work, and recreation were usually within walking distance of each other. As distances in growing cities increased, horse-pulled stagecoaches were introduced to meet the need for better transportation for the few who could afford it, and the railroad was invented. The horse car--initially a horse-pulled stagecoach body on special wheels that ran on rails--was devised to operate on the unpaved or poorly paved streets of that era. As technology developed, elevated steam railroads, cable-pulled cars, electric streetcars, and underground electric trains all became common and many of these developments were pioneered in the U.S. Not all operated on rails, and it was until the 1910-1920 periods that improved street pavement and internal combustion engines led to the widespread introduction of buses. These are some of the more important events in that history. (2012 Pubic Transportation, Fact book, 63rd Edition, September 2012).In this research the usage of public transportation is used as an indicator for measuring sustainability of urban transportation, which will be used in transportation certificate system. This variable is used as a response or independent variable in our research. The summary statistics for the variable of percentage of usage of public transportation is given in table 18.

Table 18 : Summary statistics for percentage usage of public transportation in Portland

Usage of Public Transportation	
Mean	12.3389
Median	12.2532
Std. Deviation	1.09812
Minimum	10.33
Maximum	13.65

Source: own analysis

The results of descriptive analysis for percentage of public transportation for Portland show that the mean value in this period of study is 12.3% and the trend of usage is gradually decreasing. The minimum usage is 10.3% and the maximum usage reach 13.65% during period of study.

The time series plot for percentage of usage of public transportation is presented in figure 34.

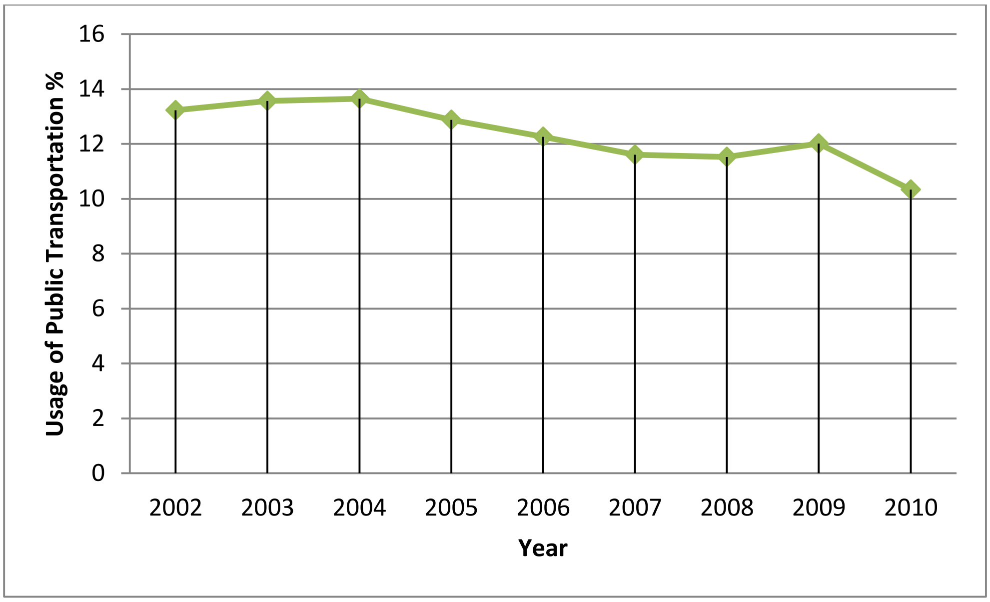


Figure 34: Time series plot of usage of public transportation

7.4.2 Social variables:

The summary statistics for the variable of population, different age groups, rural population, and population density is given in table 19.

Table 19 : Summary statistics for social variables in Portland

Summary Statistics	Population (* 10,000)	Rural Population *	Population Density **	Age 0-17 (%)	Age 18-64 (%)	Age 65+ (%)
Mean	54.8481	19.0178	2659.93	23.786	63.312	12.910
Median	53.8800	18.9900	2652.75	23.6400	63.610	12.760
Std.Deviation	1.77337	.81572	22.12	.80932	.63347	.57434
Minimum	53.29	17.86	2651.46	22.46	62.4800	12.450
Maximum	58.55	20.25	2718.90	24.76	64.1200	14.310

* Percentage of total population
** People per sq. km of land area
Source: own analysis

The time series plots of population, downtown population, and bar chart of mean percentage of different age groups are presented in figure 35,36,37,38.

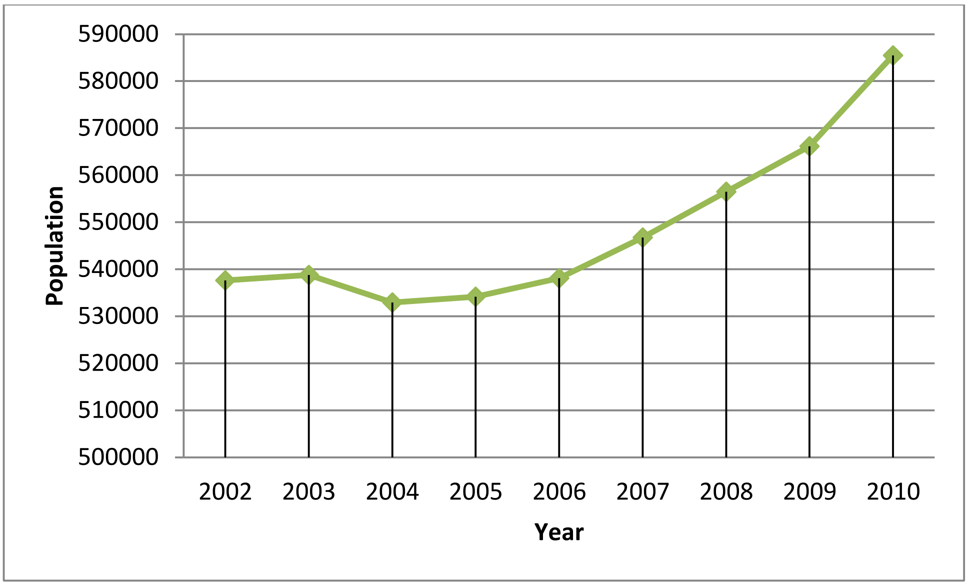


Figure 35: Time series plot of Population in Portland

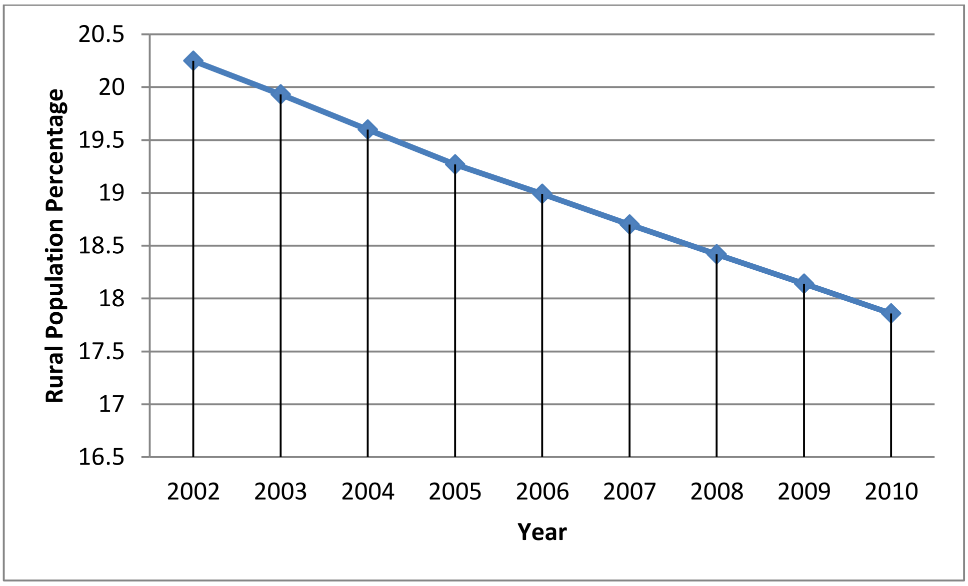


Figure 36: Time series plot of Rural Population in Portland

One of the most important, and often overlooked, aspects of delivering social sustainability is ongoing monitoring of social issues and outcomes. By monitoring communities in the long-term, we can better understand the actual effects of our activities, which helps to make more accurate predictions in the future. It also allows us to develop a greater understanding of social change over time.

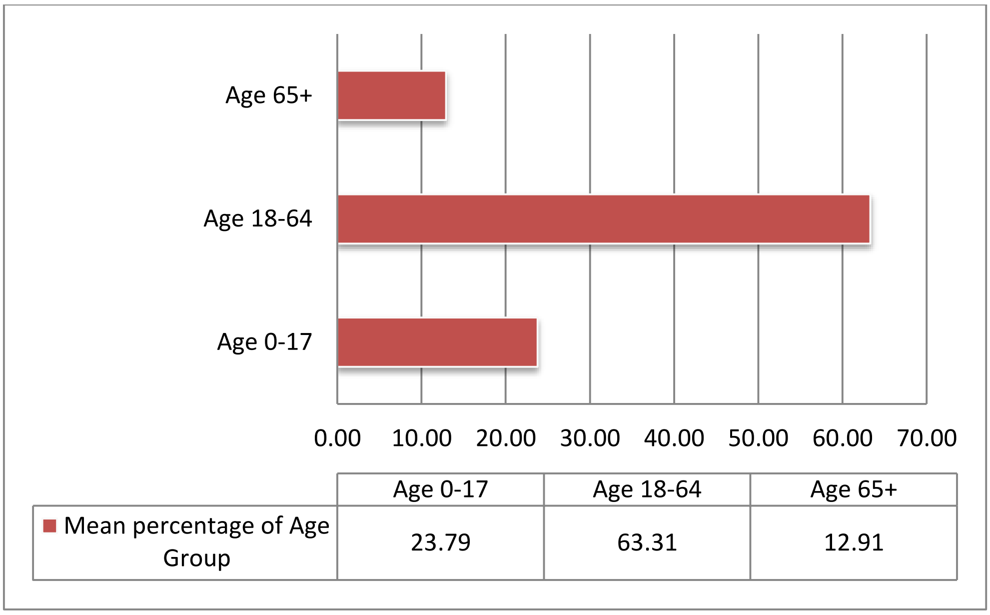


Figure 37: Bar Chart of Mean Percentage of age groups in Portland

The results of descriptive analysis for social variables for Portland show that the mean population in in the period of study is 548481, and it is shown in figure 35 the trend of population is positive it means that the population of this city is increasing.

Figure 36 shows that the mean percentage of downtown population of Portland is about 19% and the trend is negative it means that the population living city centre is more than 70% and the trend is positive.

Figure 37 illustrates that the age of 63% of population belongs to age group of 18 to 64; also, the following figure shows that the trend of age group 0-17 is decreasing and age group 65+ is increasing.

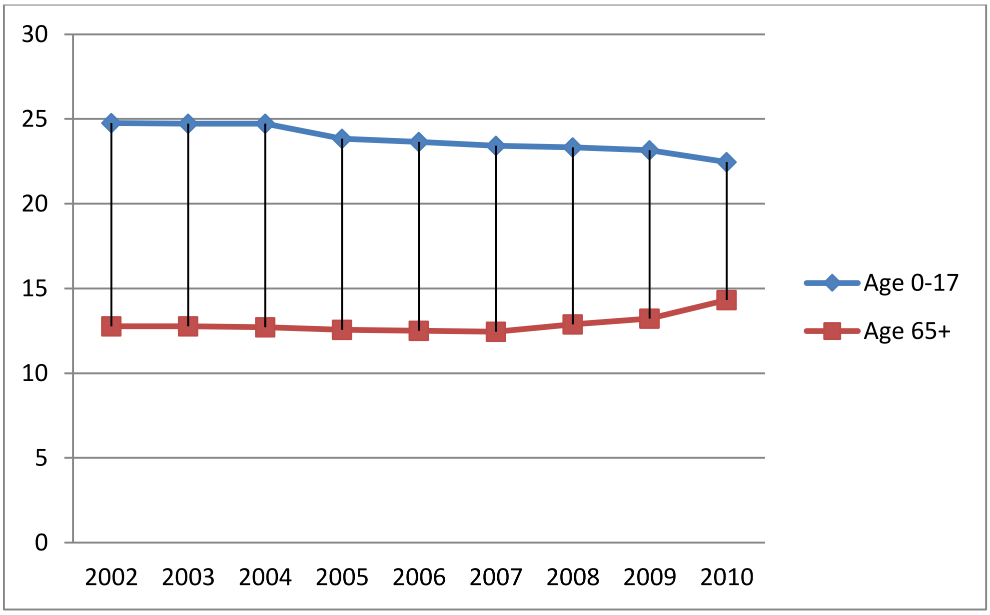


Figure 38 : Time series plot of age groups Population in Portland

7.4.3 Economic variables

The summary statistics for the economic variable of Income, GDP per capita, and GDP is given in table 20.

Table 20 : Summary statistics for economic variables in Portland

Summary Statistics	Income*	GDP per capita* (current US$)	GDP** (current US$)
Mean	33.74600	43.05611	12872.767
Median	34.70600	44.62300	13314.500
Std. Deviation	2.675274	3.790128	1426.5183
Minimum	29.797	36.819	10590.2
Maximum	37.407	46.760	14419.4

*: income and GDP per capita ×1,000
**: GDP × 1,000,000,000
Source: own analysis

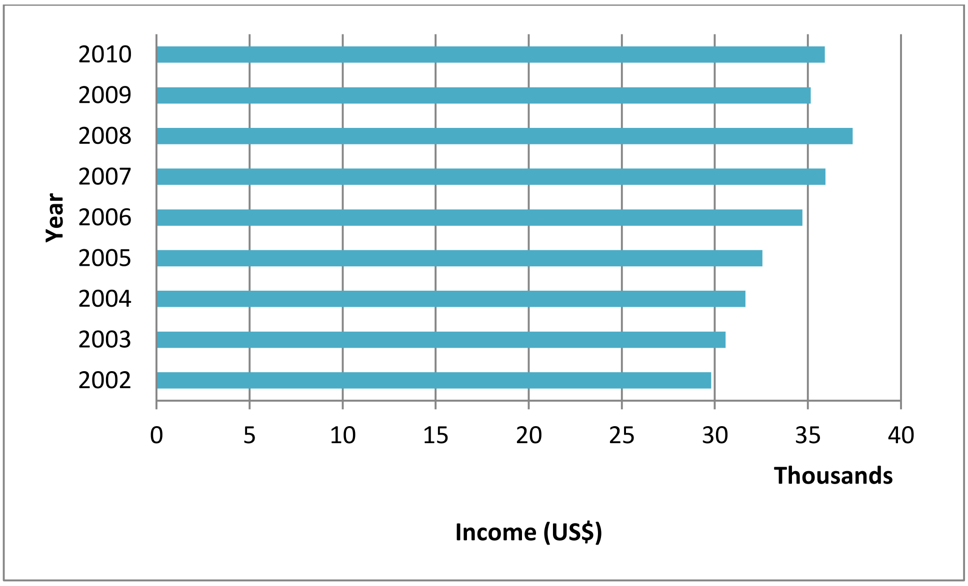


Figure 39 : Time series plot of Household Income in Portland

A sustainable economy is one that provides the monetary resources necessary to support the community. Economic growth occurs when real output increases over time. Real output is measured by Gross Domestic Product (GDP) at constant prices, so that the effect of price rises on the value of national output is removed. Sustainable economic growth means a rate of growth, which can be maintained without creating other significant economic problems, especially for future generations. There is clearly a trade-off between rapid economic growth today, and growth in the future. Rapid growth today may exhaust resources and create environmental problems for future generations, including the depletion of oil and global warming.

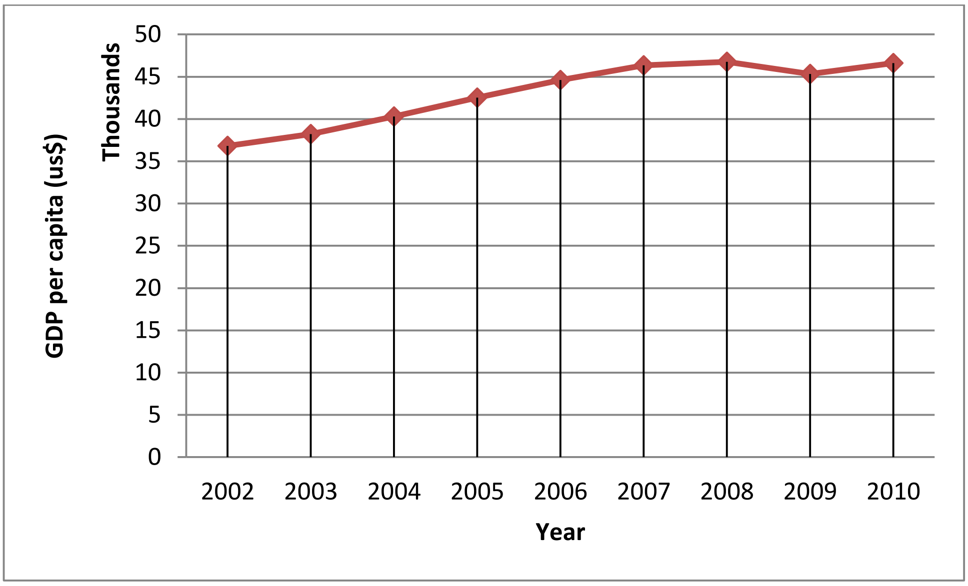


Figure 40 : Time series plot of GDP per Capita in USA

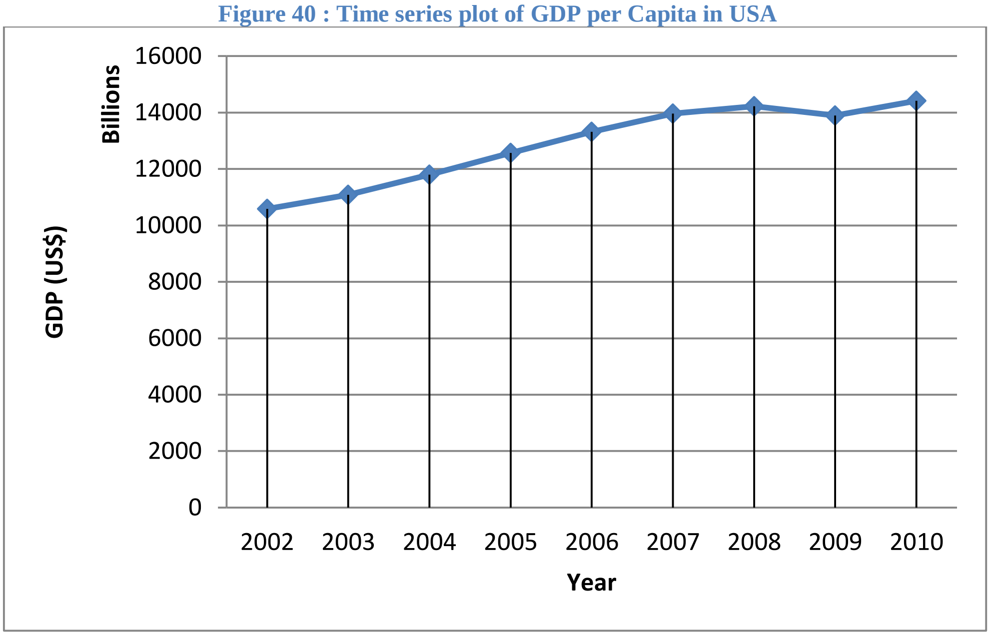


Figure 41 : Time series plot of GDP in USA

The results of descriptive analysis for economic variables for Portland show that the mean household income in the period of research is 33746 (US $), and it is obvious from figure 39 the trend of household income is positive; also from figure 40 can be concluded that GDP per capita in Portland (US) is increasing in the period of study.

Finally, The Gross Domestic Product (GDP) in the United States expanded 2.40 percent in the fourth quarter of 2010 over the previous quarter. GDP Growth Rate in the United States is reported by the U.S. Bureau of Economic Analysis. GDP Growth Rate in the United States averaged 3.24 Percent from 1947 until 2010.

7.4.4 Environmental variables

The summary statistics for the environmental variable of CO2 emissions, CO2 emissions from transport and road sector gasoline fuel consumption per capita is given in table 21.

Table 21 : Summary statistics for environmental variables in Portland

Summary Statistics	CO2 emissions*	CO2 emissions from transport**	Road sector gasoline fuel consumption per capita
Mean	12.02	155.644.0	520.344
Median	11.42	158.900.0	522.590
Std. Deviation	2.24	122.07	67.12
Minimum	10.01	137.800	560.536
Maximum	13.01	169.000	676.045

***:** (metric tons per capita)
**:(million metric tons)
***:(kg of oil equivalent)
Source: own analysis

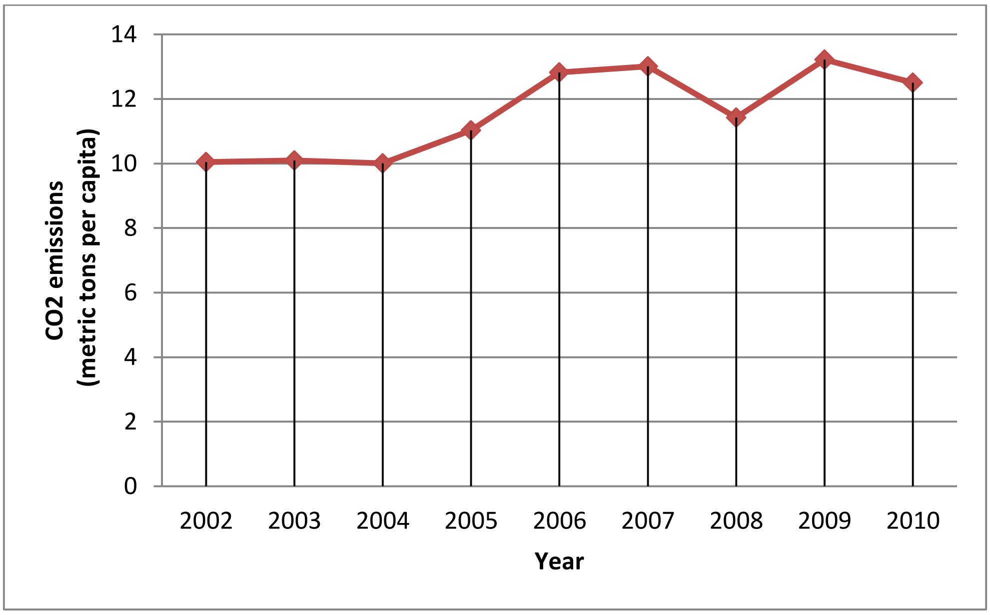


Figure 42 : Time series plot of co2 emissions in Portland

The Transportation sector includes the movement of people and goods by cars, trucks, trains, ships, airplanes, and other vehicles. The majority of greenhouse gas emissions from transportation are CO_2 emissions resulting from the combustion of petroleum-based products, like gasoline, in internal combustion engines. The largest sources of transportation-related greenhouse gas emissions include passenger cars and light-duty trucks, including sport utility vehicles, pickup trucks, and minivans. These sources account for over half of the emissions from the sector. The remainder of greenhouse gas emissions comes from other modes of transportation, including freight trucks, commercial aircraft, ships, boats, and trains as well as pipelines and lubricants.

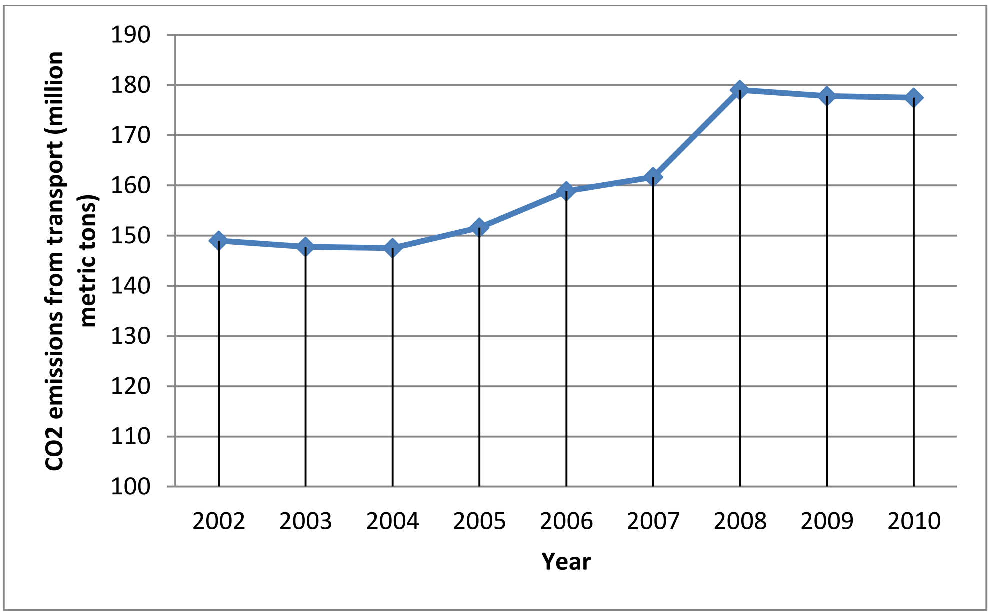


Figure 43 : Time series plot of co2 emissions from transport in Portland

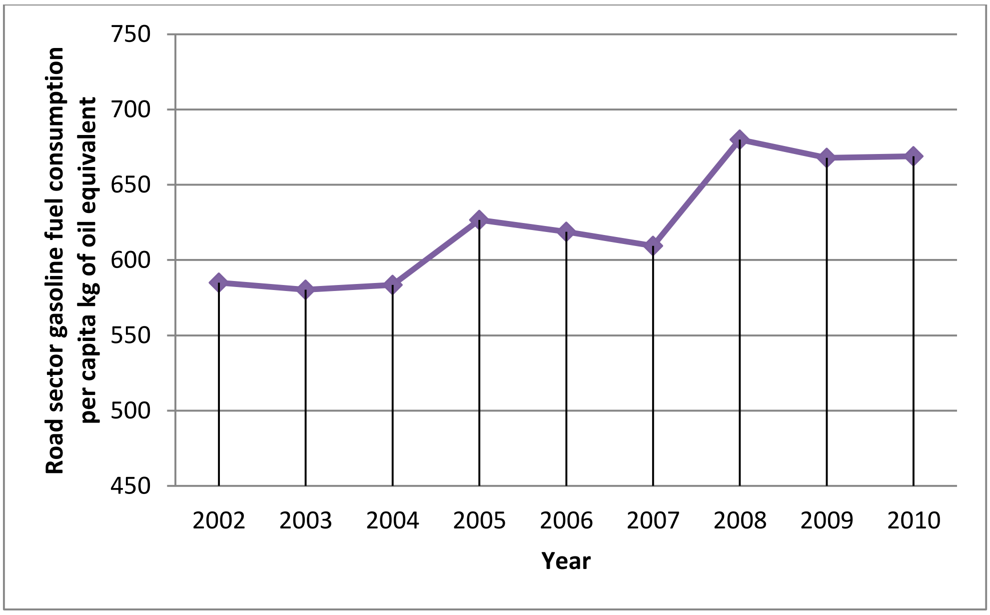


Figure 44 : Time series plot of Road sector gasoline fuel consumption per capita in Portland

In 2010, greenhouse gas emissions from transportation accounted for about 28% of total Portland greenhouse gas emissions, making it the second largest contributor of Portland greenhouse gas emissions after the Electricity sector. Greenhouse gas emissions from transportation have increased by about 18% since 1990. This historical increase is largely due to increased demand for travel and the stagnation of fuel efficiency across the Portland vehicle fleet.

7.5 Correlation and Regression analysis for data in Dortmund

For approving the strength of a relationship between new approach of sustainable transportation indicator and candidate sustainable variables correlation and liner regression analysis is used. The methodology for using these techniques of analysis is implemented as the following steps. First step the correlations between sustainable transportation indicator and sustainable variable will be calculated and interpreted. In the next step, the regression analysis is used to prove that the usage of public transportation as criteria for sustainable transportation indicator is proper criteria as an indicator for transportation certificate system.

The results of correlation analysis between the sustainable transportation indictor as response or dependent variables with social, economic and environmental variables as independent variables of Dortmund are given in the following sections.

7.5.1 Social variables

The correlation between sustainable transportation indicator and the variables of population, different age groups, downtowns population, and population density is given in table 22.

Table 22 : Correlation between Sustainable Transportation Indicator and Social variable in Dortmund[1]

Correlations		Sustainable Transportation Indicator
Social Indicators		
Population	Pearson Correlation	**-.911******
	Sig. (2-tailed)	**.001**
Rural population (% of total population)	Pearson Correlation	**.921******
	Sig. (2-tailed)	**.000**
Population density (people per sq. km of land area)	Pearson Correlation	**-.903**
	Sig. (2-tailed)	**.001**
Age 0-17	Pearson Correlation	**-.905******
	Sig. (2-tailed)	**.001**
Age 18-64	Pearson Correlation	**-.648**
	Sig. (2-tailed)	**.059**
Age 65+	Pearson Correlation	**.914******
	Sig. (2-tailed)	**.001**

Source: own analysis

The correlation coefficient is a measure of the strength of the straight-line or linear relationship between two variables. The correlation coefficient is a number between -1 and 1 that indicates the strength of the linear relationship between two variables. The sign of r (+ or

[1] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

-) indicates the direction of the relationship between X and Y. The magnitude of correlation (how far away from zero it is) indicates the strength of the relationship.

Therefore, according to the table 22 the correlation between population of Dortmund and sustainable transportation indicator is -0.911, which is highly significant at level of 0.001. It means that these two variables are strongly correlated and the negative value of correlation is due to decreasing size of population. The next variable is rural population (outside of downtowns) of Dortmund which is even more correlated with sustainable transportation indicator and the positive sign shows that by increasing the rural population the usage of public transportation will increase. The next variable consider in this study is population density which is also highly correlated with sustainable transportation indicator and the negative sign of correlation is because of decreasing size of population.

For the age groups, the results of correlation analysis show that the age group 18-64 has a weak relationship with the indicator, on the other hand two other age groups are highly correlated with sustainable transportation indicator.

Future analysis of this part will explained in Regression analysis section, regression analysis is one of the most frequently used tools for analyzing. In its simplest form, regression analysis allows monitoring and analyzes relationships between one independent and one dependent variable. The key benefits of using regression analysis are that it can:

- Indicate if independent variables have a significant relationship with a dependent variable.
- Indicate the relative strength of different independent variables' effects on a dependent variable.
- Make predictions.

Knowing about the effects of independent variables on dependent variables can help for monitoring and measurement of sustainability in many different ways. For example, it can help to understand the direction of sustainability if we know usage of public transportation significantly decrease CO2 emissions.

Knowing about the relative strength of effects is useful for achieving goals of sustainable transportation and find out main variables which directly effect on sustainability issues, because it may help answer questions such as if usage of public transportation depend more strongly on CO2 emissions from transport sector or on Household income. Most importantly, regression analysis allows us to compare the effects of variables measured on different scales such as the effect of GDP per capita (e.g., measured in USD) and the Age groups.

Regression analysis can also help make predictions. For example, regression analysis could provide a precise answer to what would happen to CO2 if usage of public transportation increases by 5%.

Table 23 : Model Summary of Regression STI and Population in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.911[a]	0.830	0.805	0.6916162	0.830	34.064

a. Dependent Variable: Sustainable Transportation Indicator
b. Predictors: (Constant), Population

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	215.309	33.070		6.511	0.000
	Population	-3.308	0.567	-0.911	-5.836	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the population and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 215.309 - 3.308\ Population$$

The data displayed on the graph resembles a line rising from right to left. Since the slope of the line is negative, there is a negative correlation between the two sets of data. This means that according to this set of data, Dortmund sustainable transportation indicator is increasing in the future while the population is decreasing.

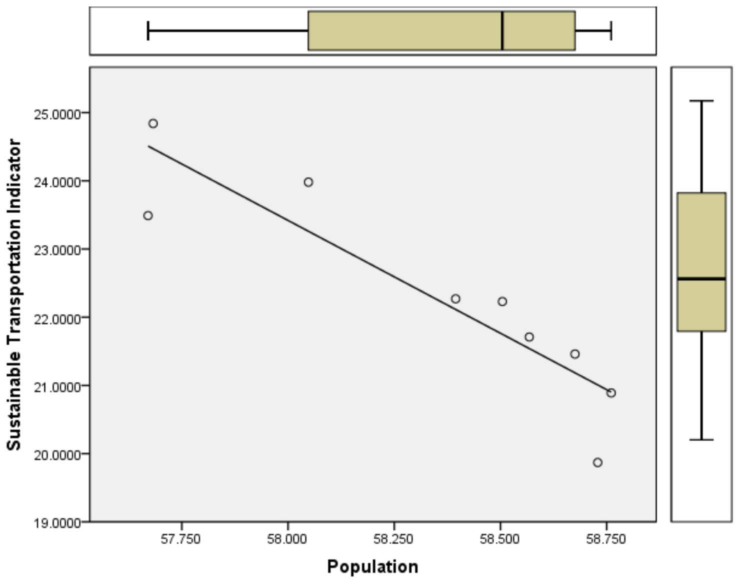


Table 24 : Model Summary of Regression STI and rural population in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.921[a]	0.849	0.827	0.6514317	0.849	39.287

a. Dependent Variable: Sustainable Transportation Indicator
b. Predictors: (Constant), Rural population (% of total population)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-456.172	76.338		-5.976	0.000
	Rural population (% of total population)	6.513	1.039	0.921	6.268	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the rural population and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = -456 + 6.5\ rural\ population$$

The data displayed on the graph shows that as the rural population increases, the usage of public transportation also increases. The results are approximately in a straight line, with a positive gradient. We therefore say that there is positive correlation between rural population and usage of public transportation.

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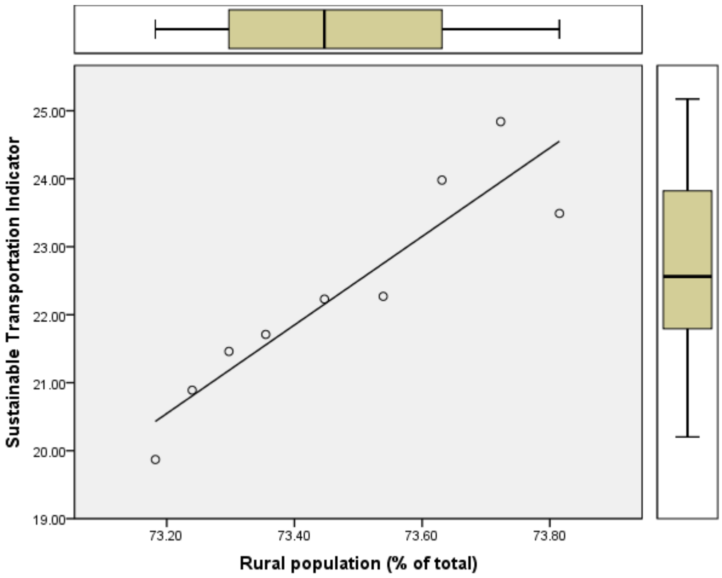


Table 25 : Model Summary of Regression STI and population density in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.903	0.816	0.789	0.71917	0.816	30.978

a. Dependent Variable: Sustainable Transportation Indicator
b. Predictors: (Constant), Population density (people per sq. km of land area)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	382.902	64.788		5.910	0.000
	Population density (people per sq. km of land area)	-0.176	0.032	-0.903	-5.566	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the population density and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 382.9 - 0.176\ Population\ density$$

The data displayed on Scatter plot shows that usage of public transportation increases as the population density decreases, indicating that there is a negative relationship between these two variables. A negative correlation means the two variables vary in opposite directions.

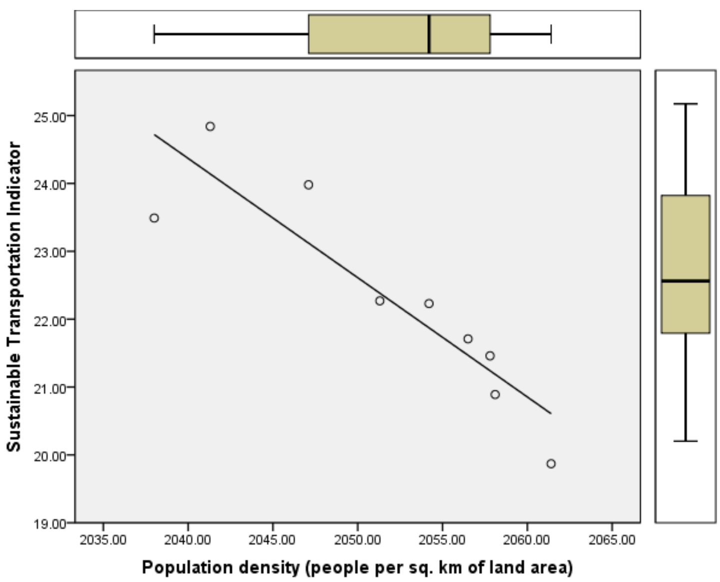


Table 26 : Model Summary of Regression STI and Age 0-17 in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.905[a]	0.819	0.793	0.7128016	0.819	31.660

a. Dependent Variable: Sustainable Transportation Indicator
b. Predictors: (Constant), age 0-17

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.064	9.913		7.875	0.000
	age 0-17	-3.345	0.595	-0.905	-5.627	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the age groups 0-17 and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 78.064 - 3.345\ Age\ group\ \ 0 - 17$$

The data displayed on Scatter plot shows that usage of public transportation increases as the age groups decreases, indicating that there is a negative relationship between these two variables. We must consider that the age group 0-17 in Dortmund is decreasing in this period of study.

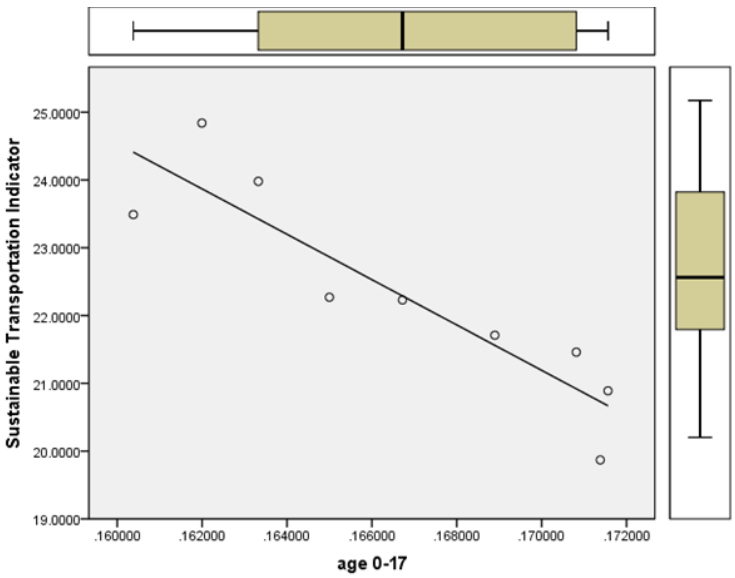


Table 27 : Model Summary of Regression STI and Age 65+ in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.914[a]	0.835	0.811	0.6814066	0.835	35.304

a. Dependent Variable: Sustainable Transportation Indicator
b. Predictors: (Constant), Age 65+

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-21.346	7.350		-2.904	0.023
	Age 65+ Retire	2.172	0.366	0.914	5.942	0.001

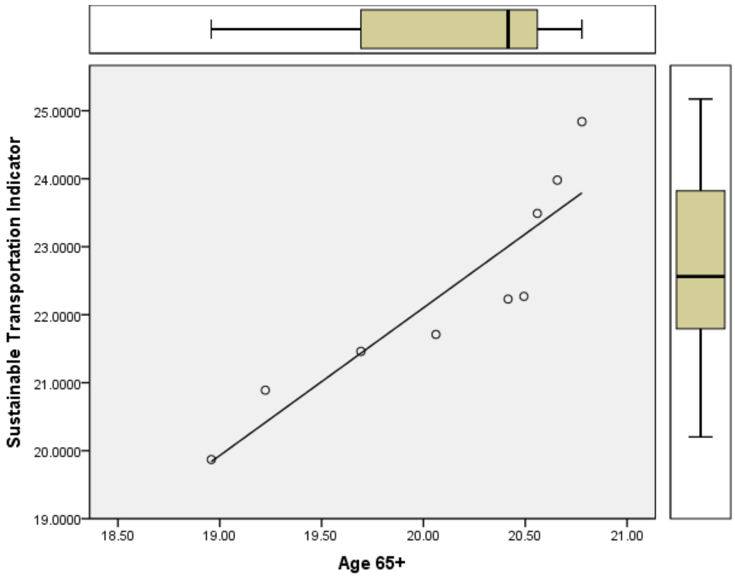
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the age groups +65 and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = -21.346 + 2.172\ Age\ group\ \ 65 +$$

The data displayed on the graph shows that as the age groups +65 increases, the usage of public transportation also increases. The results are approximately in a straight line, with a positive gradient. We therefore say that there is positive correlation between age groups +65 and usage of public transportation.



7.5.2 Economic variables

The correlation between sustainable transportation indicator and the variables of household income, GDP per capita and GDP is given in table 28.

Table 28 : Correlation between Sustainable Transportation Indicator and Economic variable in Dortmund [2]

Correlations		Sustainable Transportation Indicator
Economic Indicators		
Household income	Pearson Correlation	**0.893****
	Sig. (2-tailed)	**0.001**
GDP per capita (current US$)	Pearson Correlation	**0.903****
	Sig. (2-tailed)	**0.001**
GDP (current US$)	Pearson Correlation	**0.899****
	Sig. (2-tailed)	**0.001**

Source: own analysis

According to the table 28, the correlation between Household income of Dortmund and sustainable transportation indicator is 0.893, which is highly significant at level of 0.001. It means that these two variables are strongly correlated and the positive value of correlation is due to increasing Household income. The next variable is GDP per Capita of Dortmund, which is even more correlated with sustainable transportation indicator, and the positive sign shows that by increasing the GDP per Capita the usage of public transportation will increase. The next variable consider in this study is the GDP, which is the primary indicators used to gauge the health of a country's economy. It represents the total dollar value of all goods and services produced over a specific time – we can think of it as the size of the economy. Usually, GDP is expressed as a comparison to the previous quarter or year. For example, if the year-to-year GDP is up 3%, this is thought to mean that the economy has grown by 3% over the last year. The correlation analysis between GDP and usage of public transportation indicator is 0.899, which is highly significant at level of 0.001. It shows that there are highly correlated with sustainable transportation indicator and the positive sign of correlation is because of increasing GDP indicator.

The results of regression analysis between the sustainable transportation indictor as response or dependent variables with economic variables as independent variables of Dortmund are given in the following sections.

[2] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 29 : Model Summary of Regression STI and Income in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.893[a]	0.797	0.768	0.7552151	0.797	27.439

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Income

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-6.961	5.592		-1.245	0.253
	Income	0.002	0.000	0.893	5.238	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the income and sustainable transportation indicator in Dortmund have a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = -6.9 + \ 0.002\ Income$$

The data displayed on the graph shows that as the income increases, the usage of public transportation also increases. The results are approximately in a straight line, with a positive gradient. We therefore say that there is positive correlation between household income (US$) and usage of public transportation.

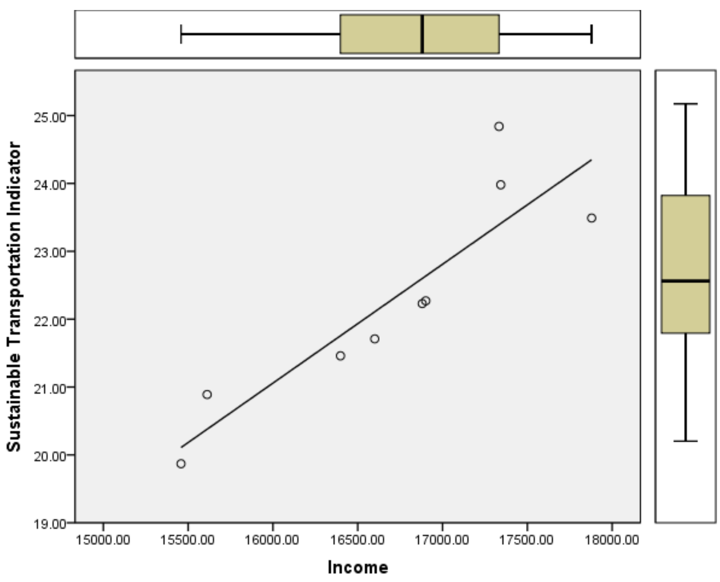


Table 30 : Model Summary of Regression STI and GDP per Capita in Germany

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.903[a]	0.815	0.789	0.72006	0.815	30.884

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), GDP per capita (current US$)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.281	1.464		9.758	0.000
	GDP per capita (current US$)	0.225	0.041	0.903	5.557	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the GDP per Capita and sustainable transportation indicator in Dortmund has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 14.2 + 0.22\ GDP\ per\ capita$$

The data displayed on Scatter plot shows that usage of public transportation increases as the GDP per Capita increases, indicating that there is a positive relationship between these two variables. We must consider that the GDP per Capita in Dortmund is increasing in this period of study. A positive correlation means that as one variable goes up in value, the other variable goes up too.

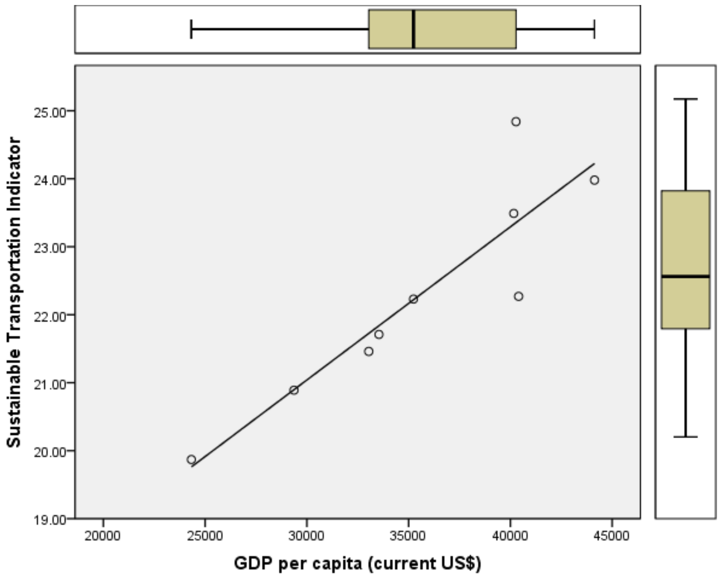


Table 31 : Model Summary of Regression STI and GDP in Germany

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.899a	0.808	0.780	0.7343945	0.808	29.420

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), GDP (current US$ × Billion)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.208	1.513		9.392	0.000
	GDP (current US$)	0.003	0.001	0.899	5.424	0.001

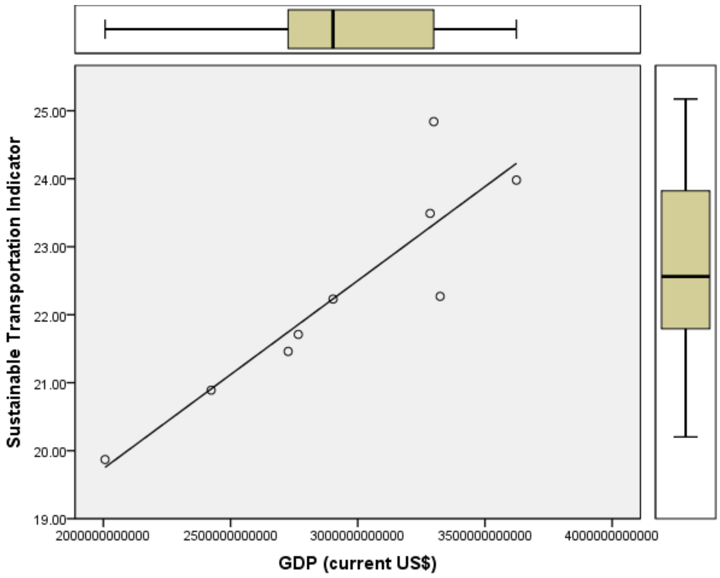
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the GDP and sustainable transportation indicator in Dortmund has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 14.2 + 003\ GDP$$

The data displayed on the graph resembles a line rising from left to right. Since the slope of the line is positive, there is a positive correlation between the two sets of data. This means that according to this set of data, Dortmund sustainable transportation indicator is increasing in the future while the GDP is increasing.



7.5.3 Environmental variables

Table 32 : Correlation between Sustainable Transportation Indicator and environmental variable in Dortmund[3]

Correlations		Sustainable Transpiration Indicator
Environmental Indicators		
CO2 emissions from transport (million metric tons)	Pearson Correlation	**-0.891****
	Sig. (2-tailed)	**0.001**
CO2 emissions (metric tons per capita)	Pearson Correlation	**-0.895****
	Sig. (2-tailed)	**0.001**
Road sector gasoline fuel consumption per capita (kg of oil equivalent)	Pearson Correlation	**-0.915****
	Sig. (2-tailed)	**0.001**

Source: own analysis

As stated in table 32, the correlation between CO2 emissions from transport of Dortmund and sustainable transportation indicator is -0.891, which is highly significant at level of 0.001. It means that these two variables are strongly correlated and the negative value of correlation is due to decreasing CO2 emissions from transport. The next variable is CO2 emissions of Dortmund, which is even more correlated with sustainable transportation indicator, and the negative sign shows that by decreasing the CO2 emissions the usage of public transportation will increase. The next variable consider in this study is the Road sector gasoline fuel consumption per capita. The correlation analysis between Road sector gasoline fuel consumption per capita and usage of public transportation indicator is -0.915, which is highly significant at level of 0.001. It shows that there are highly correlated with sustainable transportation indicator and the negative sign of correlation is because of decreasing Road sector gasoline fuel consumption per capita indicator.

The results of regression analysis between the sustainable transportation indictor as response or dependent variables with environment variables as independent variables of Dortmund are given in the following sections.

[3] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 33 : Model Summary of Regression STI and CO2 emissions from transport in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.891[a]	0.794	0.765	0.75992	0.794	27.014

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), CO2 emissions from transport (million metric tons)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	50.327	5.398		9.324	0.000
	CO2 emissions from transport (million metric tons)	-0.0184	0.035	-0.891	-5.197	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the CO2 emission from transport and sustainable transportation indicator in Dortmund has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 50.3 - 0.18\ \ CO2\ emissions\ from\ transport$$

The data displayed on Scatter plot shows that usage of public transportation increases as the CO2 emissions from transport sector decreases, indicating that there is a negative relationship between these two variables. We must consider that the CO2 emission from transport sector in Dortmund is decreasing in this period of study.

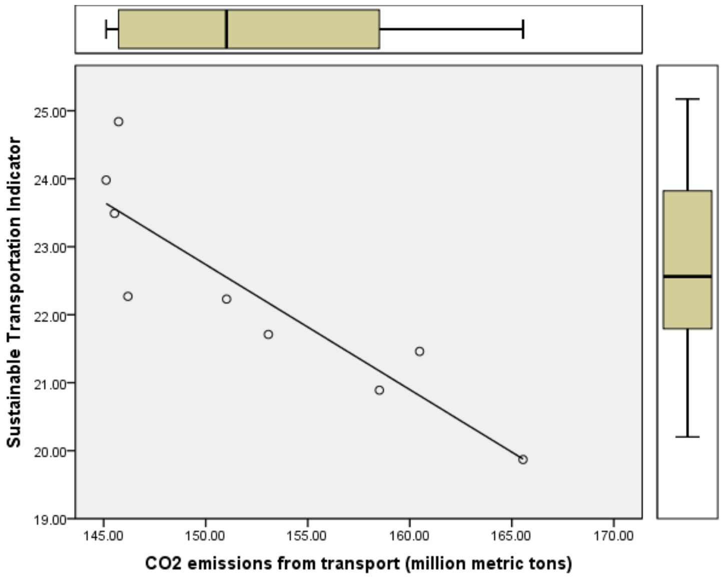


Table 34 : Model Summary of Regression STI and CO2 emissions in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.895[a]	0.801	0.773	0.74708	0.801	28.193

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), CO2 emissions (metric tons per capita)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	55.293	6.218		8.893	0.000
	CO2 emissions (metric tons per capita)	-3.417	0.644	-0.895	-5.310	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the CO2 emission and sustainable transportation indicator in Dortmund has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 55.3 - 3.4\ \ CO2\ emissions$$

The data displayed on the graph shows that as the usage of public transportation increases, the CO2 decreases. The results are approximately in a straight line, with a negative gradient. We therefore say that there is negative correlation between CO2 emissions and usage of public transportation.

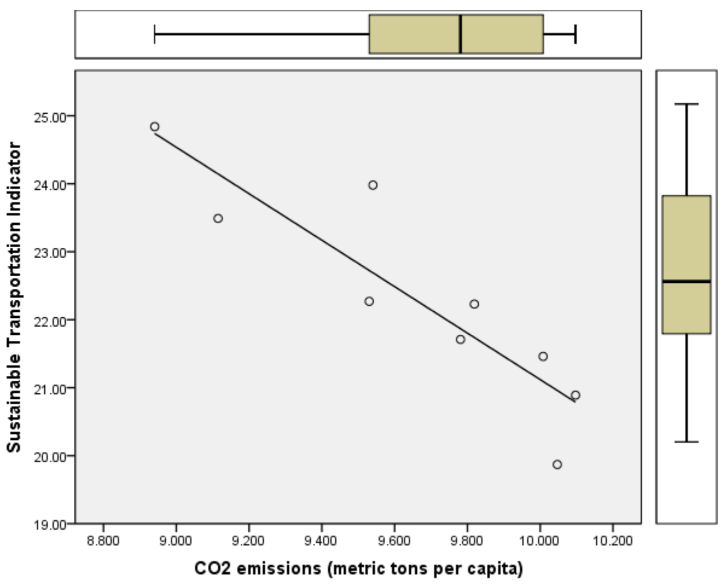


Table 35 : Model Summary of Regression STI and Road sector gasoline fuel consumption per capita in Dortmund

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.915[a]	0.837	0.814	0.67649	0.837	35.922

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Road sector gasoline fuel consumption per capita (kg of oil equivalent)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	33.092	1.814		18.243	0.000
	Road sector gasoline fuel consumption per capita (kg of oil equivalent)	-0.040	0.007	-0.915	-5.993	0.001

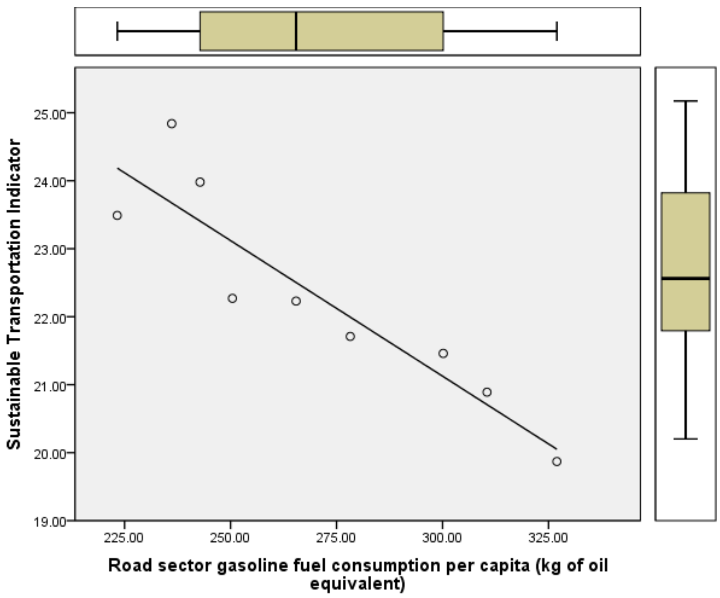
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the Road sector gasoline fuel consumption per capita and sustainable transportation indicator in Dortmund has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 33 - 0.04\ gasoline\ fuel\ consumption\ per\ capita$$

The data displayed on Scatter plot shows that usage of public transportation increases as the Road sector gasoline fuel consumption per capita decreases, indicating that there is a negative relationship between these two variables. We must consider that the road sector gasoline fuel consumption per capita in Dortmund is decreasing in this period of study.



7.6 Correlation and Regression analysis for data in Portland

Correlation is a term that refers to the strength of a relationship between two variables. A strong, or high, correlation means that two or more variables have a strong relationship with each other while a weak, or low, correlation means that the variables are hardly related. Correlation coefficients can range from -1.00 to +1.00. The value of -1.00 represents a perfect negative correlation while a value of +1.00 represents a perfect positive correlation. A value of 0.00 means that there is no relationship between the variables being tested, linear regression is a statistical technique that is used to learn more about the relationship between an independent (predictor) variable and a dependent (criterion) variable. When you have more than one independent variable in our analysis, this is referred to as multiple linear regressions. In general, regression allows the researcher to ask the general question "what is the best predictor of…? The results of correlation analysis between the sustainable transportation indictor as response or dependent variables with social, economic and environmental variables as independent variables of Portland are given in the following sections.

7.6.1 Social variables

The correlation between sustainable transportation indicator and the variables of population, different age groups, rural population, and population density is given in table 36.

Table 36 : Correlation between Sustainable Transportation Indicator and Social variable in Portland [4]

Correlations		Sustainable Transportation Indicator
Social Indicators		
Population	Pearson Correlation	**-0.859****
	Sig. (2-tailed)	**0.003**
Rural population (% of total population)	Pearson Correlation	**0.899****
	Sig. (2-tailed)	**0.001**
Population density (people per sq. km of land area)	Pearson Correlation	**-0.905****
	Sig. (2-tailed)	**0.001**
age 0-17	Pearson Correlation	**0.956****
	Sig. (2-tailed)	**0.000**
Age 18-64	Pearson Correlation	**-0.621**
	Sig. (2-tailed)	**0.074**
Age 65+	Pearson Correlation	**-0.649**
	Sig. (2-tailed)	**0.058**

Source: own analysis

[4] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Therefore, as stated in table 32 the correlation between population of Portland and sustainable transportation indicator is -0.859, which is highly significant at level of 0.003. It means that these two variables are strongly correlated and the negative value of correlation is due to increasing size of population. The next variable is rural population (outside of downtowns) of Portland which is even more correlated with sustainable transportation indicator and the positive sign shows that by decreasing the rural population the usage of public transportation will decrease. The next variable consider in this study is population density which is also highly correlated with sustainable transportation indicator and the negative sign of correlation is because of increasing size of population.

For the age groups, the results of correlation analysis show that the age group 18-64 and 65+ have a weak relationship with the indicator, on the other hand other age 0-17 are highly correlated with sustainable transportation indicator.

The results of regression analysis between the sustainable transportation indictor as response or dependent variables with social variables as independent variables of Portland are given in the following sections.

Regression is a simple statistical tool used to model the dependence of a variable on one (or more) explanatory variables. This functional relationship may then be formally stated as an equation, with associated statistical values that describe how well this equation fits the data.

Table 37 : Model Summary of Regression STI and Population in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.859[a]	0.738	0.701	0.60066	0.738	19.738

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Population

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	41.520	6.571		6.318	0.000
	Population	-0.532	0.120	-0.859	-4.443	0.003

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the population and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 41.5 - \ 0.532\ Population$$

The data displayed on the graph shows that as the population increases, the usage of public transportation decreases. The results are approximately in a straight line, with a negative gradient. We therefore say that there is negative correlation between population and usage of public transportation. A negative correlation means that as one variable goes up in value, the other variable goes down. On the other hand, as one variable goes down in value, the other variable goes up.

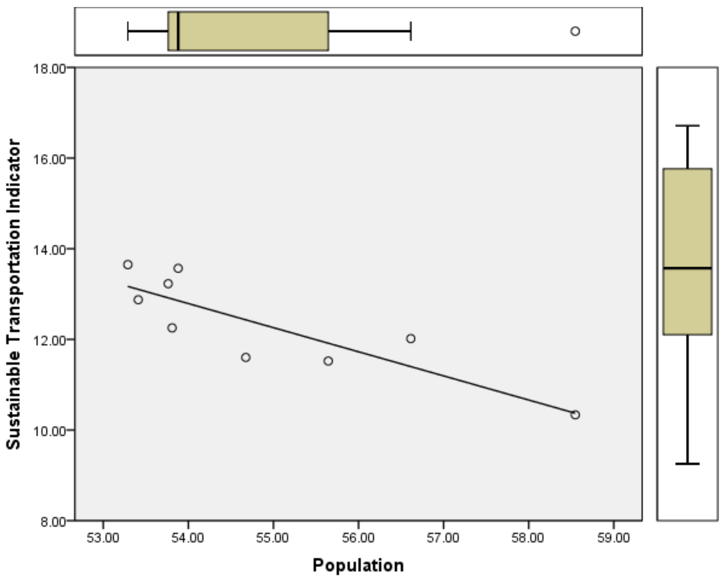


Table 38 : Model Summary of Regression STI and rural population in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.899[a]	0.807	0.780	.51532	0.807	29.328

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Rural population

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.658	4.250		-2.508	0.041
	Rural population	1.209	0.223	0.899	5.416	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the rural population and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = -10.6 + 1.2\ rural\ population$$

The data displayed on the graph resembles a line rising from left to right. Since the slope of the line is positive, there is a positive correlation between the two sets of data. This means that according to this set of data, Portland sustainable transportation indicator is decreasing in the future while the rural population is decreasing.

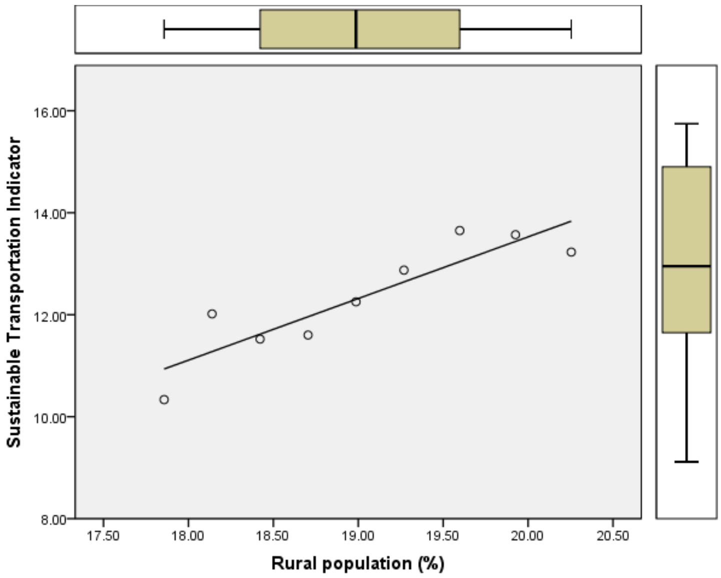


Table 39 : Model Summary of Regression STI and population density in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.905[a]	0.819	0.793	0.49965	0.819	31.642

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Population density

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	50.680	6.818		7.433	0.000
	Population density	-1.176	0.209	-0.905	-5.625	0.001

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the population density and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 50.6 - 1.17\ \ population\ density$$

The data displayed on Scatter plot shows that usage of public transportation decreases as the population density increases, indicating that there is a negative relationship between these two variables. We must consider that the population density in Portland is increasing in this period of study.

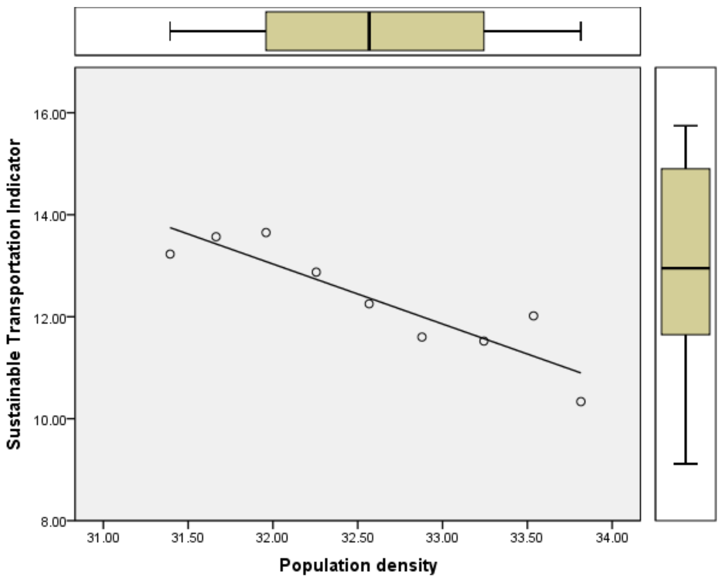


Table 40 : Model Summary of Regression STI and population age group 0-17 in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.956[a]	0.914	0.902	0.34358	0.914	74.723

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Age 0-17

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-18.511	3.571		-5.184	0.001
	Age 0-17	129.700	15.004	0.956	8.644	0.000

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the age group 0-17 and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = -18.5 + 129.7 \quad age\ group\ 0 - 17$$

The data displayed on the graph shows that as the age group 0-17 decreases, the usage of public transportation also decreases. The results are approximately in a straight line, with a positive gradient. We therefore say that there is positive correlation between age group 0-17 and usage of public transportation.

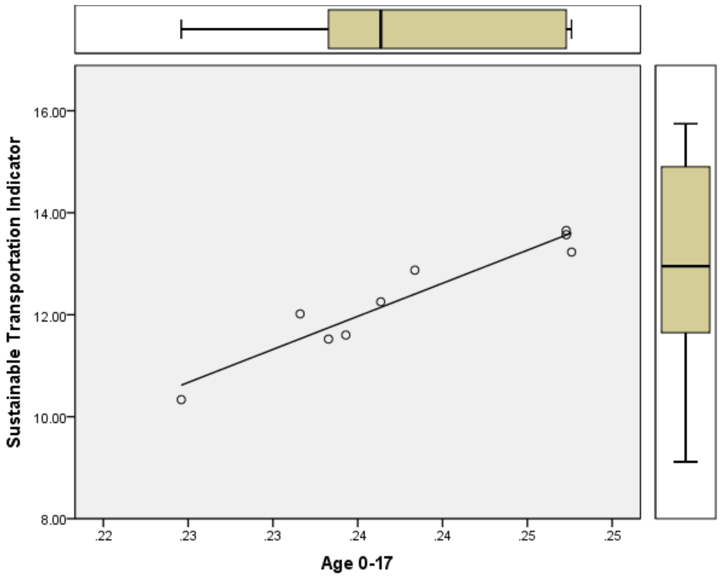


Table 41 : Model Summary of Regression STI and population age group 65+ in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.649[a]	0.421	0.339	0.89293	0.421	5.099

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), age 65+

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.321	7.084		3.998	0.005
	age 65+	-123.796	54.822	-0.649	-2.258	0.058

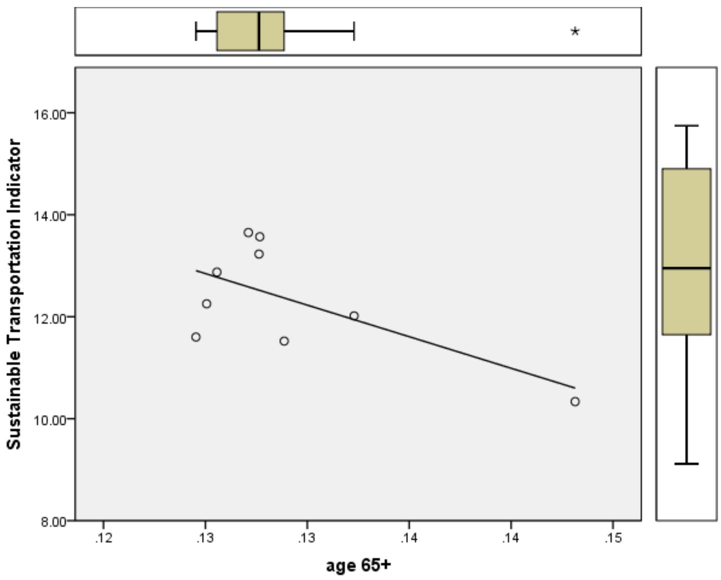
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the age group +65 and sustainable transportation indicator in Portland has a weak relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 28.3 - 123.7\ \ age\ group\ 65 +$$

The data displayed on Scatter plot shows that usage of public transportation decreases as the age group +65 increases, indicating that there is a negative relationship between these two variables. We must consider that the age group +65 in Portland is increasing in this period of study.



7.6.2 Economic variables

Table 42 : Correlation between Sustainable Transportation Indicator and Economic variable in Portland[5]

Correlations		Sustainable Transportation Indicator
Economic Indicators		
Household income	Pearson Correlation	**-0.862****
	Sig. (2-tailed)	**0.003**
GDP per capita (current US$)	Pearson Correlation	**-0.866****
	Sig. (2-tailed)	**0.003**
GDP (current US$)	Pearson Correlation	**-0.891****
	Sig. (2-tailed)	**0.001**

Source: own analysis

According to the table 42, the correlation between Household income of Portland and sustainable transportation indicator is 0.862, which is highly significant at level of 0.003. It means that these two variables are strongly correlated and the negative value of correlation is due to increasing Household and decreasing usage of public transportation. The next variable is GDP per Capita of Portland, A measure of the total output of a country that takes the gross domestic product (GDP) and divides it by the number of people in the country. The per capita GDP is especially useful when comparing one country to another because it shows the relative performance of the countries. A rise in per capita GDP signals growth in the economy and tends to translate as an increase in productivity. The analysis show that, the GDP per Capita is correlated with sustainable transportation indicator, and the negative sign shows that by increasing the GDP per Capita the usage of public transportation will decrease. The next variable consider in this study is the GDP. This variable at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. The correlation analysis between GDP and usage of public transportation indicator is -0.899, which is highly significant at level of 0.001. It shows that there are highly correlated with sustainable transportation indicator and the negative sign of correlation is because of decreasing usage of public transportation indicator.

The results of regression analysis between the sustainable transportation indictor as response or dependent variables with economic variables as independent variables of Portland are given in the following sections.

[5] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 43 : Model Summary of Regression STI and Income in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.862[a]	0.744	0.707	0.59427	0.744	20.317

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Personal income * 1000

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	24.285	2.658		9.138	0.000
	Per Capita Personal income	-0.354	0.079	-0.862	-4.507	0.003

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the Household income and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$\mathit{Sustainable\ Transportation\ Indicator} = 24.2 - 0.354\ \mathit{Household\ Income}$$

The data displayed on the graph shows that as the income increases, the usage of public transportation decreases. The results are approximately in a straight line, with a negative gradient. We therefore say that there is negative correlation between household income (US$) and usage of public transportation.

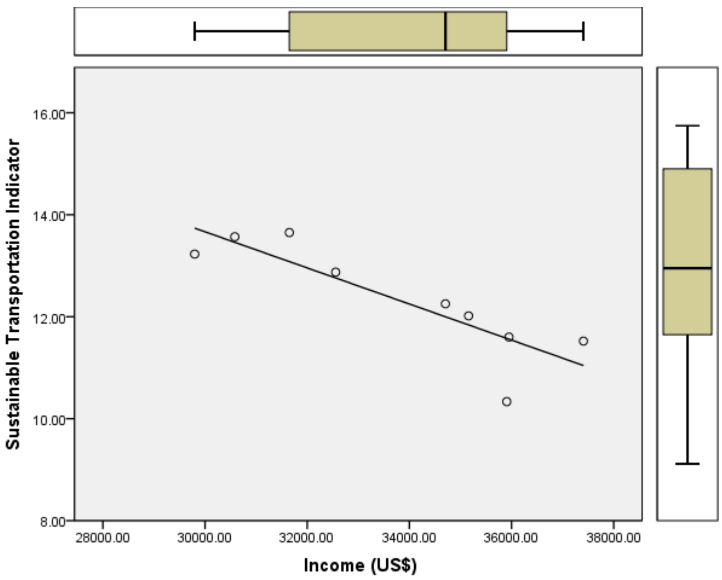


Table 44 : Model Summary of Regression STI and GDP per Capita in USA

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.866[a]	0.751	0.715	0.58633	0.751	21.061

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), GDP per capita (US$ * 1000)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.147	2.363		9.795	0.000
	GDP per capita	-0.251	0.055	-0.866	-4.589	0.003

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the GDP per capita and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 23.1 - 0.251\ GDP\ per\ capita$$

The data displayed on the graph resembles a line rising from right to left. Since the slope of the line is negative, there is a negative correlation between the two sets of data. This means that according to this set of data, Portland sustainable transportation indicator is decreasing in the future while the GDP per Capita is increasing.

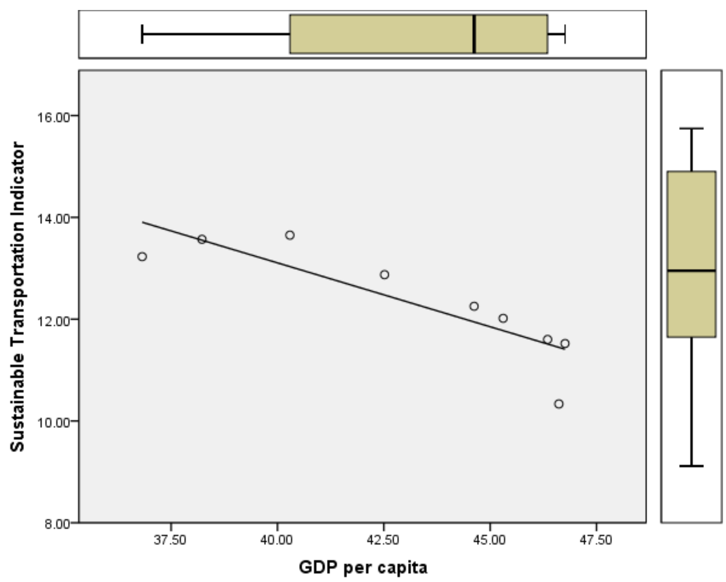


Table 45 : Model Summary of Regression STI and GDP in USA

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.891[a]	0.794	0.765	0.53261	0.794	27.007

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), GDP (current US$)

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	21.170	1.709		12.391	0.000
	GDP (current US$)	-0.001	0.000	-0.891	-5.197	0.001

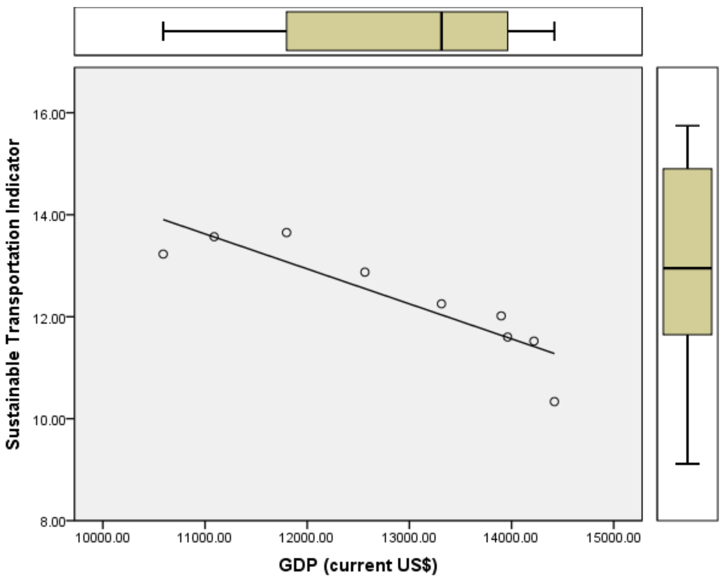
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the GDP and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 21.1. -0.001\ GDP$$

The data displayed on Scatter plot shows that usage of public transportation decreases as the GDP increases, indicating that there is a negative relationship between these two variables. A negative correlation means the two variables vary in opposite directions.



7.6.3 Environmental variables

Table 46 : Correlation between Sustainable Transportation Indicator and Economic variable in Portland [6]

Correlations		Sustainable Transportation Indicator
Environmental Indicators		
CO2 emissions from transport (million metric tons)	Pearson Correlation	**-0.891****
	Sig. (2-tailed)	**0.001**
CO2 emissions (metric tons per capita)	Pearson Correlation	**-0.895****
	Sig. (2-tailed)	**0.001**
Road sector gasoline fuel consumption per capita (kg of oil equivalent)	Pearson Correlation	**-0.915****
	Sig. (2-tailed)	**0.001**

Source: own analysis

Table 46 shows the correlation between Sustainable Transportation Indicator and Economic variable in Portland. A correlation indicates what the linear relationship is between two variables. It indicates how the two variables co-vary. A positive correlation means that as one variable goes up in value, the other variable goes up too. Alternatively, as one variable goes down in value, the other variable goes down too. A positive correlation means the two variables vary in the same direction (either they both go up when one changes, or they both go down when one changes). According table 64 the correlation between CO2 emissions from transport (million metric tons) of Portland and Sustainable Transportation Indicator is -0.891, which is highly significant at level of 0.001. It means that these two variables are strongly correlated and the negative value of correlation is due to increasing CO2 emissions from transport. The next variable consider in this study is CO2 emissions of Portland which is highly correlated with sustainable transportation indicator and the negative sign of correlation is because of decreasing of usage of publication and decreeing of CO2 emissions. The next variable is Road sector gasoline fuel consumption per capita (kg of oil equivalent) which is even more correlated with sustainable transportation indicator and the negative sign shows that by increasing the Road sector gasoline fuel consumption per capita the usage of public transportation will decrease.

[6] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 47 : Model Summary of Regression STI and Co2 emissions from transport in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.866[a]	0.749	0.714	0.58775675	0.749	20.925

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), CO2 emissions from transport

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	23.636	2.477		9.541	0.000
	CO2 emissions from transport	-0.007	0.002	-0.866	-4.574	0.003

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the CO2 emission from transport and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 23.6 - 0.007\ Co2\ emissions\ from\ Transport$$

The data displayed on the graph shows that as the CO2 emission from transport increases, the usage of public transportation decreases. The results are approximately in a straight line, with a negative gradient. We therefore say that there is negative correlation between CO2 emission from transport and usage of public transportation.

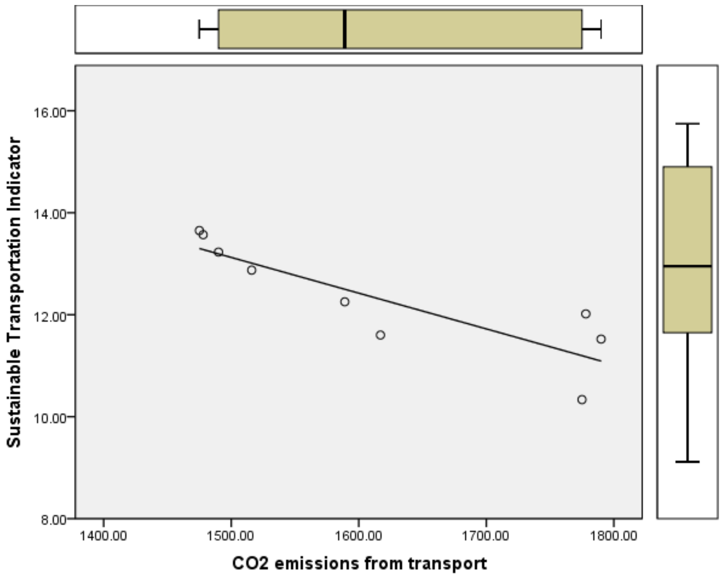


Table 48 : Model Summary of Regression STI and Co2 emissions in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.605[a]	0.366	0.275	0.93498	0.366	4.035

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), CO2 emissions

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	15.900	1.800		8.834	0.000
	CO2 emissions	-0.296	0.148	-0.605	-2.009	0.085

a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the CO2 emission and sustainable transportation indicator in Portland has a weak relationship and the model is as follow:

$$Sustianable\ Transportation\ Indicator = 15.9 - 0.296\ Co2\ emissions$$

The data displayed on the graph shows that as the CO2 emissions increases, the usage of public transportation decreases. The results are approximately in a straight line, with a negative gradient. We therefore say that there is negative correlation between CO2 emissions and usage of public transportation. It means as one variable goes down in value, the other variable goes up. A negative correlation means the two variables vary in opposite directions.

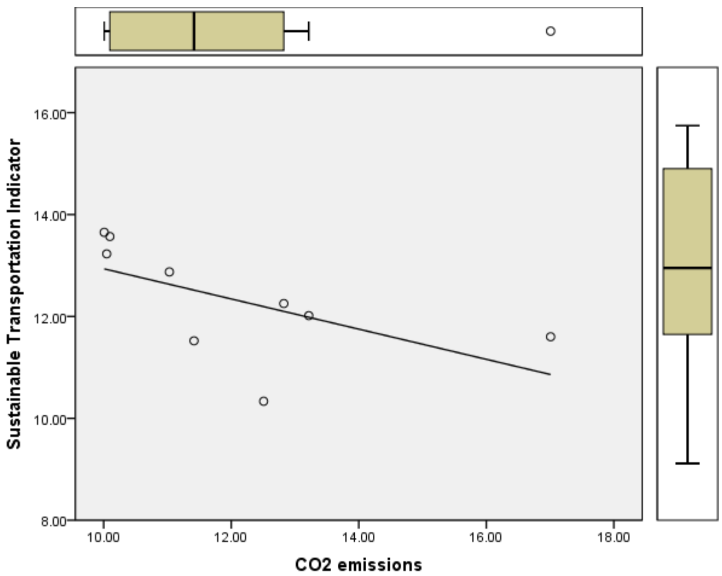


Table 49 : Model Summary of Regression STI and Road sector gasoline fuel consumption in Portland

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics	
					R Square Change	F Change
1	0.784[a]	0.615	0.560	0.72819	0.615	11.193

a. Dependent Variable: Sustainable Transportation Indicator

b. Predictors: (Constant), Road sector gasoline fuel consumption

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	28.167	4.737		5.946	0.001
	Road sector gasoline fuel consumption	-0.013	0.004	-0.784	-3.346	0.012

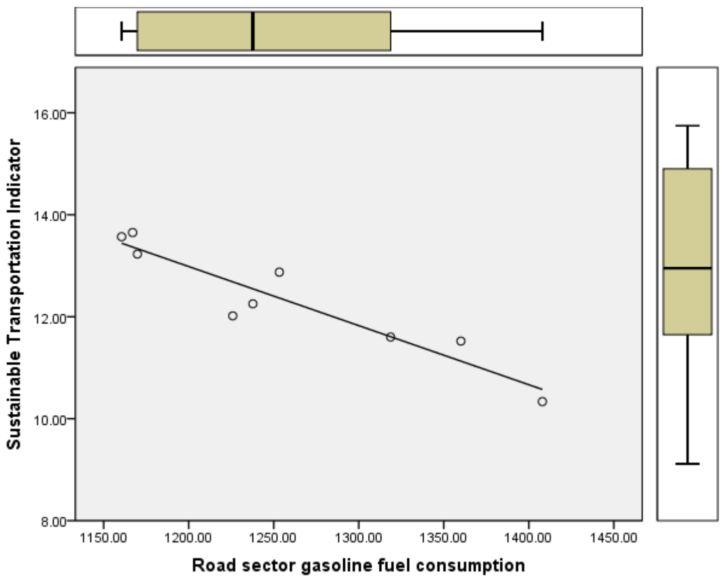
a. Dependent Variable: Sustainable Transportation Indicator

Source: own analysis

This models show that the road sector gasoline fuel consumption from transport and sustainable transportation indicator in Portland has a significant relationship and the model is as follow:

$$Sustainable\ Transportation\ Indicator = 28.1\ - 0.013\ \ Road\ sector\ gasoline\ fuel\ consumption$$

The data displayed on Scatter plot shows that the road sector gasoline fuel consumption increases as usage of public transportation decreases, indicating that there is a negative relationship between these two variables. We must consider that the road sector gasoline fuel consumption in Portland is increasing in this period of study.



7.7 Summary

To sum up, for prove the properness of the new indicator as sustainable transportation indictor a comparison of the statistical between sustainable transportation indicator and other variables are presented. In this research the methods of the correlation and regression analysis is used to find effects of independent variables on dependent variables, which can help us for monitoring, and measurement of sustainability in many different ways. In addition, it can help us to understand the direction of sustainability and the effect of usage of public transportation on other candidate variables. In details, figures below shows the trend of social economic and environmental variables from two cities, and figure 54 shows the time series trend of usage of public transportation in these two cities.

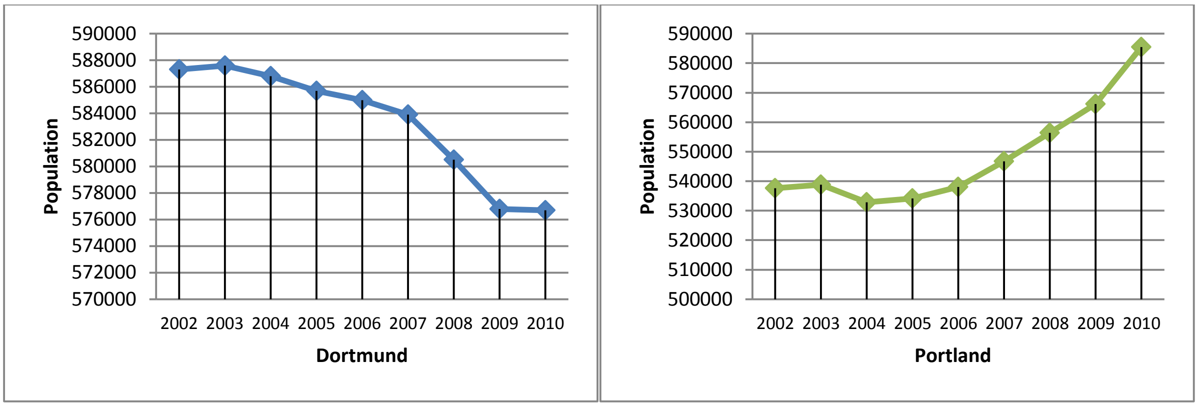


Figure 45 : Time series trend of population in Dortmund and Portland

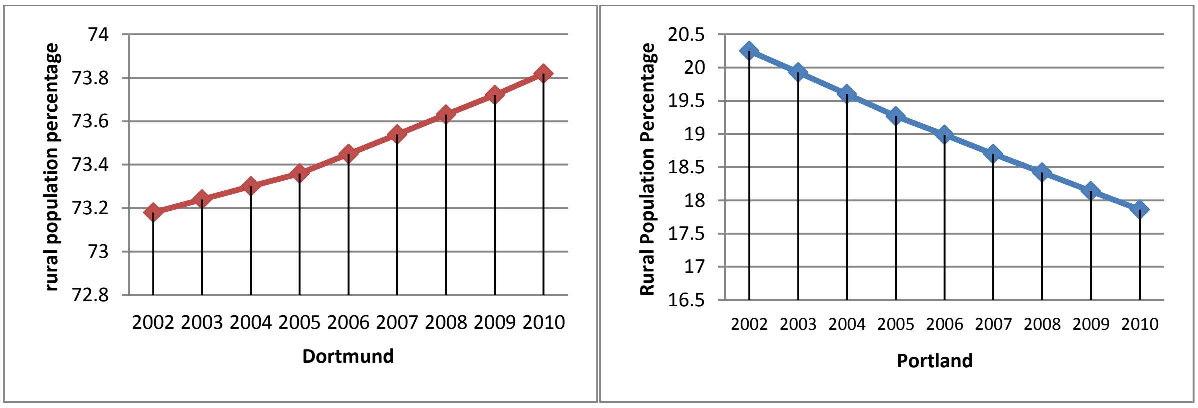
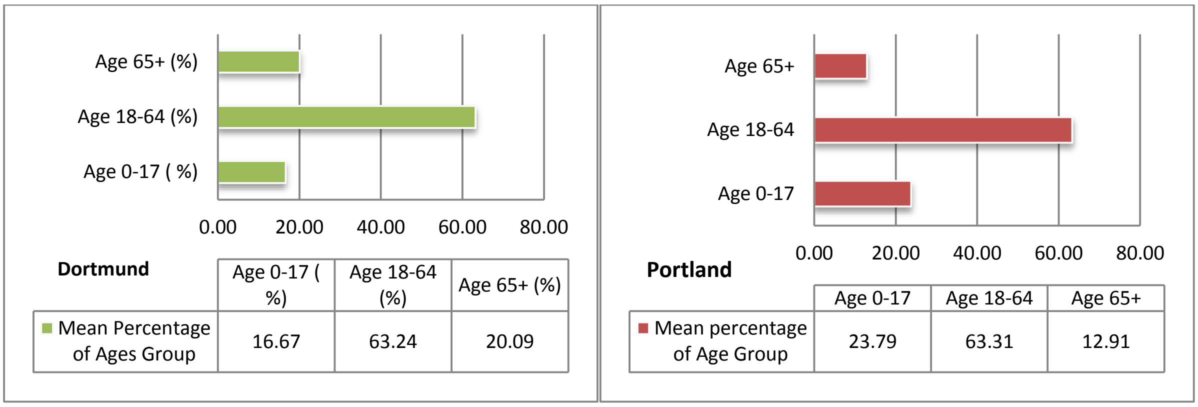


Figure 46 : Time series trend of rural population in Dortmund and Portland



Dortmund	Age 0-17 (%)	Age 18-64 (%)	Age 65+ (%)
Mean Percentage of Ages Group	16.67	63.24	20.09

Portland	Age 0-17	Age 18-64	Age 65+
Mean percentage of Age Group	23.79	63.31	12.91

Figure 47 : Time series trend of age groups in Dortmund and Portland

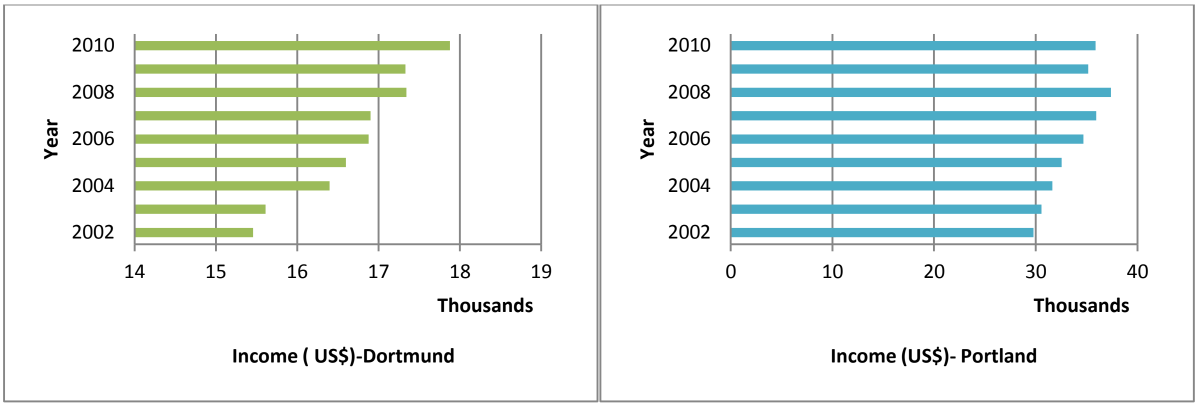


Figure 48 : Time series trend of Income in Dortmund and Portland

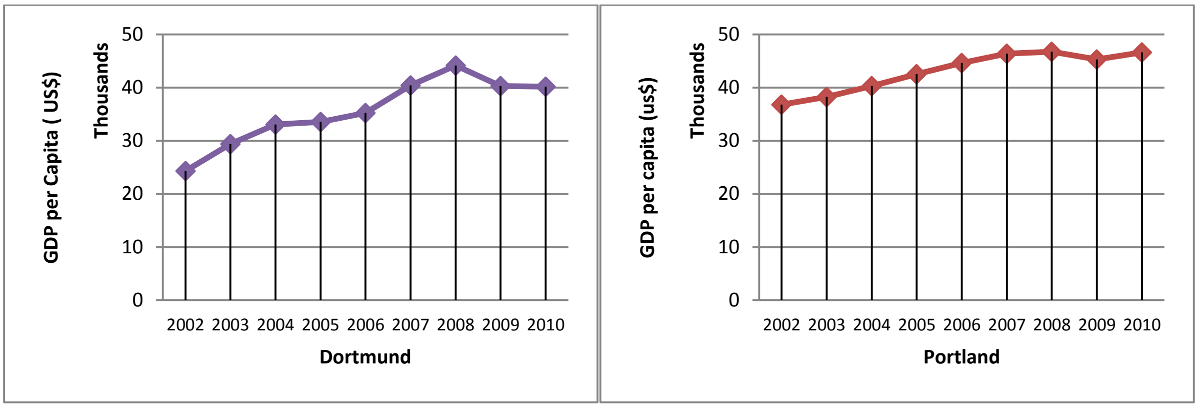


Figure 49 : Time series trend of GDP per capita in Dortmund and Portland

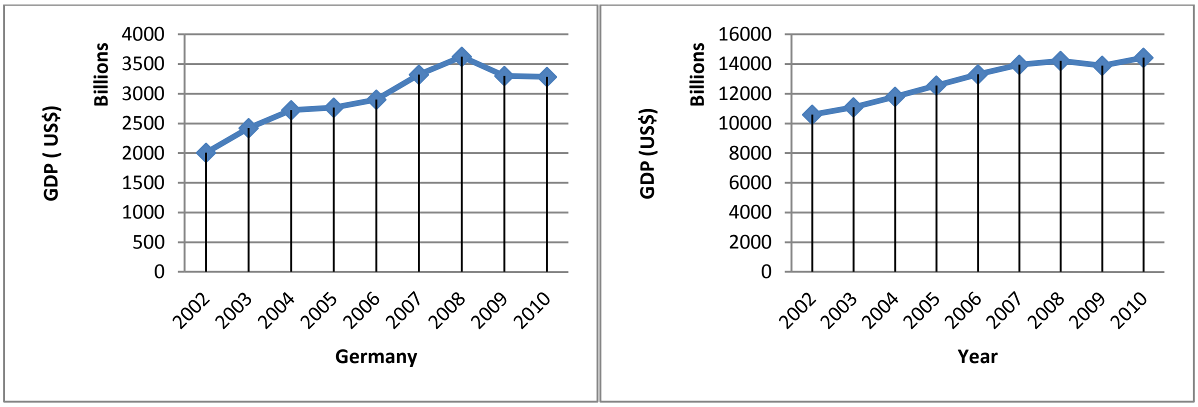


Figure 50 : Time series trend of GDP in Germany and USA

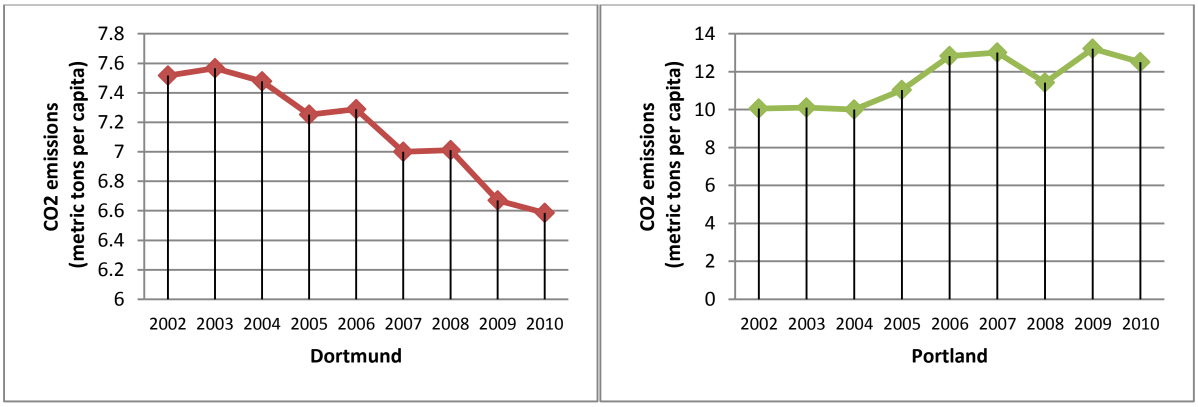


Figure 51 : Time series trend of co2 emissions in Dortmund and Portland

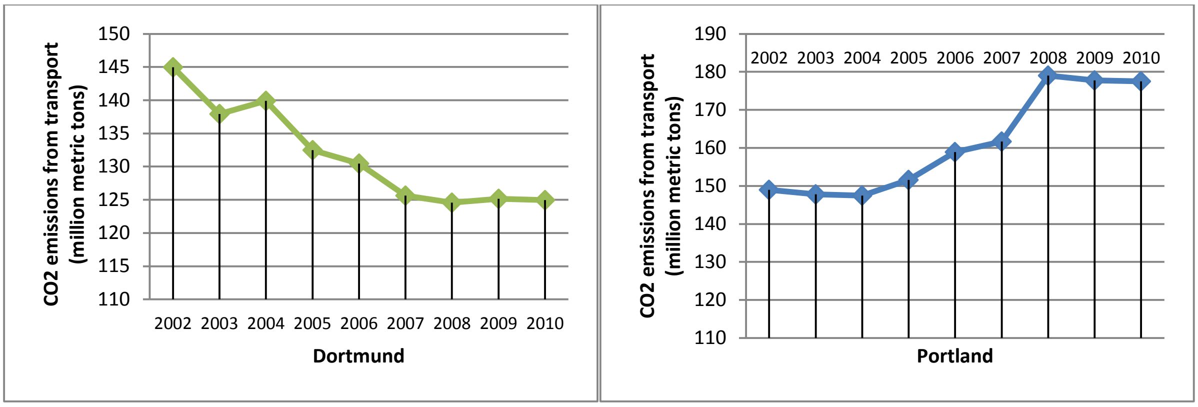


Figure 52 : Time series trend of co2 emissions from transport in Dortmund and Portland

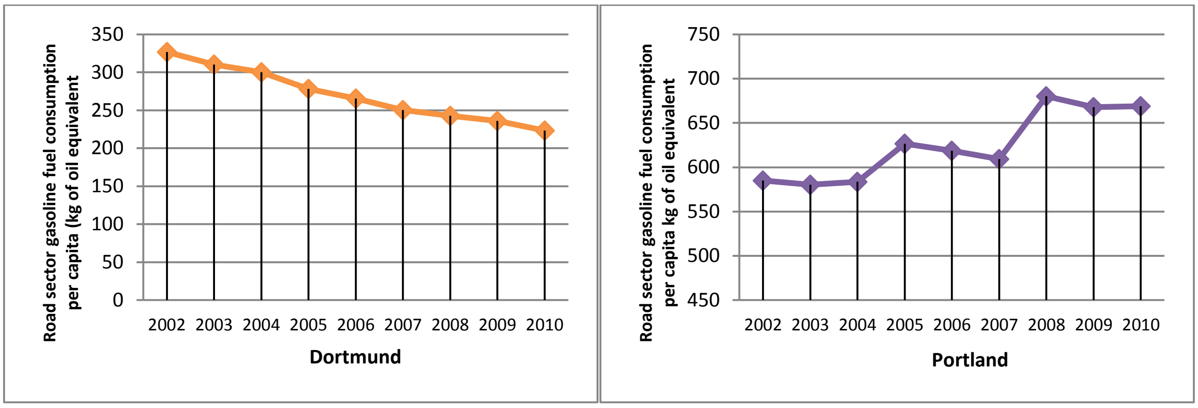


Figure 53 : Time series trend of Road sector gasoline fuel in Dortmund and Portland

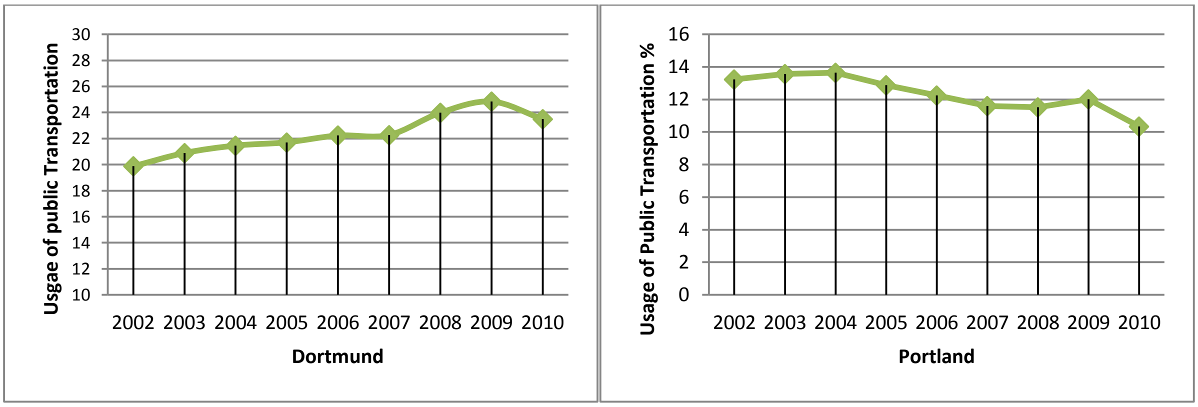


Figure 54 : Time series trend of Usage of public transportation in Dortmund and Portland

In addition, cities and city districts (as the base of sustainable development) have such a stronger role in the advancement of sustainable urban development that sustainable development in districts is the precondition for the realization of sustainable development at higher levels. In general, there are two main approaches which are opposite, but complement each other in some ways, top-down and bottom-up, Top-down views determining the general objectives and main aspects of sustainable development at national and international levels, and also details and small objectives of regional and urban levels. On the other hand, bottom-up views, determining the functional strategies and execute projects at regional and local levels; supporting and monitoring at national and international levels. Doubtless, several intermediate levels will eventually be required, although the number is far from clear at this time. It is abundantly clear that both top-down and bottom-up strategies must be integrated effectively or neither will work well.

This discussion is more than pedantic when we enter into “sector-specific” efforts to measure sustainability. Difficult questions can be raised as to whether there is any real value in attempting to analyse a sector’s “sustainability.” Beyond attempting to analyse or assess “urban sustainability,” can we further attempt to look at transport sustainability, or more narrowly urban transport sustainability, or more narrowly still, public urban transport sustainability?

Therefore, Descriptive data analysis such as, summary statistics, time series plot and other useful techniques are used to explain the behaviour of variables. In addition, for approving the strength of a relationship between new approach of sustainable transportation indicator and candidate sustainable variables, correlation and liner regression analysis is used. The methodology for using these techniques of analysis is implemented.

Given the rich description that case studies provide and using the triangulation principle, we will gather evidence and/or attempt to construct estimates on benefits of specific Sustainable transportation enabled data and look at the influences these have on the sustainable transportation indicator and the certificate system process in each specific policy domain.

The summary statistics for the Social, economic and environmental of these two cities are given in following tables.

Table 50 : The summary statistics for the social variable of Dortmund and Portland

Summary Statistics social variables	Population (* 10,000)	Population (* 10,000)	Rural Population*	Rural Population*	Population Density **	Population Density **	Age 0-17 (%)	Age 0-17 (%)	Age 65+ (%)	Age 65+ (%)
	Dortmund	Portland	Dortmund	Portland	Dortmund	Portland	Dortmund	Portland	Dortmund	Portland
Mean	58.336	54.848	73.469	19.017	2051,7	2659.9	16.667	23.786	20.093	12.910
Median	58.504	53.880	73.447	18.990	2054,2	2652.7	16.672	23.640	20.415	12.760
Std.Deviation	.43137	1.7733	.22166	.81572	8.052	22.12	.42387	.80932	.65893	.57434
Minimum	57.67	53.29	73.18	17.86	2038	2651.4	16.04	22.46	18.96	12.45
Maximum	58.76	58.55	73.82	20.25	2061	2718.9	17.16	24.76	20.78	14.31

* Percentage of total population *Source: own analysis*
** People per sq. km of land area
Source: own analysis

Table 51 : The summary statistics for the economic variable of Dortmund and Portland

Summary Statistics economic variables	Income*	Income*	GDP per capita* (current US$)	GDP per capita* (current US$)	GDP** (current US$)	GDP** (current US$)
	Dortmund	Portland	Dortmund	Portland	Dortmund	Portland
Mean	33.746	54.848	19.017	43.056	2659.9	12872.767
Median	34.706	53.880	18.990	44.623	2652.7	13314.500
Std.Deviation	2.6752	1.7733	.81572	3.7901	22.12	1426.5183
Minimum	29.797	53.29	17.86	36.819	2651.4	10590.2
Maximum	37.407	58.55	20.25	46.760	2718.9	14419.4

*: income and GDP per capita ×1,000 *Source: own analysis*

**: GDP × 1,000,000,000

Table 52 : The summary statistics for the environment variable of Dortmund and Portland

Summary Statistics environment variables	CO2 emissions*	CO2 emissions*	CO2 emissions from transport**	CO2 emissions from transport**	Road sector gasoline fuel consumption per capita	Road sector gasoline fuel consumption per capita
	Dortmund	Portland	Dortmund	Portland	Dortmund	Portland
Mean	7.12311	12.02	131.78.56	155.644.0	270.4368	520.344
Median	7.25100	11.42	130.450.0	158.900.0	265.4521	522.590
Std.Deviation	.410390	2.24	7.59214	122.07	35.93592	67.12
Minimum	6.411	10.01	124.550	137.800	223.28	560.536
Maximum	7.567	13.01	144.980	169.000	326.95	676.045

***:** (metric tons per capita) *Source: own analysis*

**:(million metric tons)

***:(kg of oil equivalent)

The summary statistics for the Social, economic and environment of these two cities are calculated in the five category of mean, median, standard deviation, minimum and maximum which each of them have specific purpose. The mean, commonly called the average, is a mathematically computed value, which represents a central value of a given data set. The Median means, if we divide the data into two equal halves where each half contains 50% of the data, the numerical value where the data are divided is called the median. We can also think of the median as the 50th percentile or as the point that would perfectly balance the data if they were placed upon a balance scale. The standard deviation means, if we take the square root of the variance, the resulting number is called the standard deviation. The standard deviation is a measure of dispersion and gives us a way to describe where any given data-

Table 53 : Correlation between Sustainable Transportation Indicator and Social, Economic and Environmental variables in Dortmund and Portland [7]

Variables	Correlation with STI	Dortmund ↗	Trend	Portland ↘	Trend
Social Variables					
Population	P. Correlation	-.911**	↘	-.859**	↘
	Sig. (2-tailed)	.001		.003	
Age 0-17	P. Correlation	-.905**	↘	.956**	↘
	Sig. (2-tailed)	.001		.000	
Age 18-64	P. Correlation	-.648	→	-.621	→
	Sig. (2-tailed)	.059		.074	
Age 65+	P. Correlation	.914**	↗	-.649	↗
	Sig. (2-tailed)	.001		.058	
Population density (people per sq. km of land area)	P. Correlation	-.903**	↘	-.905**	↗
	Sig. (2-tailed)	.001		.001	
Downtown population (% of total population)	P. Correlation	.921**	↘	.899**	↘
	Sig. (2-tailed)	.000		.001	
Environmental Variables					
CO2 emissions from transport (million metric tons)	P. Correlation	-.891**	↘	-.866**	↗
	Sig. (2-tailed)	.001		.003	
Road sector gasoline fuel consumption per capita (kg of oil equivalent)	P. Correlation	-.915**	↘	-.784**	↗
	Sig. (2-tailed)	.001		.012	
CO2 emissions (metric tons per capita)	P. Correlation	-.895**	↘	-.605**	↗
	Sig. (2-tailed)	.001		.085	
Economy Variables					
Household income	P. Correlation	.893**	↗	-.862**	↗
	Sig. (2-tailed)	.001		.003	
GDP per capita (current US$)	P. Correlation	.903**	↗	-.866**	↗
	Sig. (2-tailed)	.001		.003	
GDP (current US$)	P. Correlation	.899**	↗	-.891**	↗
	Sig. (2-tailed)	.001		.001	

Source: own analysis

[7] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

↗ Increasing trend

↘ Decreasing trend

→ No trend

-value is located with respect to the mean. In mathematics, the maximum and minimum of a function, known collectively as extreme, are the largest and smallest value that the function takes at a point either within a given neighbourhood or on the function domain in its entirety. All these statistics analysis can help us for monitoring, and measurement of sustainability of different cities. Table 53 shows the Pearson correlation coefficient of usage of public transportation as Sustainable transportation indicator with Social, Economic and Environmental variables in Dortmund and Portland and the arrow signs show the direction of trend of each variable during this period of study. According to result of table 53 we can conclude that the change of one variable is associated with a change of other variable.

In addition, Future analysis of this part will explained in Regression analysis, regression analysis is one of the most frequently used tools for analyzing. In its simplest form, regression analysis allows monitoring and analyzes relationships between one independent and one dependent variable. The key benefits of using regression analysis are that it can:

- Indicate if independent variables have a significant relationship with a dependent variable.
- Indicate the relative strength of different independent variables' effects on a dependent variable.
- Make predictions.

Regression models are used to predict one variable from other variables. Regression models are powerful tools for the decision-makers in the urban planning, allowing predictions of past, present, or future from information about past or present events. The results of regression analysis between the sustainable transportation indictor as response or dependent variables with Social, Economic and Environmental variables as independent variables of Dortmund and Portland are as follows.

$$Sustianable\ Transportation\ Indicator = 215.309 - 3.308\ Population\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 41.5 - 0.532\ Population\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = -456 + 6.5\ rural\ population\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = -10.6 + 1.2\ rural\ population\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 382.9 - 0.176\ Population\ density\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 50.6 - 1.17\ population\ density\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 78.064 - 3.345\ Age\ group\ \ 0 - 17 in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = -18.5 + 129.7\ \ Age\ group\ 0 - 17\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = -21.346 + 2.172\ Age\ group\ \ 65 +\ \ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 28.3 - 123.7\ \ Age\ group\ 65 +\ \ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = -6.9 +\ 0.002\ Income\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 24.2 - 0.354\ \ Income\ \ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 14.2 + 0.22\ GDP\ per\ capita\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 23.1 - 0.251\ GDP\ per\ capita\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 14.2 + 003\ GDP\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 21.1 - 0.001\ GDP\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 50.3 - 0.18\ \ CO2\ emissions\ from\ transport\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 23.6 - 0.007\ Co2\ emissions\ from\ Transport\ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 55.3 - 3.4\ \ CO2\ emissions\ \ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 15.9 - 0.296\ Co2\ emissions\ \ in\ Portland$$

$$Sustianable\ Transportation\ Indicator = 33 - 0.04\ Road\ sector\ gasoline\ fuel\ consumption\ in\ Dortmund$$

$$Sustianable\ Transportation\ Indicator = 28.1\ - 0.013\ \ Road\ sector\ gasoline\ fuel\ consumption\ in\ Portland$$

It can be concluded that the new approach of sustainable transportation indicator for measuring sustainability of transportation is highly correlated with selected variables, which indicates that the new indicator has meaningful applicability to be used as indicator for transportation certificate system.

It can be concluded, key issues related to sustainable transport indicators and assessment methodologies offer a basic theoretical backdrop to the idea of sustainable transport. In other words, how it could it be measured and where such a measurement effort fits into "performance based" transportation planning. This dissertation identifies some of the key issues related to putting these ideas "into practice," including: development of meaningful indicators, techniques for assessing possible interventions, differences and similarities of techniques for examining various sustainability "dimensions," establishing appropriate baselines for developing counterfactuals, and implications for technical capabilities and decision-making.

8. Conclusion

The scope of this dissertation is to study Methodology and Statistical Analysis of Sustainable Transportation Criteria for certification System to develop a set of indicators for measurement and evaluation of transport sustainability performance, which can be used in Certification systems. First several models of sustainability, different interpretation of sustainable development and indicators for sustainable development are reviewed and it is concluded that although the economies of many countries are booming but the distribution of wealth is still unequal. Changing trends in consumption patterns, which directly affects the lifestyle of people, has also led to increase health risks to people of all ages. Wherever in the world, environmental degradation is happening; it is always linked to questions of social justice, equity, rights, and people's quality of life in its widest sense. So far, Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

- the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and
- The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Thus, the goals of economic, environment, and social development must be defined in terms of sustainability in all countries - developed or developing, market-oriented or centrally planned. Interpretations will vary, but must share certain general features and must flow from a consensus on the basic concept of sustainable development and on a broad strategic framework for achieving it. Development involves a progressive transformation of economy, environmental and society. A development path that is sustainable in a physical sense could theoretically be pursued even in a rigid social and political setting. However, physical sustainability cannot be secured unless development policies pay attention to such considerations as changes in access to resources and in the distribution of costs and benefits. Even the narrow notion of physical sustainability implies a concern for social equity between generations, a concern that must logically be extended to equity within each generation.

Interpreting the sustainable development is considered as an "operational definition of sustainable development," evidenced by the hierarchy of sustainable development principles. The applied sustainable development interpreting consists of:

1. **Broad-based approaches** that support sustainable development, such as integration and coordination, ecosystem-based management, environmental protection and sustainable use of natural resources, sustainable livelihood and vulnerability/resiliency strengthening.

2. **Operational strategies** that create an effective governance framework, including: policy and institutional reforms, multi stakeholder participation, functional partnerships and networking, capacity development, information and knowledge management, financing arrangements, coastal strategy development and implementation, and monitoring and evaluation.

3. Operational tools that provide specific best practices, including: urban profiling, stakeholder analysis, governance review and coordinating arrangements, risk assessment, land use and urban planning, legal/regulatory, participatory tools, training and education, economic, and disaster preparedness/response covering manmade and natural hazards.

Therefore, a tool is required to evaluate the objectives and strategies of sustainable urban development. This need has resulted in next part of this dissertation the emergence and spread of certification systems. Considering the variety of objectives, strategies and practical approaches of sustainable development at different levels and in different areas, it can be stated that “certification systems” are a tool to assess these objectives and approaches. In other words, they are a quantitative standard to measure the concept of sustainable development in each area. It is obvious that meeting the objectives, which are identified in this research, is not possible without having proper strategies. On the other hand, differences in the objectives, regional conditions, facilities, and needs result in different strategies. Therefore, considering these difference, the main question is whether it is possible to develop specific strategies for sustainable development. The answer is that if the general objectives and fundamental aspects of sustainable development are identified at international and national levels, the details are considered at regional and urban levels; practical strategies and projects are devised at regional levels, and supported and monitored at national and international levels, reaching common strategies for sustainable development becomes possible. Strategies required for sustainable urban development and Sustainable Transportation Criteria can then be categorized as follows:

- Create a plan for sustainable development
- Support local and regional governance (decentralization)
- Create a strong local partnership (between different groups in each city quarter)
- Investment on knowledge- R&D
- Support regional cooperation (between neighbourhood city quarters)
- Cohesive urban development
- Monitoring and reporting the progress

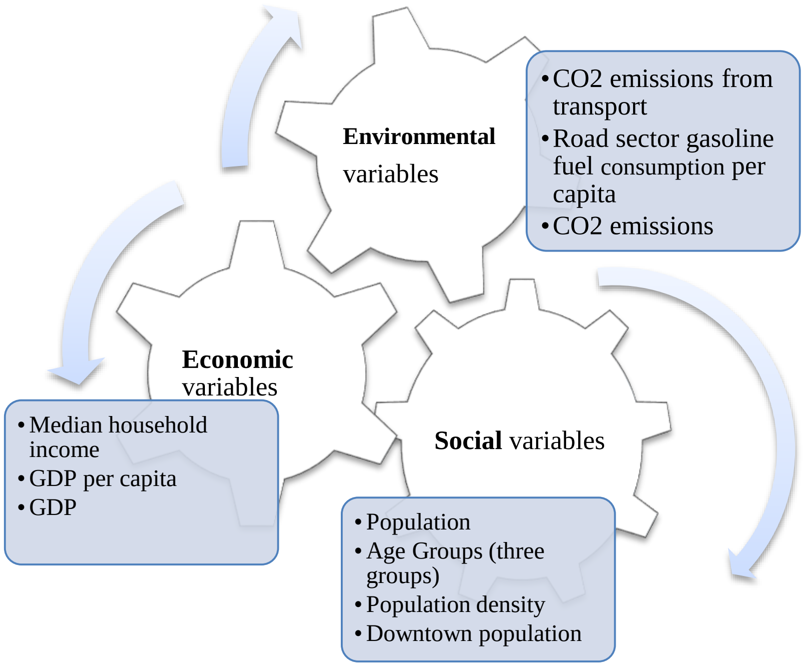
Therefore, to find out proper criteria for measuring the sustainability of urban transportation the transportation planning and different aspects of sustainable transportation and role of indicators on defining and characterizing sustainable transport are reviewed.

The purpose of the Sustainable Transportation Indicators is to develop a set of indicators that can be used to monitor the progress of transport systems towards (or away from) sustainability. The introducing proper indicator for measuring urban sustainable transportation proceeds in three steps:

The first step included a review of 17 international sources of sustainable transportation related indicator sets. The 160 indicators in those sets were evaluated and rated for their relevance for measuring progress towards sustainable transportation, and a preliminary list of candidate indicators for further work was identified. Step 1 was completed with a brief explanation in section sustainable transportation indicator. The second step of the finding proper sustainable indicator is conducted as the result of introducing proper indicator for measuring urban sustainable transportation. The aim is to enable the selection of indicator sets with a limited number of indicators from the long list of ‘candidate’ indicators. The third step is innovative approach of the proper indicator for measuring urban sustainable transportation to base the selection and construction of sustainable transportation indicators on an explicit definition of sustainable transportation.

The introduction of a core set helps to keep the indicator set manageable, whereas the larger set allows the inclusion of additional indicators that enable countries to do a more comprehensive and differentiated assessment of sustainable development. Core indicators fulfil three criteria. First, they cover issues that are relevant for sustainable development in most countries. Second, they provide critical information not available from other core indicators. Third, they can be calculated by most countries with data that is either readily available or could be made available within reasonable time and costs. Conversely, indicators that are not part of the core are either relevant only for a smaller set of countries, provide complementary information to core indicators or are not easily available for most countries.

The candidate indicators are shown in the figure below. Sustainable transport indicators were considered, three indicators in each parts of environmental and economic, and six indictors in social. These sustainable transport indicators were selected from other researches and some new indicator were developed based on criteria’s found in the literature.



Source: own analysis

In addition, the prove the properness of the new indicator as sustainable transportation indictor a comparison of the correlation results between sustainable transportation indicator and other variables is presented. In this research the methods of the correlation and regression analysis is used to find effects of independent variables on dependent variables, which can help us for monitoring, and measurement of sustainability in many different ways. For example, it can help us to understand the direction of sustainability and the effect of usage of public transportation on CO2 emissions. In details, figure 55 shows the trend of CO2 emissions from two cities, and figure 56 shows the time series trend of usage of public transportation in these two cities.

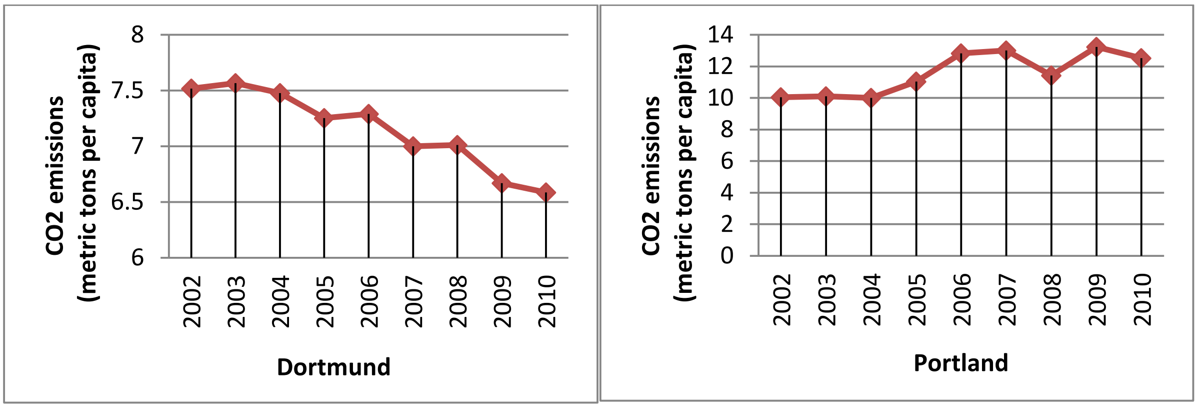


Figure 55 : Time series trend of co2 emissions in Dortmund and Portland

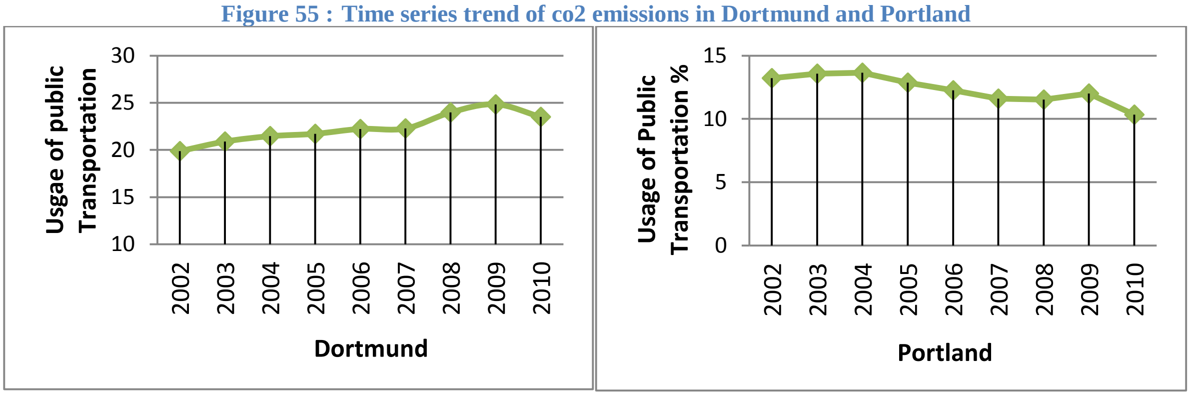


Figure 56: Time series trend of usage of public transportation in Dortmund and Portland

The summary statistics for the variable of CO2 emissions and usage of public transportation of these two cities are given in table 54.

Table 54 : The summary statistics for the variable of percentage of CO2 emissions and usage of public transportation

Summary Statistics	CO2 emissions in Dortmund	CO2 emissions in Portland	usage of public transportation in Dortmund	usage of public transportation in Portland
Mean	7.12311	12.02	22.3044	12.3389
Median	7.25100	11.42	22.2300	12.2532
Std. Deviation	.410390	2.24	1.56694	1.09812
Minimum	6.411	10.01	19.87	10.33
Maximum	7.567	13.01	24.84	13.65

Source: own analysis

Table 55 : Pearson correlation coefficient of usage of public transportation with CO2 emissions in Dortmund and Portland

City	Trend of co2 emission	Trend of usage of public transportation	P. Correlation
Dortmund	↘	↗	-0.895
Portland	↗	↘	-0.605

Source: own analysis

Table 55 shows the Pearson correlation coefficient of usage of public transportation as Sustainable transportation indicator with CO2 emissions and the arrow signs show the direction of trend of each variable during this period of study. According to result of table 51 we can conclude that the change of one variable is associated with a change of other variable. For example, in Dortmund the increase usage of public transportation has decrease the CO2 emission.

In addition, Regression models are used to predict one variable from other variables. Regression models are powerful tools for the decision-makers in the urban planning, allowing predictions of past, present, or future from information about past or present events. The results of regression analysis between the sustainable transportation indictor as response or dependent variables with CO2 emissions variables as independent variables of Dortmund and Portland are as follows.

$$Sustainable\ Transportation\ Indicator = 55.3 - 3.4\ \ CO2\ emissions\ (Dortmund)$$

$$Sustainable\ Transportation\ Indicator = 15.9 - 0.296\ CO2\ emissions\ (Portland)$$

By using these Regression analysis models, we can make predictions. For example, regression analysis could provide an answer to what would happen to CO2 if usage of public transportation increases by 5%.

It can be concluded that the new approach of sustainable transportation indicator for measuring sustainability of transportation is highly correlated with selected variables, which indicates that the new indicator has meaningful applicability to be used as indicator for transportation certificate system. Table 56 shows the the Pearson correlation coefficient of usage of public transportation as Sustainable transportation indicator with other variables and the arrow signs show the direction of trend of each variable during this period of study.

Table 56 : Correlation between Sustainable Transportation Indicator and Social, Economic and Environmental variables in Dortmund and Portland[8]

Variables	Correlation with STI	Dortmund ↗	Trend	Portland ↘	Trend
Social Variables					
Population	P. Correlation	-.911**	↘	-.859**	↘
	Sig. (2-tailed)	.001		.003	
Age 0-17	P. Correlation	-.905**	↘	.956**	↘
	Sig. (2-tailed)	.001		.000	
Age 18-64	P. Correlation	-.648	→	-.621	→
	Sig. (2-tailed)	.059		.074	
Age 65+	P. Correlation	.914**	↗	-.649	↗
	Sig. (2-tailed)	.001		.058	
Population density (people per sq. km of land area)	P. Correlation	-.903**	↘	-.905**	↗
	Sig. (2-tailed)	.001		.001	
Downtown population (% of total population)	P. Correlation	.921**	↘	.899**	↘
	Sig. (2-tailed)	.000		.001	
Environmental Variables					
CO2 emissions from transport (million metric tons)	P. Correlation	-.891**	↘	-.866**	↗
	Sig. (2-tailed)	.001		.003	
Road sector gasoline fuel consumption per capita (kg of oil equivalent)	P. Correlation	-.915**	↘	-.784**	↗
	Sig. (2-tailed)	.001		.012	
CO2 emissions (metric tons per capita)	P. Correlation	-.895**	↘	-.605**	↗
	Sig. (2-tailed)	.001		.085	
Economy Variables					
Household income	P. Correlation	.893**	↗	-.862**	↗
	Sig. (2-tailed)	.001		.003	
GDP per capita (current US$)	P. Correlation	.903**	↗	-.866**	↗
	Sig. (2-tailed)	.001		.003	
GDP (current US$)	P. Correlation	.899**	↗	-.891**	↗
	Sig. (2-tailed)	.001		.001	

Source: own analysis

[8] **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

↗ Increasing trend

↘ Decreasing trend

→ No trend

For comparing the Sustainable Transportation Indicator in our case studies, the independent T-Test method is used. The Independent T-Test involves examination of the significant differences on one factor or dimension (dependent variable) between means of two independent groups or two experimental groups (control group vs. treatment group). In this case, we want to know whether there is a significant difference on the mean level of usage of public transportation between Dortmund and Portland.

The hypotheses for this test are given as:

$H_0 : \mu_D = \mu_P$ Vs. $H_1 : \mu_D = \mu_P$

μ_D : The mean percent Sustainable Transportation Indicator in Dortmund

μ_P : The mean percent Sustainable Transportation Indicator in Portland

The result of test is shown in table 57 by using SPSS software.

Table 57 : Analysis of Comparing Mean public Transport usage in Dortmund & Portland

Mean Comparison			
Sustainable Transportation Indicator	Mean	Std. Deviation	Std. Error Mean
Portland	0.1234	0.01100	0.00367
Dortmund	0.1936	0.03010	0.00657

Independent Samples Test					
		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Sustainable Transportation Indicator	Equal variances assumed	9.388	0.005	-6.754	28
	Equal variances not assumed			-9.340	27.684

Independent Samples Test				
		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
Sustainable Transportation Indicator	Equal variances assumed	0.000	-0.07025	0.01040
	Equal variances not assumed	0.000	-0.07025	0.00752

Independent Samples Test			
		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Sustainable Transportation Indicator	Equal variances assumed	-0.09156	-0.04895
	Equal variances not assumed	-0.08567	-0.05484

Source: own analysis

The table 57 shows the comparison of means percentage of public transport usage in Dortmund and Portland. As one can see in the table, the mean usage of public transport in Dortmund is significantly higher than the usage in Portland. According to the results of previous studies (Ralph Buehler, John Pucher), Dortmund urban transportation system is known as sustainable transportation comparing to Portland, and the comparisons show that the new approach of sustainable transportation indicator is a proper criteria for measuring the sustainability of urban transportation. Moreover, this indicator can use as standardize indicator in certification systems for measuring and monitoring the sustainable urban transportation.

9. Overview

Governments set the policy framework for individual travel behaviour through targeted transportation and other non-transportation policies. Daily transportation decisions are made by individuals within the policy and incentive frameworks. This dissertation tries to measuring and monitoring of urban transportation sustainability from viewpoint of an urban planner. The question comes out from the relation between urban transportation sustainability and usage of public transportation. How these two facts link between each other? Are there any logical relation between usage of public transportation and sustainable development? How can we define specific indicator for measuring sustainability of transportation? Alternatively, on the other words, how can we standardized indicator to measure and monitor the urban sustainable transportation? Finally, how can we make a common approach method for measuring and monitoring the urban transportation sustainability conclusion of one or more cities?

For providing the proper answers to the raised questions, the following steps are taken.

- A number of models of sustainability, different interpretation, and indicators for sustainable development are reviewed. It is concluded that considering the variety of objectives, strategies and practical approaches of sustainable development at different levels and in different areas, required a tool to evaluate a proper indicator for measuring sustainable urban development.

- This need has resulted the emergence and spread of certification systems. It can be stated that certification system is a quantitative standard to measure the concept of sustainable development in each area. Accordingly, the idea of how one can standardize indicator to measure and monitor the urban sustainable transportation comes up.

- In the next step, the transportation planning and different aspects of sustainable transportation and role of indicators on defining and characterizing sustainable transport are reviewed. From the result of this step, it can be concluded that the purpose of evaluating sustainability of transportation is to develop a set of indicators that can be used to monitor the progress of transportation systems towards (or away from) sustainability.

- Introducing a proper indicator for measuring urban sustainable transportation has been proceeded in three steps:

    - In first step, 17 international sources of sustainable transportation related indicator sets are reviewed and 160 indicators in those sources were evaluated and rated for their relevance of measuring progress towards sustainable transportation. Finally, a preliminary list of candidate indicators for further work was identified.

  - The aim of second step was selection of proper sustainable indicators for measuring urban sustainable transportation from a long list of 'candidate' indicators.

  - The third step was to introduce the proper indicator for measuring urban sustainable transportation based on the selection and construction of sustainable transportation indicators on an explicit definition of sustainable transportation, which is an innovated approach. The final selections of important factors affecting urban transportation sustainability are based on correlation analyses.

- For approving applicability of the new approach, the data for selected variables are collected from different sources of available and accurate databases.

- Descriptive data analysis such as, summary statistics, time series plot and other useful techniques are used to explain the behaviour of variables. In addition, for approving the strength of a relationship between new approach of sustainable transportation indicator and candidate sustainable variables, correlation and liner regression analysis is used. The methodology for using these techniques of analysis is implemented as the following steps.

  - First, the correlations between sustainable transportation indicator and sustainable variable is calculated and interpreted.

  - In the next step, the regression analysis is used to obtain models between the usage of public transportation as indicator for sustainable transportation and other selected variables to prove the properness of the indicator as a standardize indicator for transportation certificate system.

The above procedure can be used for measuring, monitoring, and evaluating the sustainability of urban transportation for different areas and used the results as a standardize indicator for transportation certificate system for comparing and ranking the transportation sustainability of different cities. In addition, the result of this study can be used as for monitoring and assessment of plan (step 8) for Sustainable urban mobility planning as shown in figure 57.

Figure 57 : Sustainable urban mobility planning

Source: Guidelines- Developing and Implementing a Sustainable Urban Mobility Plan. Version January 2014

For the future research, we suggest to use this procedure for different cities in different area and use the result for comparing and clustering of cities with respect to certification systems for sustainable urban transportation, which can be used as monitoring document for government and policy makers of cities.

The open question for future research is which other indictors can be added to selected indicator in this research as new sustainable transportation indicator and how one can use the new obtained indicator as standardize indicator for transportation certificate systems.

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Appendix

A. Sustainability and sustainable transport indicator

Below are appendix of sustainability and sustainable transport indicator sets.

1- **Genuine Progress Indicator developed for Alberta, Canada**. Table below is an example of a, reflecting overall sustainability. Other regions, goals, and analysis perspectives may require somewhat different indicators. These indicators can be applied to transport planning, by selecting those that are affected by transport facilities and activities, and using them to evaluate options.

Economic	Social	Environmental
Economy, GDP and Trade	Time Use	Energy
Economic growth (GDP)	Paid work time	Oil and gas reserve life
Economic diversity	Household work	
Trade	Parenting and eldercare	Agriculture
	Free time	Agricultural sustainability
Personal Consumption	Volunteerism	
Expenditures, Disposable Income	Commuting time	Forests
and Savings		Timber sustainability
Disposable income	Human Health and Wellness	Forest fragmentation
Personal expenditures	Life expectancy	
Taxes	Premature mortality	Parks and Wilderness
Savings rate	Infant mortality	Parks and wilderness
	Obesity	
Money, Debt, Assets and Net		Fish and Wildlife
Worth	Suicide	Fish and wildlife
Household Debt	Suicide	
		Wetlands and Peatlands
Income Inequality, Wealth,	Substance Abuse: Alcohol, Drugs	Wetlands
Poverty and Living Wages	and Tobacco	Peatlands
Income distribution	Drug use (youth)	
Poverty		Water Resource and Quality
	Auto Crashes and Injuries	Water quality
Public and Household	Auto crashes	
Infrastructure		Energy Use Intensity and Air
Public infrastructure	Family Breakdown	Quality
Household infrastructure	Divorce	Energy use intensity
		Air quality-related emissions
Employment	Crime	Greenhouse gas emissions
Weekly wage rate	Crime	
Unemployment rate		Carbon Budget
Underemployment	Gambling	Carbon budget deficit
	Problem gambling	
Transportation		Municipal and Hazardous Waste
Transportation expenditures	Democracy	Hazardous waste
	Voter participation	Landfill waste
	Intellectual & Knowledge Capital	Ecological Footprint
	Educational attainment	Ecological footprint

This table summarizes Genuine Progress Indicators used to evaluate sustainability.

2- Green Community Checklist

The US Environmental Protection Agency (EPA, 2003) proposes that a "green" community strives to:

Environment
• Comply with environmental regulations.
• Practice waste minimization and pollution prevention.
• Conserve natural resources through sustainable land use.

Economic
• Promote diverse, locally owned, and operated sustainable businesses.
• Provide adequate affordable housing.
• Promote mixed-use residential areas, which provide for open space.
• Promote economic equity.

Social
• Actively involve citizens from all sectors of the community through open, inclusive public outreach.
• Ensure that public actions are sustainable, while incorporating local values and historical and cultural considerations.
• Create and maintain safe, clean neighbourhoods and recreational facilities for *all*.
• Provide adequate and efficient infrastructure (water, sewer, etc.) that minimizes human health and environmental harm, and transportation systems that accommodate broad public access, bike, and pedestrian paths.
• Ensure equitable and effective educational and health-care systems.

3- Ecological Footprint (www.footprintnetwork.org)

The Ecological Footprint is a resource management tool that measures how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes under prevailing technology. This includes, for example, the amount of farmland needed to provide food and fibres, the amount of forest needed to provide wood and paper, the amount of watershed needed to provide water, the amount of land needed to produce energy, and the amount of land needed to absorb wastewater on a sustainable basis for person's consumption pattern.

Today, humanity's Ecological Footprint is over 23% larger than what the planet can regenerate. In other words, it now takes more than one year and two months for the Earth to regenerate what we use in a single year. We maintain this overshoot by liquidating the planet's ecological resources. By measuring the Ecological Footprint of a population (an individual, a city, a nation, or all of humanity) we can assess our overshoot, which helps us manage our ecological assets more carefully. Ecological Footprints enable people to take personal and collective actions in support of a world where humanity lives within the means of one planet.

4- Happy Planet Index (www.happyplanetindex.org)

The Happy Plant Index (HPI) developed by *Friends of the Earth* is calculated by multiplying indicators of *Life Satisfaction* times *Life Expectancy* and dividing by *Ecological Footprint* (resource consumption). Developing nations tend to rate relatively high by this index because they require fewer resources to achieve a given level of happiness, indicating greater ecological efficiency.

5- USDOT Environmental Performance Measures

The US Department of Transportation uses the following environmental performance indicators (FHWA, 2002).

Emissions – Tons of mobile source emissions from on-road motor vehicles

Greenhouse Gas Emissions – Metric tons of carbon equivalent emissions from transportation sources.

Energy – Transportation-related petroleum consumption per gross domestic product.

Wetlands Protection – Acres of wetlands replaced for every acre affected by Federal-aid Highway projects.

Liveable Communities/Transit Service – Percent urban population living within 1-mile of transit stop with service of 15 minutes or less.

Airport Noise Exposure – Number of people in US exposed to significant aircraft noise levels.

Maritime Oil Spills – Gallons of oil spilled per million gallons shipped by maritime sources.

Fisheries Protection – Compliance with Federal fisheries regulations.

Toxic Materials – Tonns of hazardous liquid materials spilled per million ton-miles shipped; and gallons of hazardous liquid spilled per serious transportation incident.

Hazardous Waste – Percent DOT facilities categorized as No Further Remedial Action Planned under Superfund Act.

Environmental Justice – Environmental justice cases that remain unresolved over one year.

6- Sustainable Transportation Performance Indicators

The Sustainable Transportation Performance Indicators (STPI) project by the Centre for Sustainable Transportation produced the indicators summarized in Table below. Sustainable Transportation Performance Indicators (Gilbert, et al, 2003)

Framework	Initial STPI	Short-term Additions	Long-Term Additions
1. Environmental and Health Consequences of transport.	Use of fossil fuel energy for all transport. Greenhouse gas emissions for all transport. Index of emissions of air pollutants from road transport. Index of incidence of road injuries and fatalities.	Air quality. Waste from road transport. Discharges into water. Land use for transport. Proximity of infrastructure to sensitive areas and ecosystem fragmentation.	Noise Effects on human health. Effects on ecosystem health.
2. Transport activity	Total motorized movement of people. Total motorized movement of freight. Share of passenger travel *not* by land-based public transport. Movement of light-duty passenger vehicles.	Utilization of passenger vehicles. Urban automobile vehicle-kilometers. Travel by non-motorized modes in urban areas. Journey-to-work mode shares.	Urban and intercity person-kilometers. Freight modal participation. Utilization of freight vehicles.
3. Land use, urban form and accessibility	Urban land use per capita.	Urban land use by class size and zone. Employment density by urban size, class and zone. Mixed use (percent walking to work, ratio of jobs to employed labour force.	Share of urban population and employment served by transit. Share of population and employment growth on already urbanized lands. Travel and modal split by urban zone.
4. Supply of transport infrastructure and services.	Length of paved roads.	Length of sustainable infrastructure. Transit seat-kilometers per capita.	Congestion index.
5. Transport expenditures and pricing.	Index of relative household transport costs. Index of relative cost of urban transport.	Percent of net government transport expenditures spent on ground-based public transport.	Transport related user charges. Expenditures by businesses on transportation.
6. Technology adoption.	Index of energy intensity of cars and trucks. Index of emissions intensity of the road-vehicle fleet.	Percent of alternative fuel vehicles in the fleet.	Percent of passenger-kms and tonne-kms fuelled by renewable energy. Percent of labour force regularly telecommuting.
7. Implementation and monitoring.		Number of sustainable transport indicators regularly updated and widely reported. Public support for initiatives to achieve sustainable transport.	Number of urban regions where planning and delivery of transport and related land use matters have a single authority.

7- Environmentally Sustainable Transport

The following indicators of Environmentally Sustainable Transport (EST)

• *CO2* – Climate change is prevented by avoiding increased per-capita carbon-dioxide emissions.

• *NOX* – Ambient NO2, ozone levels and nitrogen deposition is greatly reduced.

• *VOC* – Damage from carcinogenic VOCs and ozone is greatly reduced.

• *Particulates* – Harmful ambient air levels are avoided by reducing emissions of fine particulates (particularly those less than 10 microns in size).

• *Noise* – Ambient noise levels that present a health concern or serious nuisance (maximum 55-70 decibels during the day and 45 decibels at night and indoors).

• *Land use* – Transport facility land consumption is reduced to the extent that local and regional objectives for ecosystem protection are met.

The OECD concludes that environmentally sustainable transport will require:

• Significant reduction in car ownership and use, and shifts to more efficient vehicles

• Reduced long-distance passenger and freight travel, particularly air travel, and increased non-motorized short-distance travel.

• Energy-efficient, electric powered, high-speed rail

• Energy-efficient, less polluting shipping

• More accessible development patterns

• Increased use of telecommunications to substitute for physical travel

• More efficient production to reduce long-distance freight transport

8- Global Reporting Initiative (www.globalreporting.org)

The Global Reporting Initiative provides guidance for organizations to use for disclosure about their sustainability performance using a universally applicable *Sustainability Reporting Framework* that allows consistent, understandable, and comparable results. This effort supports a variety of reporting and accounting programs, including the UN Global Compact (UNGC) and ISO 14000.

9- Performance Indicators

Transportation planners use various performance indicators for evaluating transportation conditions, prioritizing improvements, and day-to-day operations. Meyers (2005) describes and compares various performance indicators used by transportation planners in three countries. These include indicators related to roadway conditions (congestion, travel times, crashes), freight transport efficiency, pollution emissions, quality of various modes (including walking, cycling and public transit) and user satisfaction.

10- Mobility for People with Special Needs and Disadvantages

Special consideration should be given to evaluating the ability of a transportation system to serve people who face the greatest mobility constraints, such as wheelchair users and people with very low incomes (Litman and Richert, 2005; Litman, 2005a). Special effort may be made to identify these users in transportation surveys and ridership profiles, evaluation of transportation system features in terms of their ability to accommodate people with disabilities. The following are possible performance indicators.

1. Surveys of disadvantaged people to determine the degree to which they are constrained in meeting their basic mobility needs (travel to medical services, school, work, basic shopping, etc.) due to inadequate facilities and services.

2. Travel surveys that identify the degree of mobility by disadvantaged people, and how this compares with the mobility of able-bodied and higher-income people.

3. The degree to which various transportation modes and services accommodate disadvantaged people, including the ability of walking facilities and transit vehicles to accommodate wheelchair users and users with other disabilities, and transportation service discounts and subsidies for people with low incomes.

4. Degree to which disadvantaged people are considered in transportation planning through the involvement of individuals and advocates in the planning process, special data collection, and special programs.

5. The portion of pedestrian facilities that accommodate wheelchair users, and the number of barriers within the system

6. The frequency of failures, such as excessive waiting times, inaccurate user information and pass ups of disadvantaged people by transportation services.

7. User surveys to determine the problems, barriers and costs disadvantaged people face using transportation services.

8. The portion of time and financial budgets devoted to transportation by disadvantaged people.

9. Indicators of the physical risks facing people with disabilities using the transportation system, such as the number of pedestrians with disabilities who are injured or killed by motor vehicles, and the frequency of assault on transit users, particularly those with disabilities and lower incomes (who are often forced to use transit services in less secure times and locations, due to fewer transportation options.)

11- World Business Council Sustainable Mobility Indicators

The table below summarizes sustainable mobility indicators developed for the World Business Council's Sustainable Mobility project.

User Concerns	Societal Concerns	Business Concerns
Ease of access to means of mobility Financial outlay required of user Average door-to-door time required Reliability, measured as variability in average door-to-door time Safety (chance of death or serious injury befalling the user) Security (chance of the user being subjected to robbery, assault, etc.)	Impacts on the environment and on public health and safety Greenhouse gas emissions (CO_2 equivalent) "Conventional" emissions – NOx, CO, SO_2, VOC, particulates Safety (number of deaths and serious injuries) Security Noise Land use Resource use (including recycling) Impacts on public revenues and expenditures "Launching aid" Publicly-provided infrastructure Required operating subsidies Potential for reducing public expenditures Potential for generating government revenues Equity impacts	Profitability (ability to earn at least a competitive return on investment) Total market size Conditions determining market acceptance Required competences Private investment required Necessity/possibility of "launching aid" and payback conditions Investment net of publicly-provided infrastructure Cash flow generation Potential cash flow from operations Gap between likely actual and required cash flow; potential for public subsidies Policy barriers/incentives

Eliminating overlaps resulted in the following set

- Ease of accessibility to means of mobility.
- Financial outlay required.
- Average required door-to-door time.
- Reliability (variability in required average door-to-door time).
- Safety (risk of death or serious injury befalling the user).
- Security (risk of the user being subjected to robbery, assault, etc.).
- Transport-related GHG emissions.
- Impact on environment, public health and safety (with associated sub-indicators).
- Impact on public revenues and expenditures (with associated sub-indicators).
- Equity implications (with associated sub-indicators).
- Prospective rate of return (with associated sub-indicators).

12- Sustainability Checklist

Below are sustainability indicators developed by Region 10 USEPA employees working on implementation sustainable planning.

• Identify Non-sustainability: Determine if the project has identified those currently non-sustainable practices and behaviours that are to be addressed by the project.

• Value Natural Capital: Determine if the project will succeed at placing value on natural capital (soil and agricultural productivity, climate regulation, wetlands treatment of contaminants, etc.).

• See Waste as Food: Ask if our activity is systems-focused in that it seeks to model nature's patterns of waste as food where the goal is established of eliminating the practice and concept of waste.

• Use Local Resources: Identify whether the project maximizes or has a plan to maximize the efficient use of local resources (human, material, energy) rather than depending more on the import of material goods and services for its success.

• Promote Social Equity: Determine if the project explicitly addresses a goal of fairly sharing its benefits and burdens within the affected community.

• Practice Value-added Economics: Examine whether the project features maximum value-added economic activity as a way of optimizing the efficient use of human and natural resources within the community.

• Promote Ecosystem Health: Ask if the project demonstrates and promotes the goal of enhanced ecosystem integrity for the specific bioregional project areas to be affected by the proposal (watershed, riparian zone, wetlands, headwaters, grasslands, forest, and maintenance of biodiversity).

• Enhance Meaningful Work: Identify if the project will provide both the quality and quantity of employment opportunities needed to address a pre-existing situation of underemployment with the affected community.

• Support Community Inclusiveness: Ask whether the project features or encourages the participation of all members of the community directly or indirectly affected by the proposed course of action. Is greater opportunity for equity promoted?

• Avoid Problem Shifting: Look to see if the project minimizes the shifts of impacts from one community to another (locally, regionally, nationally, or internationally) in areas such as waste disposal, resource depletion, and economic dislocation.

• Reflect Intergenerational Equity: See if the project has a sufficiently long-term time horizon that addresses the likelihood that the project can continue indefinitely without violating any of the checklist items above.

13- TERM

The European Union's *Transport and Environment Reporting Mechanism* (TERM) identifies the sustainable transportation indicators summarized in Table below.

Group	Indicators	
Transport and Environment Performance		
Environmental consequences of transport	Transport final energy consumption and primary energy consumption, and share in total (fossil, nuclear, renewable) by mode.	
	Transport emissions and share in total emissions for CO_2, NO_x, NM, VOCs, PM_{10}, SO_x, by mode.	
	Exceedances of air quality objectives.	
	Exposure to and annoyance by traffic noise.	
	Infrastructure influence on ecosystems and habitats ("fragmentation") and proximity of transport infrastructure to designated sites.	
	Land take by transport infrastructures.	
	Number of transport accidents, fatalities, injured, polluting accidents (land, air and maritime).	
Transport volume and intensity	*Passenger transport (by mode and purpose):* total passengers total passenger-kilometers passenger-kilometers per capita passenger-kilometers per GDP	*Freight transport (by mode and group of goods):* total tonnes total tonne-kilometers tonne-kilometers per capita tonne-kilometers per GDP
Determinants of the Transport/environment System		
Spatial planning and Accessibility	Average passenger journey time and length per mode, purpose (commuting, shopping, leisure) and territory (urban/rural).	
	Access to transport services e.g.: motor vehicles per household, portion of households located within 500m of public transport.	
Transport supply	Capacity of transport infrastructure networks, by mode and by type of infrastructure (e.g. motorway, national road, municipal road etc.).	
	Investments in transport infrastructure/capita and by mode.	
Price signals	Real passenger and freight transport price by mode.	
	Fuel price.	
	Taxes.	
	Subsidies.	
	Expenditure for personal mobility per person by income group.	
	Proportion of infrastructure and environmental costs (including congestion costs) covered by price.	
Technology and utilization efficiency	Energy efficiency for passenger and freight transport (per pass-km and per tonne-km and by mode).	
	Emissions per pass-km and emissions per tonne-km for CO_2, NO_x, NM, VOCs, PM_{10}, SO_x by mode.	
	Occupancy rates of passenger vehicles.	
	Load factors for road freight transport (LDV, HDV).	
	Uptake of cleaner (unleaded petrol, electric, alternative fuels) and alternative fuelled vehicles.	
	Vehicle fleet size and average age.	
	Proportion of vehicle fleet meeting certain air and noise emission standards (by mode).	
Management integration	Number of Member States that implement an integrated transport strategy.	
	Number of Member States with national transport and environment monitoring system.	
	Uptake of strategic environmental assessment in the transport sector.	
	Uptake of environmental management systems by transport companies.	
	Public awareness and behaviour.	

14- SUMMA

SUMMA (Sustainable Mobility Measures and Assessment) is a European Commission sponsored project to define and operationalize sustainable mobility, develop indicators, assess the scale of sustainability problems associated with transport, and identify policy measures to promote sustainable transport (www.SUMMA-EU.org). Table below shows the scope of its analysis.

Economic	Environmental	Social
EC1: Accessibility Economic accessibility has two aspects: (1) local access of goods and people to services, work, industrial plants, etc., and (2) long distance links among regions.	*EN1: Resource use* The use of materials, energy and other resources by the transport sector.	*SO1: Accessibility and affordability* The time and cost required to reach basic services. Lower income individuals generally have poorer accessibility to basic services than those well off.
EC2: Transport operating costs The costs to the user of the transport system, both direct user costs (fuel, ticket prices, transport equipment), and indirect costs, such as the costs of congestion.	*EN2: Direct ecological intrusion* The impacts of transport on flora and fauna that are not caused by emissions or pollution, but rather by transport infrastructure (building, using, and maintaining).	*SO2: Safety and security* Safety implies freedom from danger. Security concerns freedom from fear (of crime or other undesired actions).
EC3: Productivity/Efficiency Providing conditions for an expanding, productive and efficient economy, and therefore for more individual and public welfare. Inefficiencies increase the resources needed to produce benefits.	*EN3: Emissions to air* Emissions of pollutants, etc. into the air, which affect health and harm buildings. Also the emission of greenhouse gasses, which contributes to global warming.	*SO3: Fitness and health* The trend to perform short trips by car decreases fitness and increases the threat to health (through increased pollution).
EC4: Costs to economy All costs of transport (except for the individual user), i.e. infrastructure investments, maintenance, public subsidies, final energy consumption and external costs of transport.	*EN4: Emissions to soil and water* Emissions of pollutants to soil and water, wastewater from manufacture and maintenance, runoff from roads, discharges of oil and wastewater by ships, etc.	*SO4: Livability and amenity* Transport influences our *quality of life*. It concerns an individual's direct surroundings and the impact transport has on it. It concerns not only measurable aspects (noise, pollution) but also perceptions and attitudes.
EC5: Benefits to economy The gross value added generated by the transport sector, national revenues from taxes and traffic system charging, and economic growth induced by transport.	*EN5: Noise* Transport is one of the most significant sources of noise in urban areas. There is evidence that noise is related to human and animal health and wellbeing.	*SO5: Equity* This concerns the fair distribution of costs and benefits among different groups in society, among income classes, among regions, and among generations.
	EN6: Waste Transport vehicles and infrastructure create large amounts of waste during their life cycle, which can partly be recycled or reused, but is otherwise disposed of by incineration and in landfills.	*SO6: Social cohesion* The ongoing process of developing a community of shared values, challenges and opportunities based on trust, hope and reciprocity. It is related to *social capital*, which refers to features of social organisation such as networks, norms, and social trust that facilitate co-operation for mutual benefit.

15- Lyons Regional Indicators

Nicolas, Pochet and Poimboeuf (2003) describe how local travel survey data and other available information is used to evaluate transport system sustainability in Lyons, France. This region has 1.2 million inhabitants with a relatively centralized, urban development pattern.

Indicators were organized to reflect economic, social, and environmental impacts. Economic indicators reflect transport cost-efficiency, that is, the economic costs per unit of travel, including costs to residents, businesses, and governments. Social indicators reflect the relative mobility and transportation cost burdens for people in different income classes. Environmental indicators reflect various transport pollution emissions and land requirements. These impacts were disaggregated by mode (automobile, public transit, walking), geographic location (central, middle and outer urban areas) and household demographics. Table below summarizes these indicators.

Dimension	Indicator	Level of Analysis
Mobility		
Service provided	Daily number of trips Trip purposes Average daily travel time	Overall and by geographic location
Organization of urban mobility	Mode split Daily average distance traveled Average travel speed	Overall and by travel mode
Economic		
Cost for the community	Annual transportation costs (total, per resident and per passenger-km) • Households • Businesses • Local government	Overall and per mode
Social		
	Household vehicle ownership Personal travel distance Household transportation expenditures (total and as a portion of income)	Overall, by income and geographic location
Environmental		
Air pollution - global	Annual energy consumption and CO2 emissions (total and per resident)	Overall, by mode, by location of emission, and location of resident.
Air pollution - local	CO, NOx, hydrocarbons and particulates (total and per resident)	Overall, by mode, by location of emission, and location of resident.
Space consumption	Daily individual consumption of public space for transport and parking. Space required for transport infrastructure.	Overall, by mode and place of residence.
Other	Noise Accident risk	Overall, by mode and place of residence.

B. Over view of Portland

Background/History

The Oregon Territory was created in 1848, and Oregon became the 33rd state on February 14, 1859. Salem is the state's capital and third-most-populous city; Portland is the most populous. Oregon's 2010 population is just over 3.8 million, a 12% increase over 2000. Portland is the 29th-largest U.S. city, with a population of 583,776 (2010 US Census) and a metro population of 2,241,841, the 23rd-largest U.S. metro area. The valley of the Willamette River in western Oregon is the state's most densely populated area and is home to eight of the ten most populous cities. Oregon's population grew about 1.5 percent annually from 1995 to 2007, slightly faster than the nation's 1.2-% annual growth rate.

Figure 58 : Oregon County Map

Oregon contains a diverse landscape including the windswept Pacific coastline, the volcanoes of the rugged and glaciated Cascade Mountain Range, many waterfalls , dense evergreen forests, and high desert across much of the eastern portion of the state, extending into the Great Basin. The tall Douglas firs and redwoods along the rainy Western Oregon coast contrast with the lower density and fire prone pine tree and juniper forests covering portions of the eastern half of the state. Stretching east from Central Oregon, the state also includes semi-arid scrublands, prairies, deserts, steppes, and meadows. Mount Hood is the highest point in the state at 11,249 feet (3,429 m). Crater Lake National Park is the only national park in Oregon.

The land contains a large part of farmlands. Agriculture is one of the Oregon’s most important industries. For more than three decades, Oregon has maintained a strong policy to protect farmland. In 2007, according to the latest data from the Oregon Department of Agriculture, farms in Oregon generated $4.9 billion in gross sales. With value-added processing sales of farm-related goods and services and farm-related employment, the total direct and indirect contribution by agriculture to Oregon's economy is more than $12 billion. This equates to 10 percent of Oregon's gross state product and more than nine percent of all employment in the state.

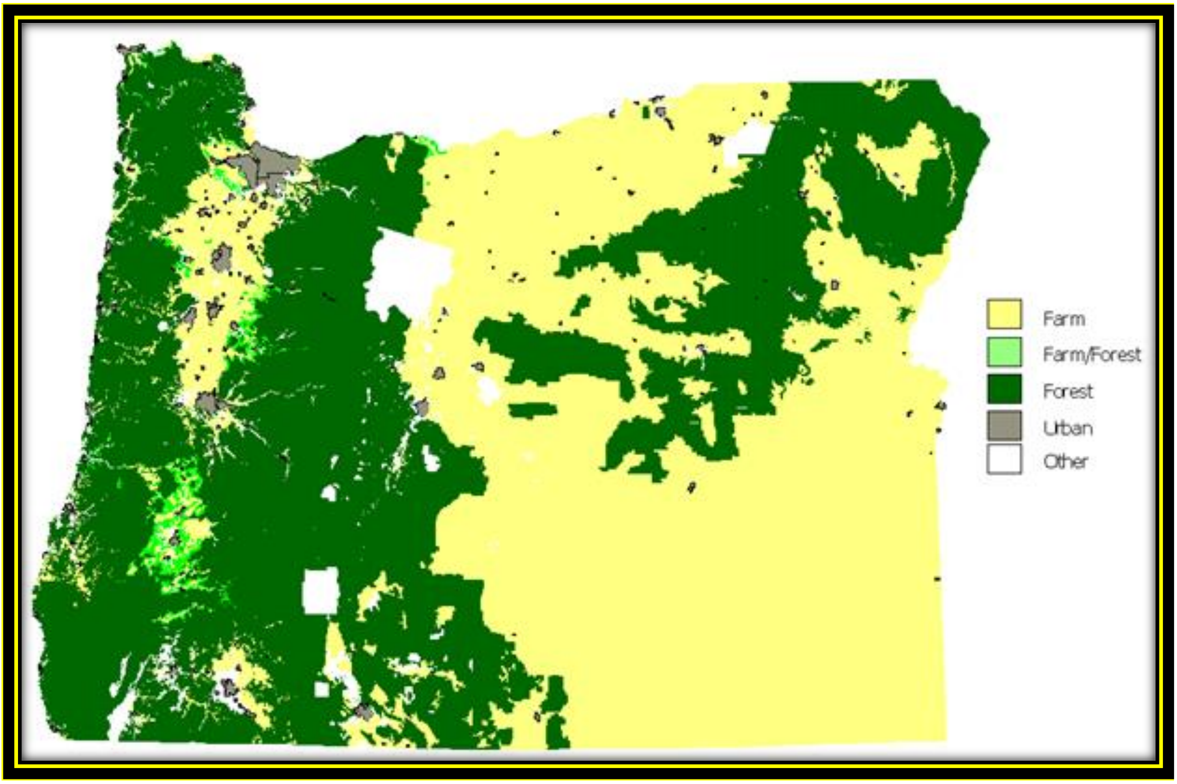


Figure 59 : Generalized Zoning

As it can be seen in figure 49 there are not much urbanized areas in the state as there is not in other states.

The form of planning in Oregon is not so much different from other states, but the substance is different from other states. In most states, standards for local planning are not uniform from one jurisdiction to another.

For example, for the first time many laws established the Oregon Coastal Conservation and Development Commission, and mandated local governments to prepare comprehensive land use plans and develop land use controls.

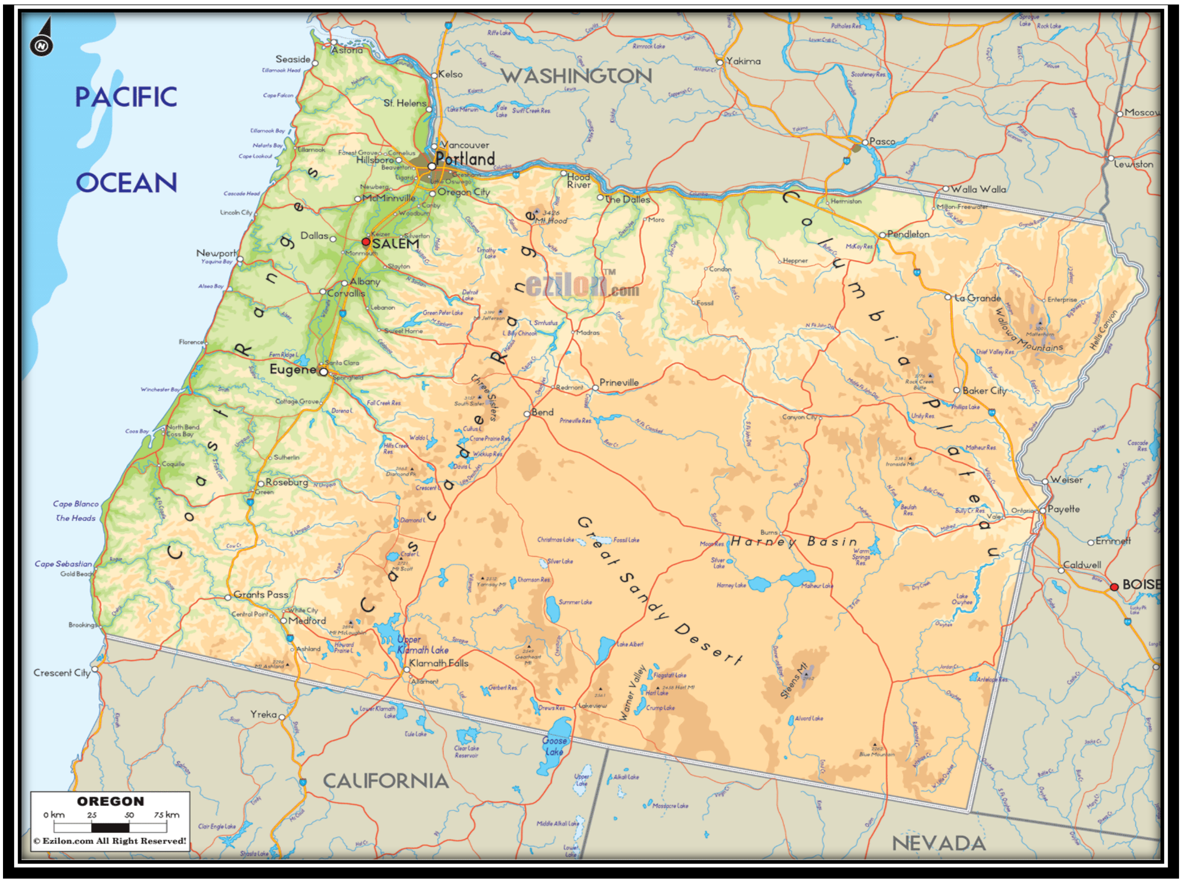


Figure 60: map of Oregon

Population

As of the census of 2010, Oregon has a population of 3,831,074, which is an increase of 409,675, or 12%, since the year 2000. ”that rate was the slowest in 20 years apparently due to a declining birth rate and immigration”. In November 2010, the Population Research Canter at Portland State University, which tracks Oregon population growth for state government from a host of sources beyond the census, reported that the state's population had declined for a fourth straight year. The number of births have decreased, the number of deaths have increased, and the net number of newcomers is less than half that of 2009.

The population density is 39.9 persons per square mile. There are 1,675,562 housing units, a 15.3% increase over 2000. Among them, 90.7% are occupied.

The centre of population of Oregon is located in Linn County, in the city of Lyons. More than 57% of the state's population lives in the Portland metropolitan area.

As of 2004, Oregon's population included 309,700 foreign-born residents (accounting for 8.7% of the state population).

Table 58: Oregon population dispersion in rural and urban areas

Population			
Year	*Rural*	*Urban*	*Total*
1980	*703,830*	*1,929,326*	*2,633,156*
1990	*711,828*	*2,130,493*	*2,842,321*
2000	*803,666*	*2,617,733*	*3,421,399*
2010	*852,523*	*2,978,551*	*3,831,074*

Health, Poverty

Duo to the uprising rate of unemployment (that will be survey in economy part) the rate of poverty is rising up too and the rate is faster than ever in the last decade. This was unpreventable duo to the economic hit that the U.S. has conceded in the last few years.

Table 59: Poverty and income rates

Income			
	Rural	*Urban*	Total
Per-capita income (2009 dollars)			
2008	30,575	38,409	36,677
2009	30,733	37,719	36,191
Percent change	0.5	-1.8	-1.3
Earnings per job (2009 dollars)			
2008	34,963	46,508	44,272
2009	34,741	46,772	44,426
Percent change	-0.6	0.6	0.3
Poverty rate (percent)			
1989	15.4	11.4	12.4
1999	13.8	11	11.6
2009	17.2	13.5	14.3

Health is another factor that has a straight relation with the incomes of people. The high rates of insurance and medicines have forced the governments to spend millions of budgets. Oregon faces a $3.5 billion budget crisis and health care is an ever-increasing portion of the state budget. Health care spending accounts for 16 percent of the state general fund budget. The need to reform the health care system is more urgent than ever.

Table 60 : Oregon Health factors

Percentage of Population with a Disability (ages 21-64; ages 16-64): 2000, 2006	Ages 21-64, 2000: 18.0 Ages 16-64, 2006: 13.8
Percentage of adults that report their health as "excellent", "very good" or "good"	84.3 %
Percentage of adults who have at least one of the following conditions: arthritis, asthma, diabetes, high blood pressure, high cholesterol, or stroke, 2002-2005	61 %
Percentage of adults who have at least one of the following risk factors for chronic disease: current smoking, overweight or obesity, physical inactivity, or low fruit and vegetable consumption, 2002-2005	89 %
Percentage of adults who met CDC recommendations for physical activity, 2002-2005	55 %
Percentage of adults who consumed at least 5 servings of fruits and vegetables per day, 2002-2005	26 %
percentage of adults classified as obese, 2002-2005	22 %
Percentage of adults classified as overweight, 2002-2005	37 %
Percentage of adults who currently smoke cigarettes, 2002-2005	20 %

Education

As of 2005, the state had 559,215 students in public primary and secondary schools. There were 199 public school districts at that time, served by 20 education service districts. The five largest school districts as of 2007 were: Portland Public Schools (46,262 students), Salem-Keizer School District (40,106), Beaverton School District (37,821), Hillsboro School District (20,401), and Eugene School District (18,025). The Oregon University System supports seven public universities and one affiliate in the state. Oregon State University holds the distinction of being the state's flagship research university with top ranked programs in science, engineering, and agriculture.

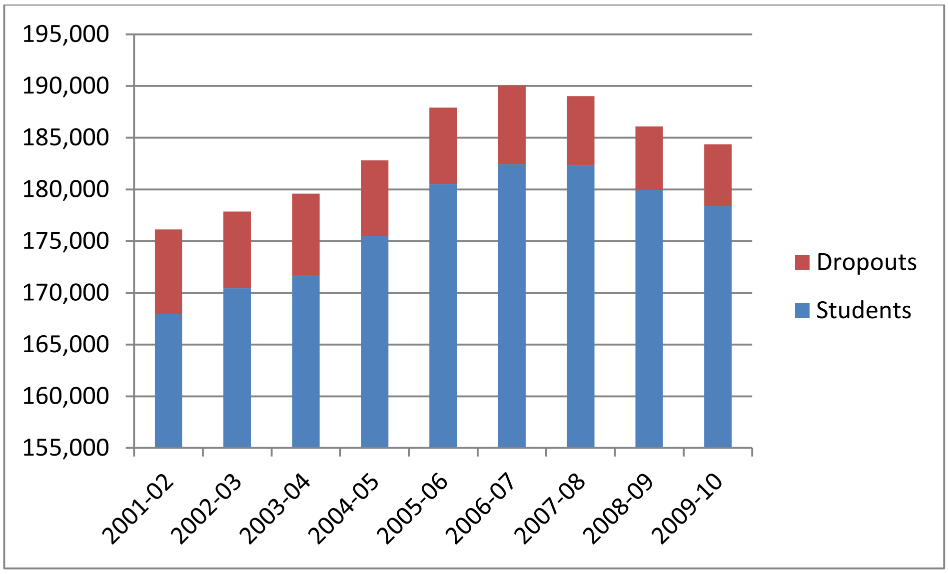


Figure 61: stateside Dropout Rates, Grades 9-12

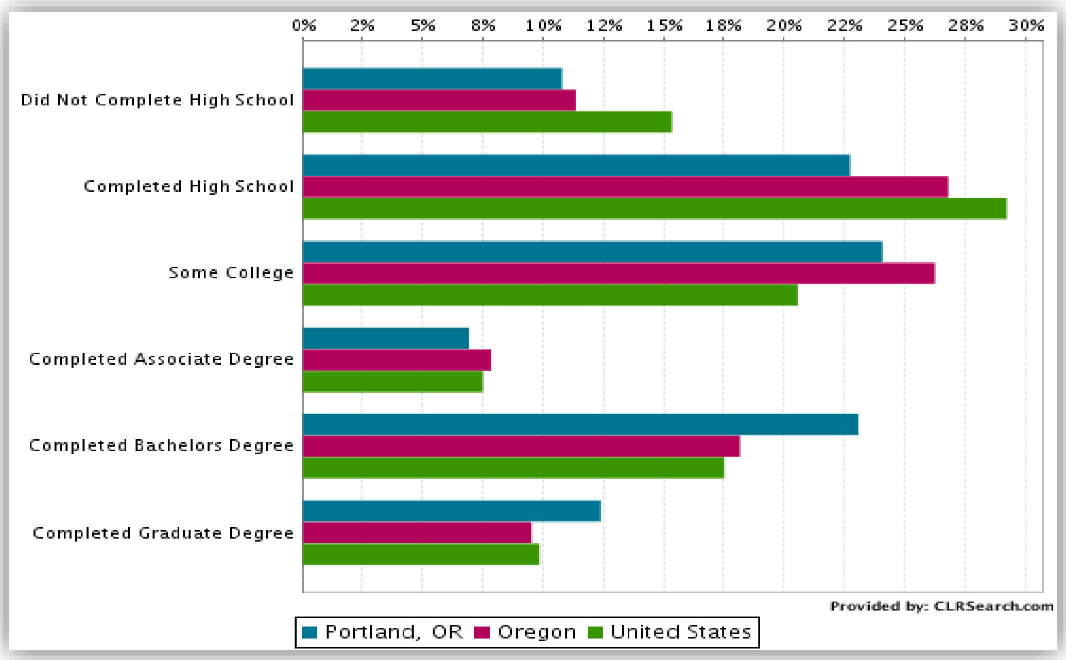


Figure 62:2010 Highest education level attained (age 25+) for Portland, Oregon

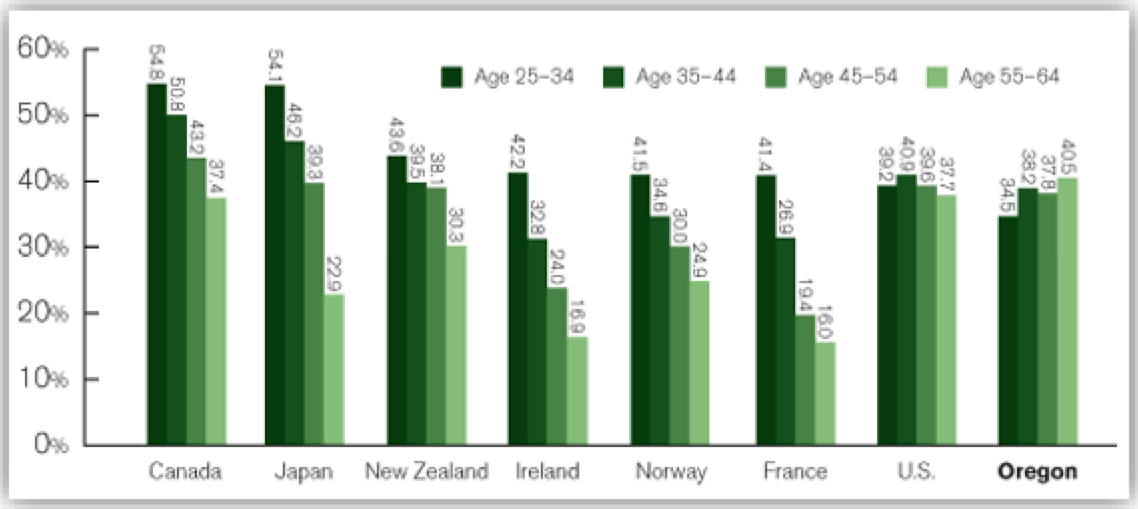


Figure 63: Percent of adults with an associate's degree or higher by age group compared to leading OECD countries

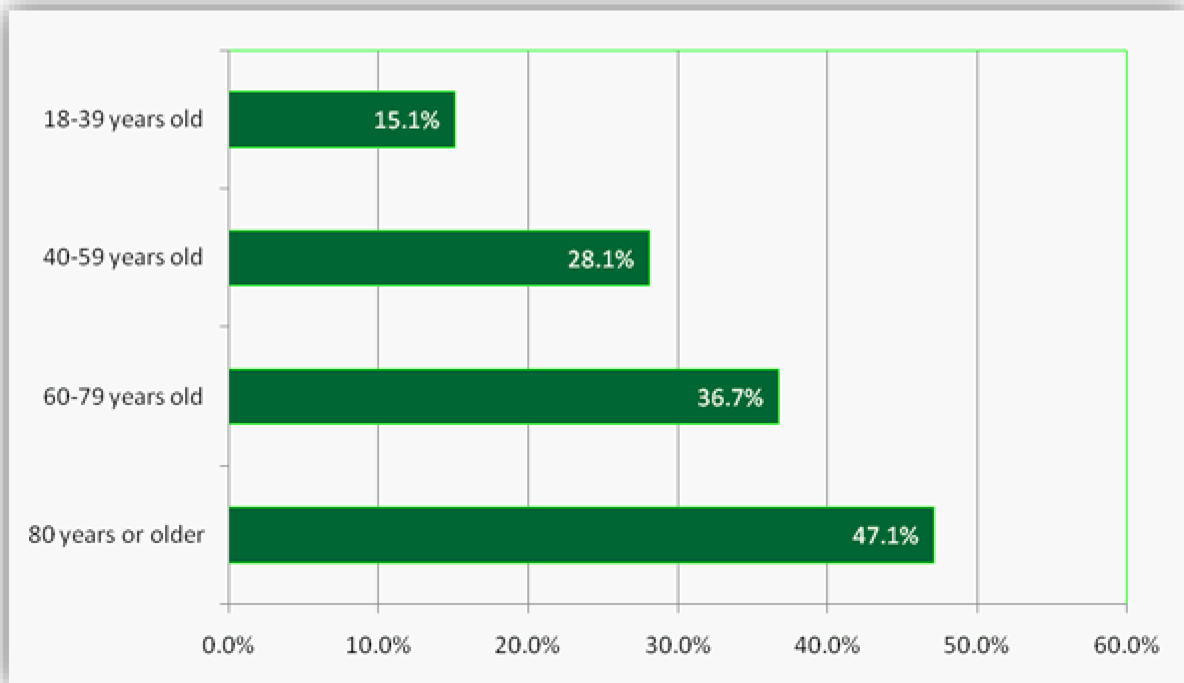


Figure 64: Percent of disability in different age groups

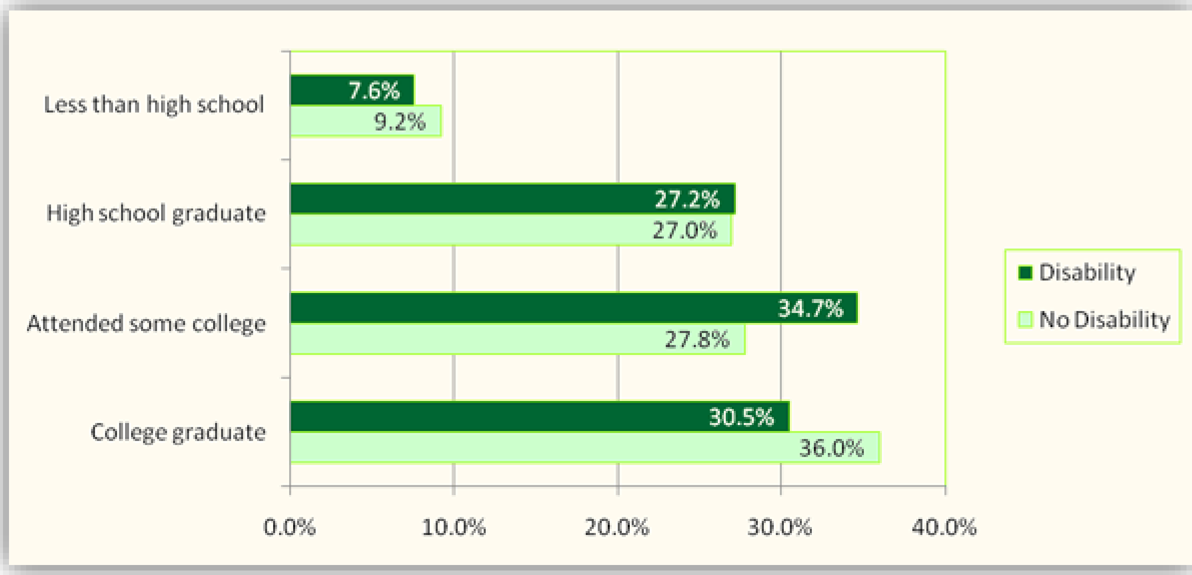


Figure 65: Education levels of people with and without disabilities

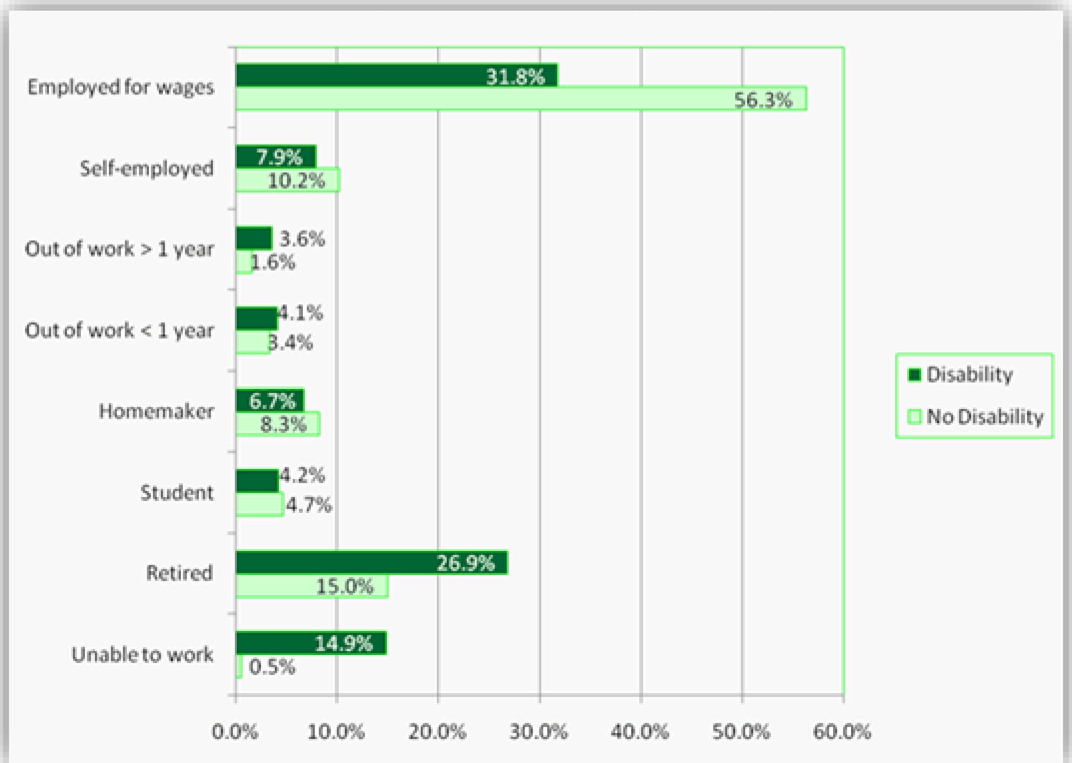


Figure 66: Employment status of people with or without disabilities

Housing

Oregon has been unable to escape the credit squeeze that grips the nation's housing market. Building permits have fallen to record lows, sales are sluggish, inventory is at an all-time high, and prices have turned negative. Oregon's residential housing market may well avoid the free falling prices that plague states like Florida, California, and Nevada – but national realities are more difficult to avoid for industries like logging, wood products, finance, and real estate.

In the first quarter of 2008, Oregon issued 3,305 housing permits, an abysmally low figure. This was more than 4,100 below its 2005 first quarter peak and nearly 1,200 below its previous low in 2000. Negatively Oregon's population grew about 1.5 percent annually from 1995 to 2007, slightly faster than the nation's 1.2-percent annual growth rate. Population is not the only factor that influences housing construction.

Overall, single family housing permits have been increasing steadily since February 2009 but remain over 50 percent below their relatively stable 1992 – 2002 levels.

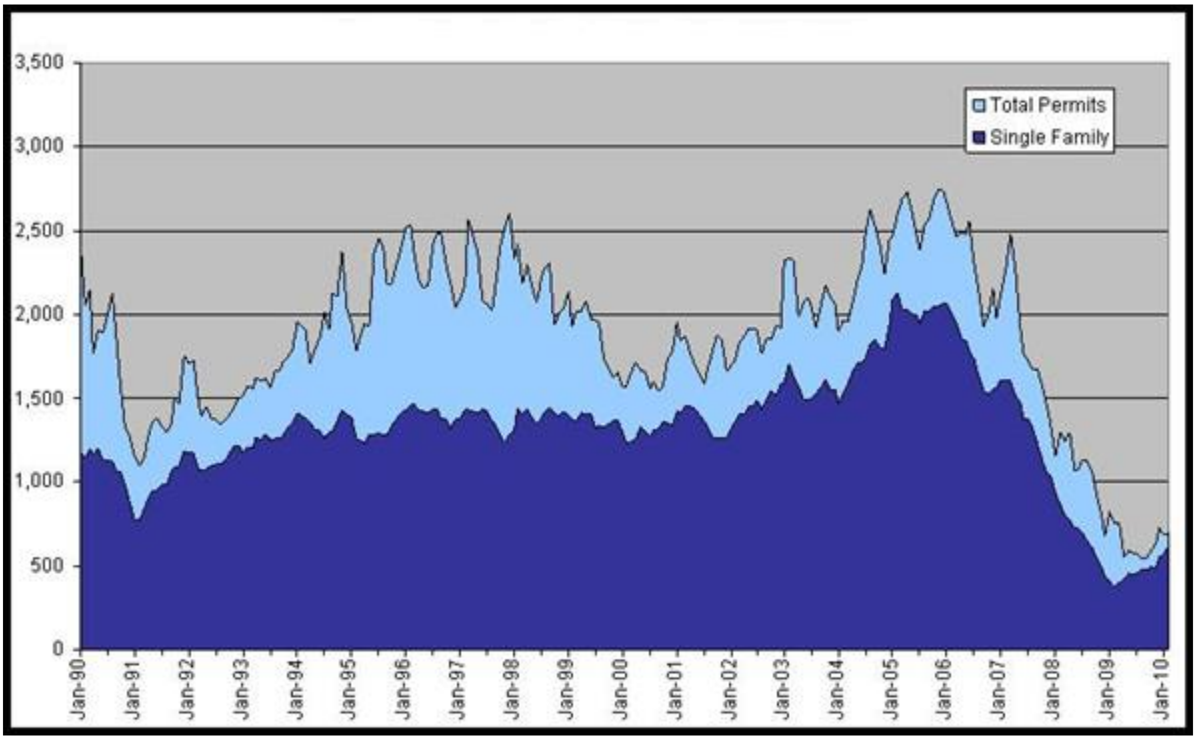


Figure 67: number of House Permits in Oregon

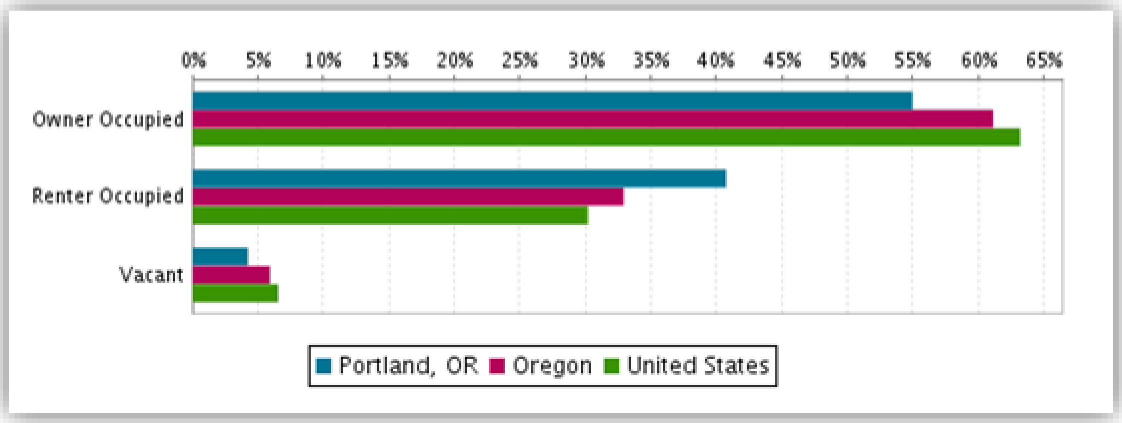


Figure 68: 2010 housing statistics, occupancy statistics for Portland, Oregon

Employment

Oregon's unemployment rate continues to fall, but that figure masks a slowdown in job creation that is consistent with the softening of the national economy. According to the BLS current population survey (CPS), the unemployment rate for Oregon fell 0.2 percentage points in May 2011 to 9.3%. The state unemployment rate was 0.2 percentage points higher than the national rate for the month. The unemployment rate in Oregon peaked in May 2009 at 11.6% and is now 2.3 percentage points lower.

Table 61: Recent Employment changes

Employment			
	Rural	Urban	Total
Total number of jobs			
2008	446,423	1,858,614	2,305,037
2009	429,552	1,773,142	2,202,694
Percent employment change			
2007-2008	-0.5	0.6	0.4
2008-2009	-2.9	-4.0	-3.8
2009-2010	0.9	0.5	0.6
Unemployment rate (percent)			
2009	12.4	10.8	11.1
2010	12.2	10.5	10.8
Unemployment Rate	May 2011	Month/Month	Year/Year
National	9.1%	+0.1	-0.5
Oregon	9.3%	-0.2	-1.6

Energy

Portland legislature passed a law in 2010 that requires utilities to get at least 25 percent of Portland's power from renewable sources by 2025. For 10 years beginning March 2002, through Oregon's Renewable Resource Programs, Portland General Electric (PGE) and Pacific Power customers pay a 3 percent charge on their monthly bills for conservation and renewable resource programs under Oregon's electric industry restructuring law. About 17 percent of the funds, estimated at $10 million to $13 million per year, are for projects that generate electricity from renewable resources. The Energy Trust of Oregon administers the funds. Its goal for renewable resources is that they supply 10 percent of the state's electricity needs by 2012, an eight-fold increase. That goal has been largely attained.

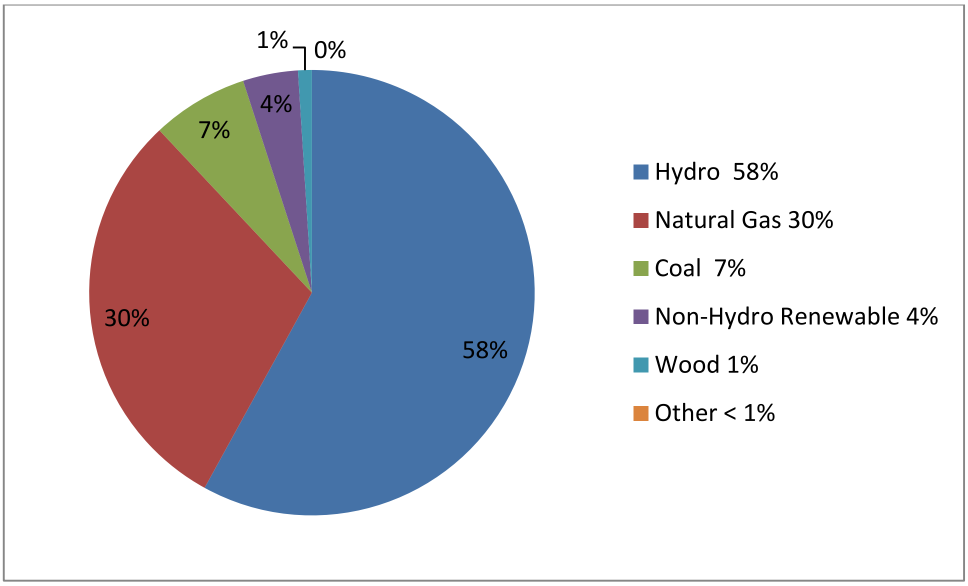


Figure 69: Portland's Electricity Generation 2007

Energy is the most important factor of Oregon's sustainability. The state is a pattern in using clean energy in the United States.

Oregon and Portland is becoming a green energy hub, with utility scale energy generation using Wind, Solar, and Wave, investments in electric car charging infrastructure, batteries and inverter technology, and a green building hub providing leadership nationwide.

Advocates say renewable energy companies have invested $5.4 billion dollars in Oregon to date and the wind and solar industries have become a vital part of our economic fabric. Wind and solar projects by companies like Horizon Wind Energy, enXco and NextEra have brought hundreds of construction jobs to Oregon and millions of dollars of tax revenues to rural communities.

The Portland Development Commission is focusing on three core clusters within the clean technology industry, reports Sustainable Business Oregon.

- Clean energy, with a focus on wind- and solar-powered generation.

- Green development, which includes both green building technologies and energy-efficiency retrofits.

- Electric vehicles and the associated sectors, which includes energy storage.

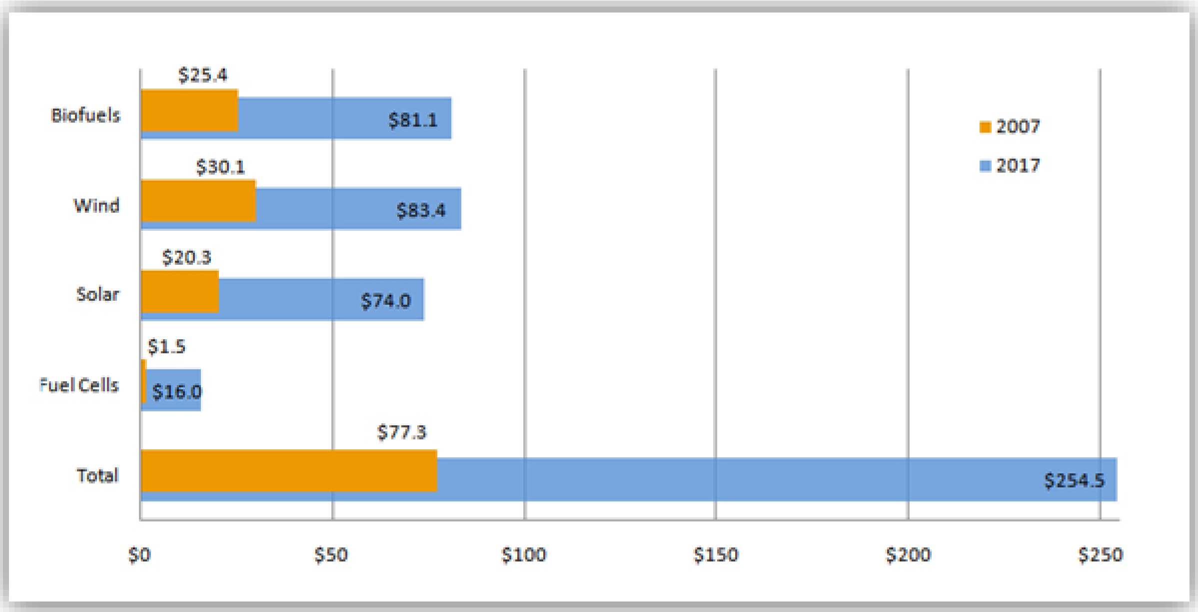


Figure 70: Clean Energy projected growth 2007-2017 ($US billions)

Transportation systems

Oregon is often held up as national model for transportation planning. Since 2000, state legislators have invested in railroads, ports, transit, and highways. The Oregon Department of Transportation has streamlined project delivery and improved environmental results. The 2009 Jobs and Transportation Act ensured accountability and innovation in transportation funding, including funding for public transit.

However, the transportation revenue model is broken. Revenues flowing into the federal Highway Trust Fund have fallen significantly due to higher gas prices, recession pressures, and the shift to alternative fuels. Meanwhile, state fuel tax revenue can only be used for highway transportation projects.

Portland as the best sample has a comprehensive public transportation system. The bus and rail system is operated by TriMet, its name reflecting the three metropolitan area counties it serves (Multnomah, Clackamas, and Washington). Portland's rate of public transit use (12.6% of commutes in 2008) is comparable to much larger cities like Los Angeles, and higher than in most similarly sized U.S. cities. Much of the downtown Portland area (the city centre) is in the "Free Rail Zone" (formerly known as Fareless Square), within which rides on light rail and streetcars are fare-free.

Figure 71: Buses and bikes in downtown Portland

Figure 72: view from Portland Aerial Tram, Portland, OR, USA

Despite all the development of the public Transportation, the use of the private vehicle is extremely high.

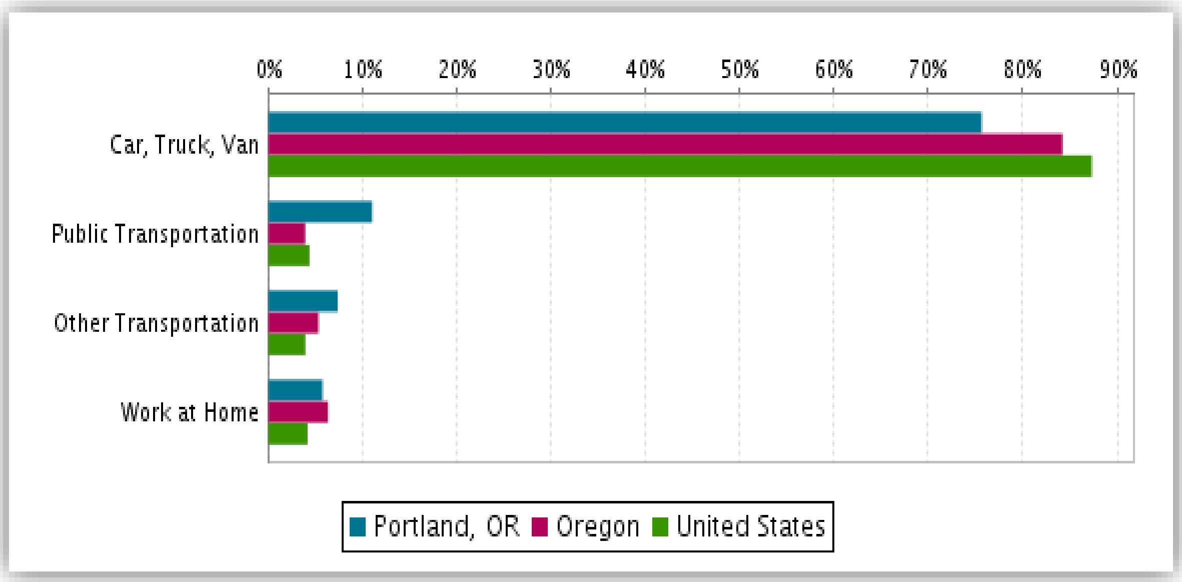


Figure 73: 2010 Mode of Transportation to work (Employees age 16+)

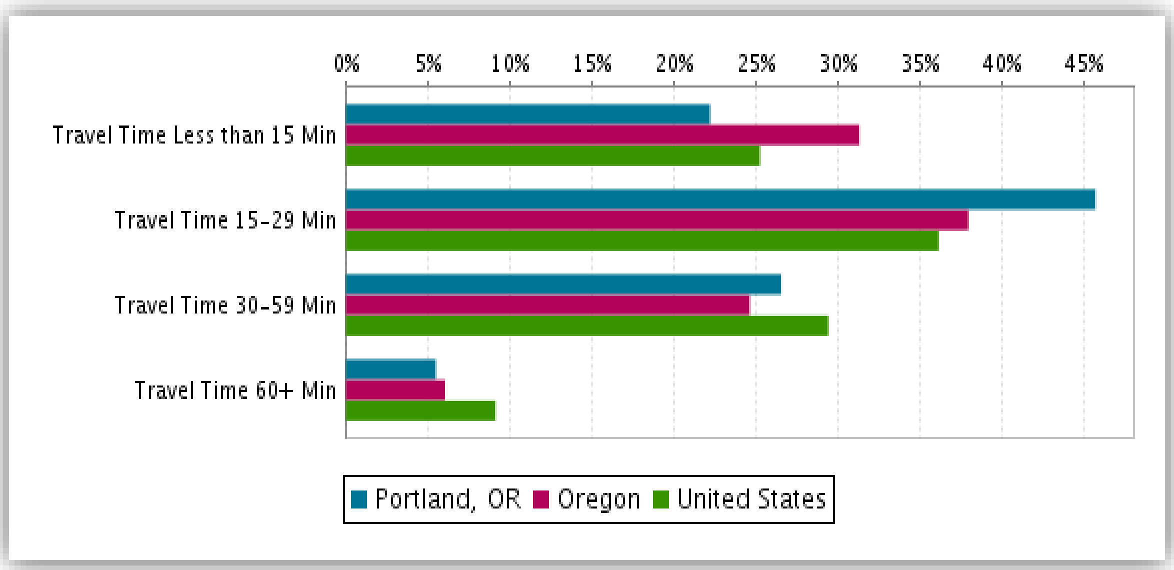


Figure 74: 2010 Travel Tiles to Work, Age 16+

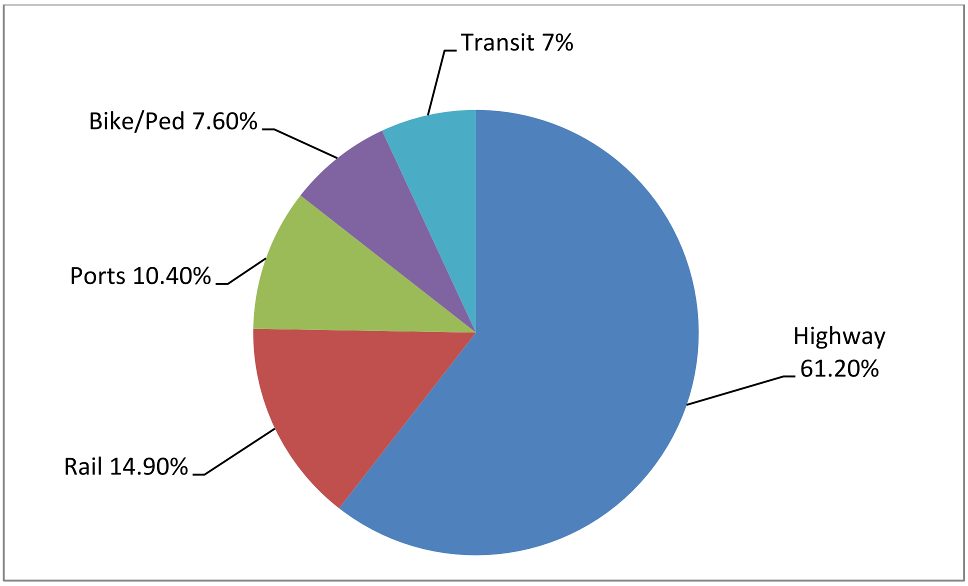


Figure 75: A modal breakdown of ODOT's recommendation for how to spend the state's remaining $101 million dollars in federal stimulus money.

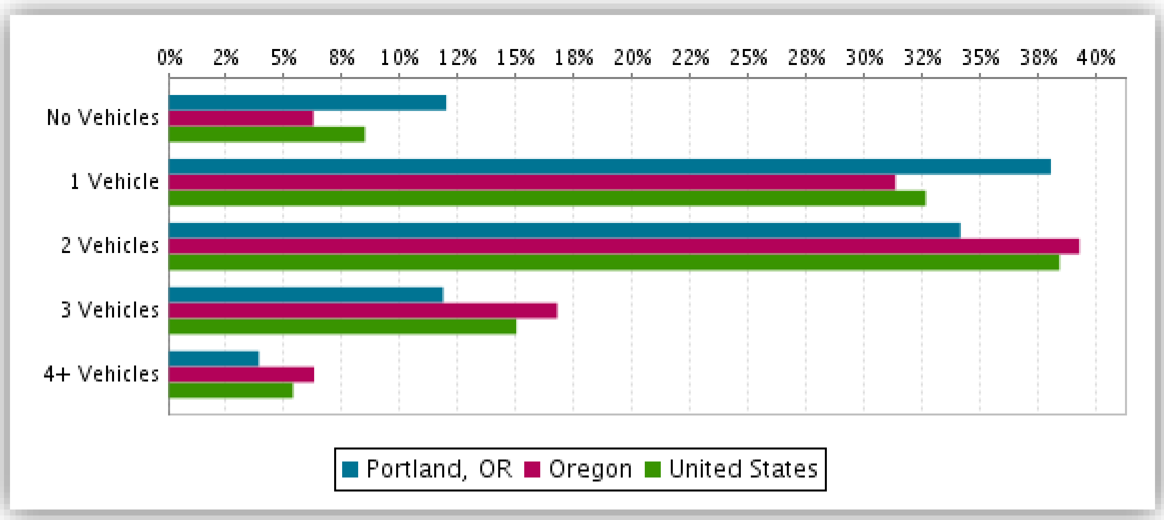


Figure 76: 2010 Number of Vehicles per Household

C. Over view of Dortmund

Background / History

The history of Dortmund goes back over 1,100 years. The city experienced two significant periods during which she was of European importance. Nearly 600,000 people live in the vibrant metropolis of over 1100 - year history. The Hanseatic city offers attractive living space with a variety of residential, cultural, and recreational opportunities.

Dortmund is located in the center of Europe, is an important junction and has an excellent infrastructure - and is still a green city: almost half of the city is covered by green and parks. The city experienced two significant periods during which she was of European importance: once in the 14th Century as a suburb of the Westphalia Hanseatic cities at the height of the Hanseatic League and the second time the 19th and 20th Century. As a center of industrialization in the Ruhr during the early days and then up to the steel crisis an important location of the mining industry.

Figure 77 : Dortmund country map

Westphalia's first city lies on the north-west edge of the Ruhr, bordering with the Sauerland to the south-west and with the Münsterland to the north. The River Ruhr and the River Lenne flow to the south of Dortmund and the Datteln-Hamm Canal to the north. The Dortmund-Ems Canal terminates in the large Dortmund Harbor - i.e. almost in the middle of town. Mild winters and relatively cool summers are typical for the climate in the Dortmund region, the average year-round temperature being 9 - 10°.Mean annual rainfall is a total of 750 mm with a maximum of 80 - 90 mm in July and a minimum of 40 - 50 mm in February.

Population

Dortmund's population grew rapidly in times of 19th century industrialisation when coal mining and steel processing started. For the first time in 1904, more than 100,000 people lived in Dortmund. Not taking war years into account population figures had constantly risen to 657,804 in 1965. Subsequently, population figures have fallen to approximately 580,000 in 2011; projections forecast a further decline to 550,000 inhabitants by 2030. Contrary to those projections, population figures have been slightly rising in the previous years, which is due to net migration gains. Younger people (18 to 25-year old) in particular come to settle in Dortmund mainly because of its universities or other education-related activities. Data of the EU-wide 2011 census revealed massive inaccuracies with regard to German population figures. Consequently, respective figures have been corrected, which resulted in a statistical "loss" of 9,000 inhabitants in Dortmund. As of 2012, Dortmund had a population of 571.403 of whom about 177.000 (~30%) were of non-German origin.

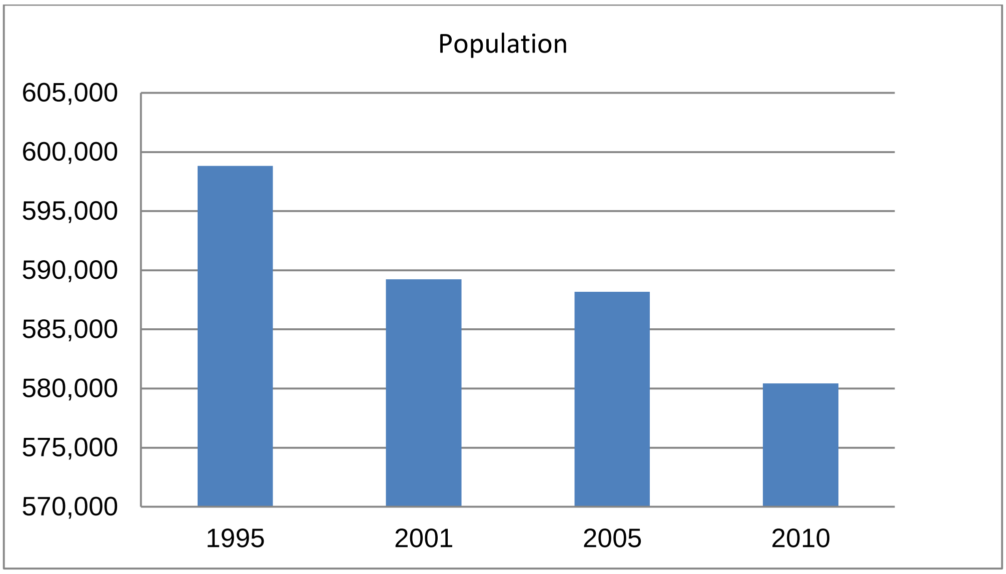


Figure 78: Dortmund demography

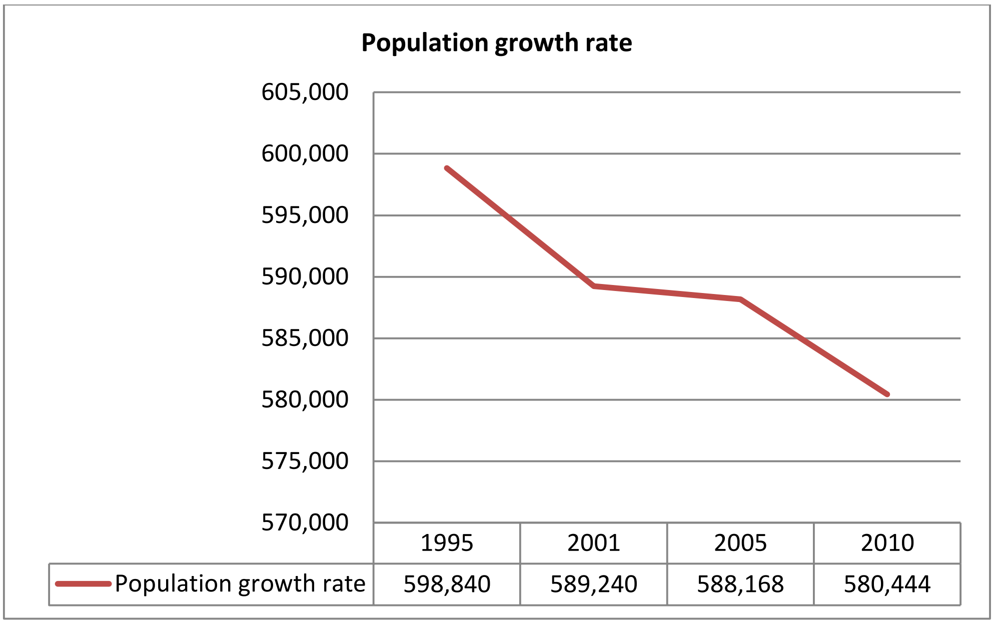


Figure 79 : Dortmund Population growth rate

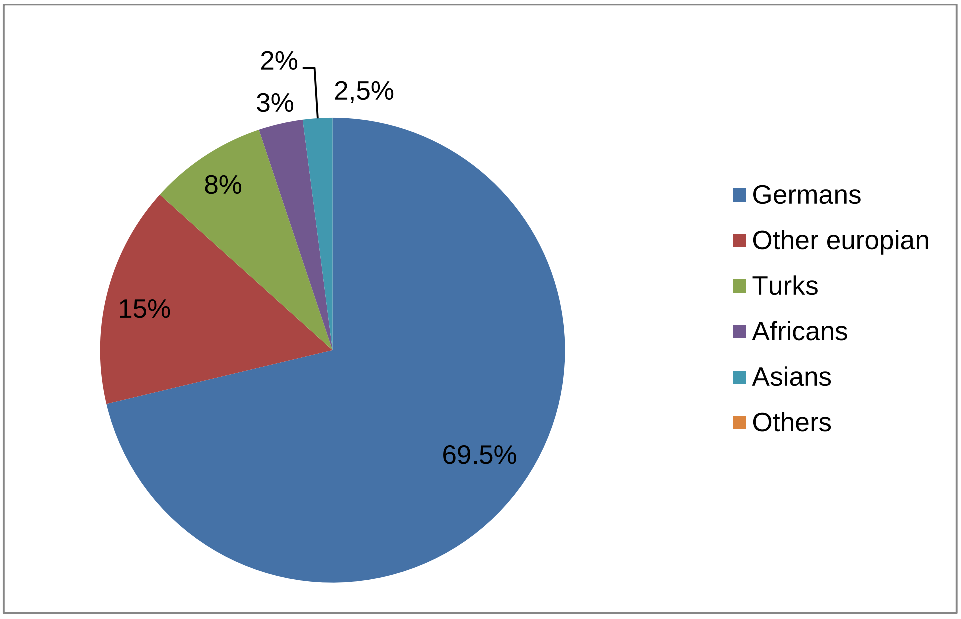
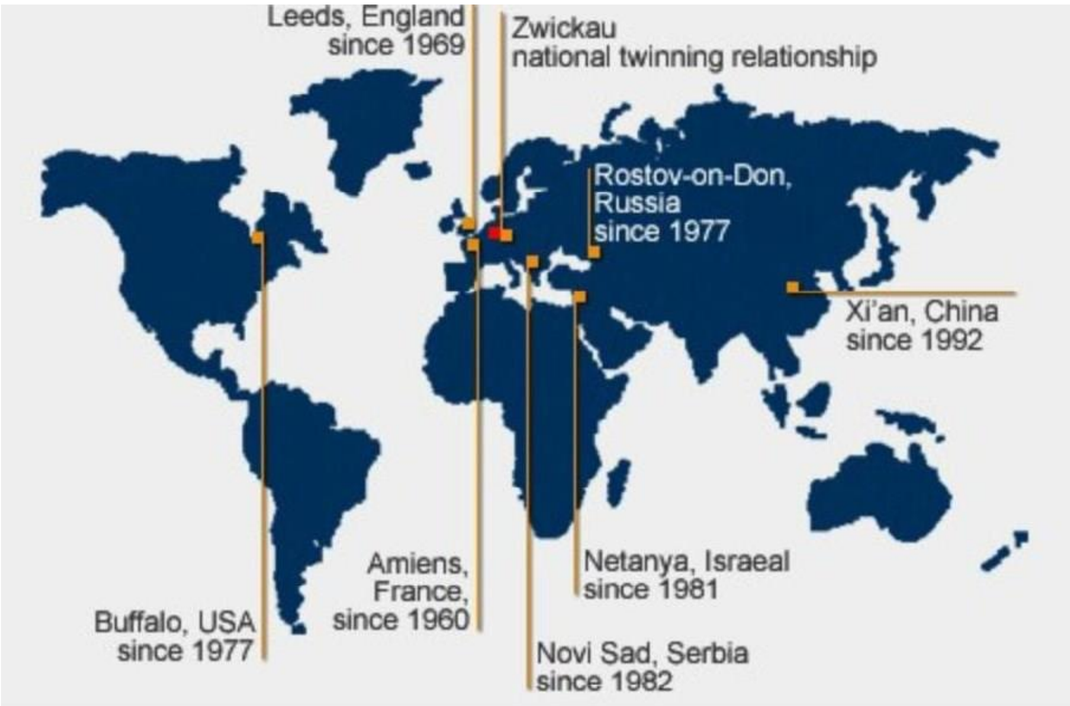


Figure 80 : Number of minorities in Dortmund in percentage

Twin towns - Sister Cities

Town twinning arrangements serve to further, experience and understand cross-border relationships in the intellectual, cultural and economic walks of life. The precondition for any town twinning relationship is therefore that the cities involved maintain a firm intention to cultivate the spirit of solidarity among their citizens and thus to make a vital contribution to international understanding, friendship and peace.



Dortmund's eight twinning arrangements

Education

The research center and higher education background of the Ruhr Dortmund gives six universities, numerous scientific institutes and research facilities as well as various centres of excellence Dortmund industries of the future. These include the micro-and nanotechnology, information technology, biomedicine and medical technology, as well as logistics.

In addition, Dortmund offers a variety of schools with different priorities and an excellent training program. Additionally, the community college offers many instructive and interesting courses, as well as the various Dortmund training institutions. There is in addition to the libraries of the universities with the city and state library, a well-equipped communal library with about a million media. TU Dortmund University was established in 1968 with a focus on natural sciences, engineering, and economics and planning sciences; 1980 extended by the faculties of the Ruhr College of Education (originated in 1929), the TU Dortmund was named University of Dortmund in November 2010, and a TU logo was set up on the Mathematics Building.

University of Applied Sciences Dortmund was established in 1971 by the union of a formerly State School of Engineering, the School of Applied Arts, an advanced school of social work, an advanced school of social work, and a business school.

International School of Management: was originated in 1990 in private ownership since 1994 recognized by the state. The training center offers various courses in the field of business administration. University of Music Detmold, Dortmund site was established in 1947 in Detmold as one of the first music schools in Germany. The Municipal Conservatory

Dortmund were incorporated (in 1901) and for the training of professional musicians of the Westphalian School of Music in Münster (established in 1919).Orchestra NRW in Brückstraße has the Music in Detmold, part of the costs borne by the four state music academies of North Rhine -Westphalia's program "orchestral playing." The orchestra center is affiliated organization of the Folkwang University of the Arts. IT Center Dortmund was established in 2000, private educational institution run by public technical college, ISM, Industry and Commerce to Dortmund and networker Westphalia eV offers a BA degree in Information Technology.

Table 62: Educational structure of population in year 2010

Population	Viewing area	All communities of	
		RVR*	Land
By the highest level of general education	585 800	5 200 200	17 943 000
Elementary and secondary school	208 400	2 039 000	6 432 400
Secondary school	100 700	881 000	3 200 000
University college entrance	142 100	1 104 900	4 186 000
By the highest professional training qualification	585 800	5 200 200	17 943 000
• Teaching and semi-skilled training	251 900	2 342 600	7 689 100
• Master or technical school	19 000	-	732 000
• technical college / university degree	58 900	454 500	1 929 100
• without education	254 600	2 183 800	7 564 900

* Regionalverband Ruhr (RVR, Ruhr Regional Association)

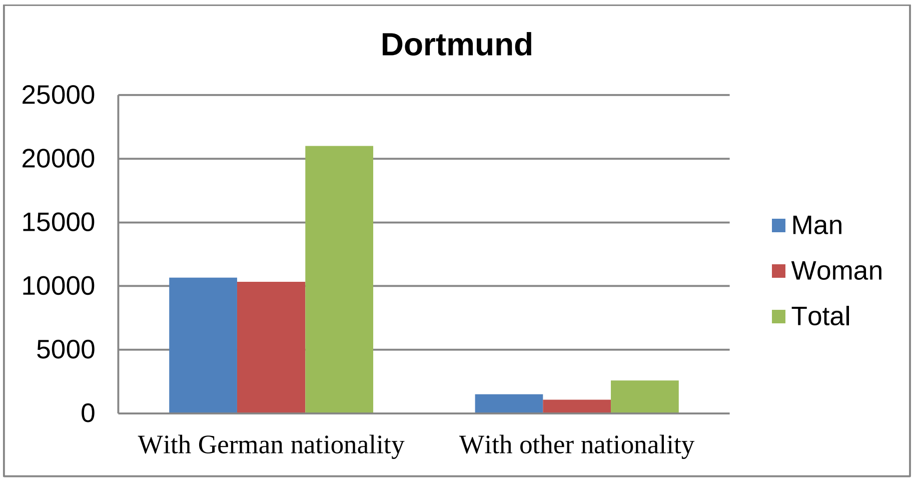


Figure 81: Proportion of nationality in Ruhr area – Dortmund– WS (2009/10)

Housing

Dortmund is growing and changing - many construction projects demonstrate the rapid development of the city: The Urban Redevelopment Rheinische Straße / Dortmunder U or the major projects PHOENIX are just two examples of innovative and pioneering projects.

Regardless of whether home, rental, or apartment house - a good supply of housing is of vital importance, which finds not only private property developers, but also commercial investors in Dortmund ideal conditions and expert advice.

Table 63: Buildings and housing in Dortmund

Dortmund	Residential building			Living area
	Building by number of houses			
	Total	1 House	2 Houses	1000 (qm)
	number	number	number	
2010	92009	40329	15471	22793.4
2009	91523	39920	15450	22687.6
2008	91128	39580	15425	22604.7
2007	90763	39269	15402	22532.0
2006	90254	38796	15394	22441.1
2005	89507	38135	15375	22300.7
2004	88925	37613	15346	22194.1
2003	88128	36925	15308	22055.4
2002	87388	36325	15255	21895.9
2001	86553	35644	15226	21714.2
2000	85155	34505	15159	21414.7
1999	84619	34109	15121	21269.5
1998	83812	33538	15085	21056.0
1997	83323	33245	15031	20902.8
1996	82826	32975	14974	20742.4
1995	82287	32734	14921	20539.4

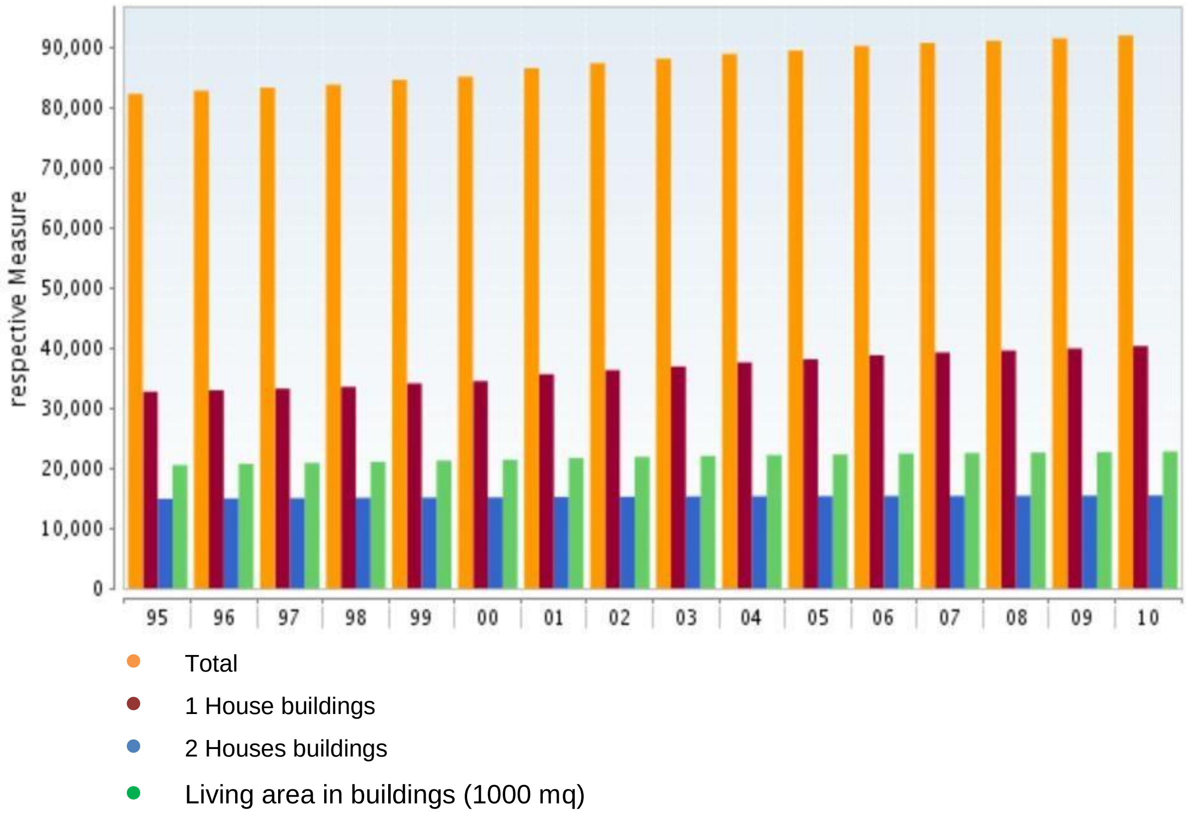


Figure 82: Buildings and housing stock in Dortmund

Employment

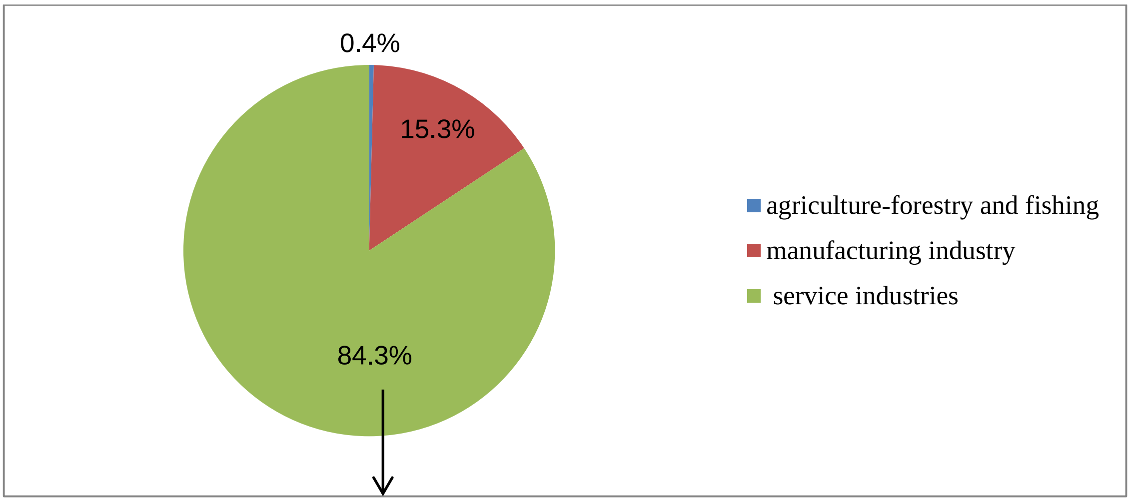
Dortmund has become a centre for future-oriented sectors such as IT, micro- and nanotechnology, logistics, and increasingly also for biomedicine and robotics, and the figures confirm that this trend is continuing. The number of people in employment is rising, with more than 37,000 employed by more than 1,400 companies in these sectors.680 IT and software companies with 12,000 employees are based in Dortmund, making the city one of Germany's biggest software locations.

More than 3,000 employees in 100 companies are specialised in e-commerce, and there are approximately 640 companies with almost 22,000 employees in the logistics sector. Eight per cent of Europe's employees in the micro-technology sector work in Dortmund, and 24 companies with around 1,700 employees mean Dortmund is Germany's biggest MST cluster and one of the biggest in Europe.

Table 64: Employment in Dortmund – 2008

Employed persons	Viewing area	All communities of	
		RVR*	Land
Total	**297 900**	**2 295 300**	**8 689 600**
• agriculture-forestry and fishing	1 300	20 700	129 400
%	0,4	0,9	1,5
• manufacturing industry	45 500	504 000	2 105 000
%	15,3	16,9	19,6
manufacturing industry excluding building industry	33 600	389 000	1 704 900
%	11,3	16,9	19,6
manufacturing (working)	28 900	339 000	1 590 500
%	9,7	14,8	18,3
building industry	11 900	115 100	400 100
%	4,0	5,0	4,6
• service industries	251 100	1 770 700	6 455 100
%	84,3	77,1	74,3
trade-hospitality industry-transport	79 100	611 400	2 276 500
%	26,6	26,6	26,6
financing-Leasing and others	77 200	426 000	1 578 100
%	25,9	18,6	18,2
public and private service	94 800	733 400	2 600 500
%	31,8	32,0	29,9

* Regionalverband Ruhr (RVR, Ruhr Regional Association)



Trade-hospitality industry-transport	26,6 %
Financing-Leasing and others	25,9 %
public and private service	31,8 %

Figure 83: Proportion of employed person in Dortmund – 2008

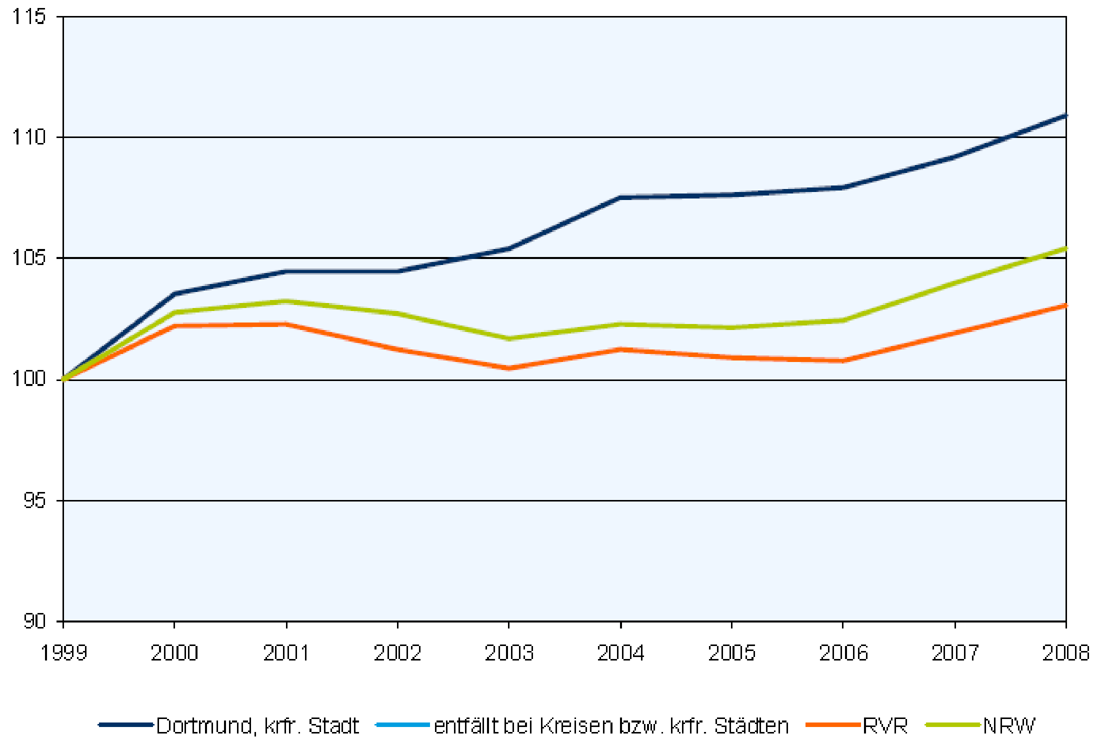


Figure 84: Development of employment in Dortmund

Figure 85: Development of unemployment in Dortmund

Energy

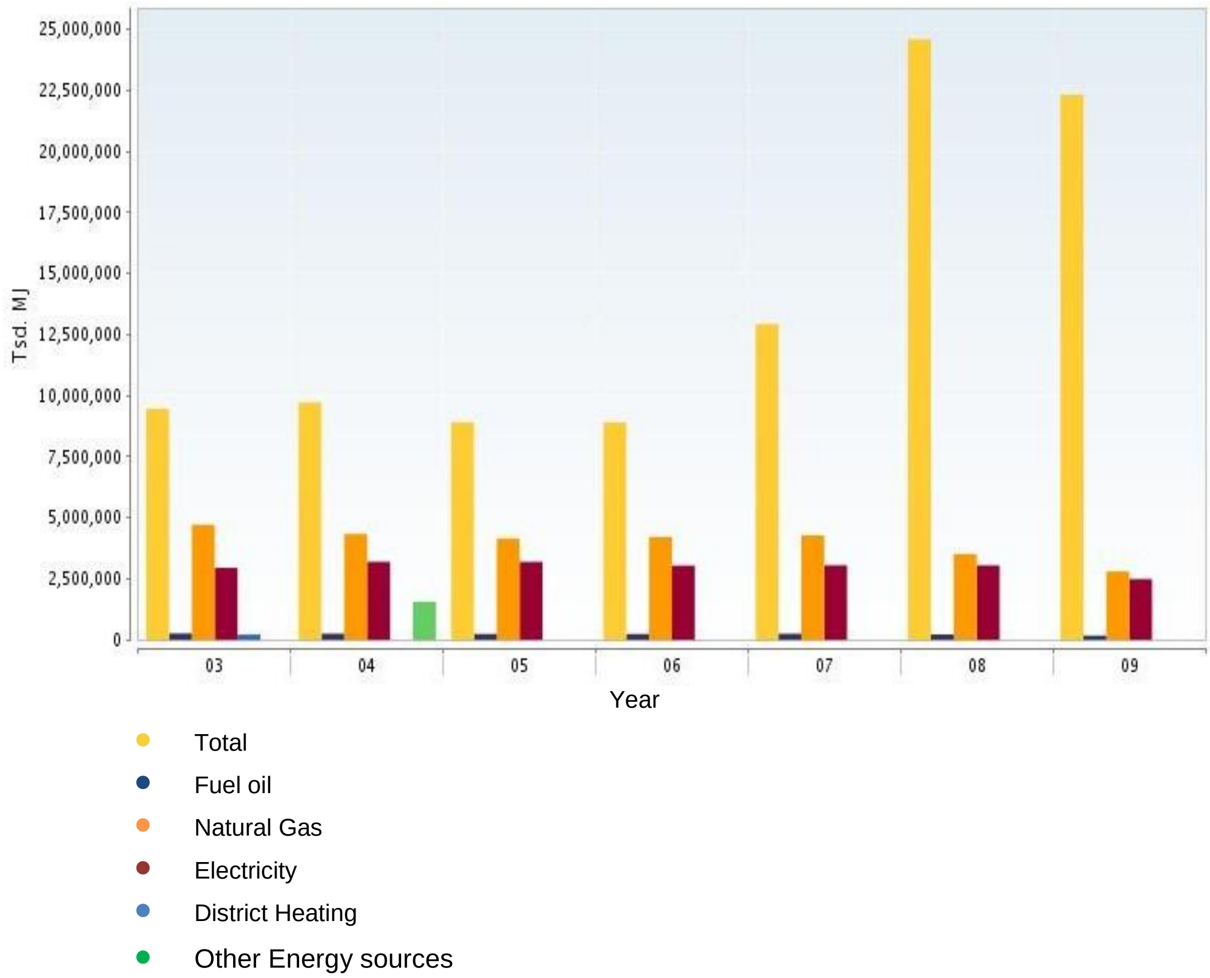
Dortmund-Bochum-Essen-Duisburg (Ruhr Area)

Dortmund is a part of Ruhr area and the metropolis Ruhr plays an important role in Europe when it comes to energy conversion, energy supply, and electrical engineering. The complete value chain is represented from obtaining energy sources to plant construction, the use of regenerative resources, the production of electricity, heat, fuel and the efficient use of energy.

Table below shows the Energy Source of Dortmund.

Table 65 : Energy resource of Dortmund

Dortmund	Energy source					
	Total	**Fuel oil**	**Natural Gas**	**Electricity**	**District Heating**	**Other Energy sources**
	Tsd. MJ	**Tsd. MJ**	**Tsd. MJ**	**Tsd. MJ**	**Tsd. MJ**	**Tsd. MJ**
2009	22326508	180141	2808133	2496123	.	.
2008	24594082	228805	3522347	3055202	.	.
2007	12931048	258926	4283027	3057819	.	.
2006	8910341	245219	4219448	3045576	.	.
2005	8913523	246503	4157148	3197625	.	.
2004	9722523	262504	4336827	3201814	.	1568387
2003	9469266	270787	4719750	2953454	220647	.
*Tsd. MJ (thousand million joule)						



*Tsd. MJ (thousand million joule)

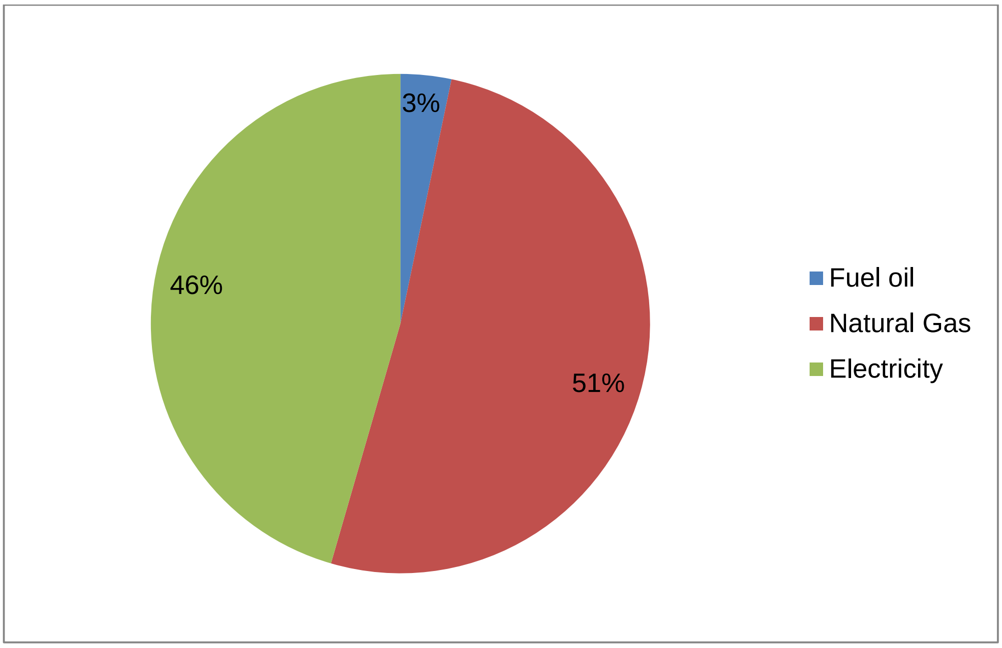


Figure 86 : Use of Energy in year 2010

It is worth to mention, Industry and research center in the metropolis Ruhr are increasingly focusing on the fields of new and renewable energies.

Transportation system

Dortmund is the most important transportation hub in North Rhine-Westphalia. In road transport the city has connected with highways: A 1 (Bremen–Köln), A 2 (Oberhausen–Berlin), A 40 (Dortmund–Venlo), A 42 (Dortmund–Kamp-Lintfort), A 44 (Aachen–Dortmund to Dortmund–Kassel),A 45 (Dortmund–Aschaffenburg) and four federal highway (B 1,B 54,B 235,B 236) to main road network.

Figure 87: Transport accessibility of Dortmund

Dortmund Central Station (Dortmund Hauptbahnhof) is one of Germany's most important railway stations. Approx. 150,000 passengers use it every day for 130 indispensable EC, IC and ICE trains to other large cities in Germany and Europe.

The station's origins lie in a joint station of the Köln-Mindener Eisenbahn and Bergisch-Märkische Eisenbahn which was built north of the city center in 1847. This station was replaced by a new station, established in 1910 at the current site. It featured raised embankments to allow a better flow of traffic. At the time of its opening, it was one of the largest stations in Germany. It was however destroyed in an Allied air raid on 6 October 1944.

The Dortmund main station (Dortmund Hauptbahnhof) was rebuilt in the year 1952 in a contemporary style. Its stained glass windows feature then-common professions of Dortmund. Dortmund Hauptbahnhof is the third largest long distance traffic junction in Germany. 982 trains pass though it each day and make Dortmund Hauptbahnhof the busiest railway station in the Ruhr Area and (excluding the S-Bahn networks) the second busiest in Germany only after Köln Hauptbahnhof.

Figure 88 : Dortmund Hauptbahnhof

Local transport

The Dortmund local transport is handled mostly by the DSW21 (Dortmunder Energie- und Wasserversorgung GmbH (DEW21)) . In rail transport (regional rail transport), Dortmund developed by four S-Bahn lines S1, S2, S4 and S5, many regional express trains and local trains.

The municipal transport Dortmund has a network of eight underground along the city railway lines: U41, U42, U43, U44, U45, U46, U47 and U49. The tram lines 403 and 404 were converted after the opening of the East-West tunnel and they call now U43 and U44. There are still 56 bus lines. Everything is mostly operated by the DSW21 in the Rheine-Ruhr. This network includes 852.1 km and carries 125 million people annually.

Figure 89 : Public transport in Dortmund

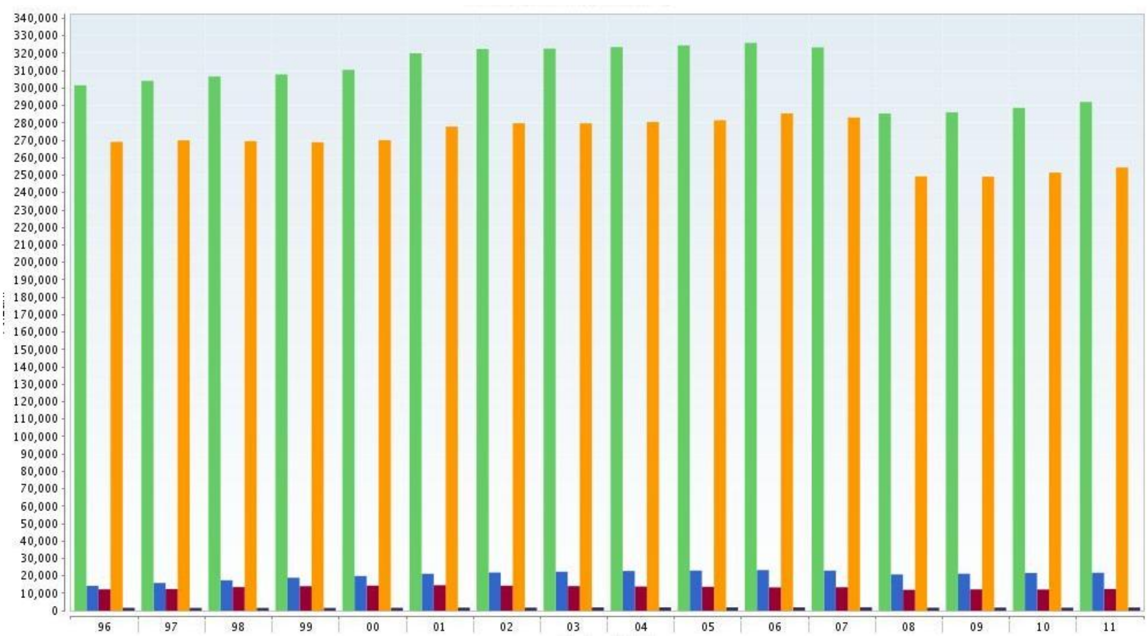


Figure 90: Numerical figure of motor vehicle types in Dortmund

Table 66 : Vehicle types in Dortmund

Dortmund	Motor vehicle types				
	Total	**Cars**	**Trucks**	**Tractors**	**Motorcycles**
2011	292094	254470	12489	1916	21840
2010	288676	251531	12220	1826	21732
2009	286141	249258	12310	1875	21304
2008	285468	249379	12043	1812	20879
2007	323387	283168	13520	2043	23086
2006	325967	285497	13431	1996	23386
2005	324538	281548	13787	1978	23103
2004	323561	280546	13945	1980	22861
2003	322667	279813	14188	1973	22429
2002	322450	279857	14422	1856	21980
2001	320023	277909	14699	1839	21263
2000	310516	270169	14463	1735	19988
1999	307906	268916	14133	1655	18998
1998	306685	269600	13621	1669	17529
1997	304184	270039	12480	1682	15984
1996	301650	269160	12324	1739	14366

The table shows, 254,400 private cars with 576 824 inhabitants' means 387 cars per 1,000 inhabitants. Excluding the children and young people, currently 46% of Dortmund's residents have more than a private car.

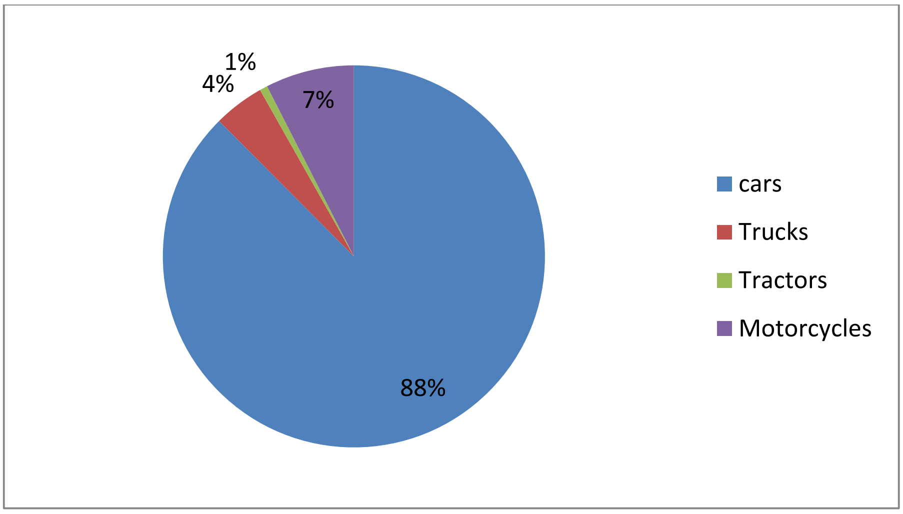


Figure 91 : Contribution of motor vehicle types in Dortmund -2011

The small scale of sub-district shows that the density equipment is very different in parts of city. (Relatively) few cars driving in the northern city. Only south garden city in the Inner city has very high-density values of cars. (Relatively) many passenger cars can be found beside the garden city especially in southern sub-district in Aplerbeck,Hörde and Hombruch.

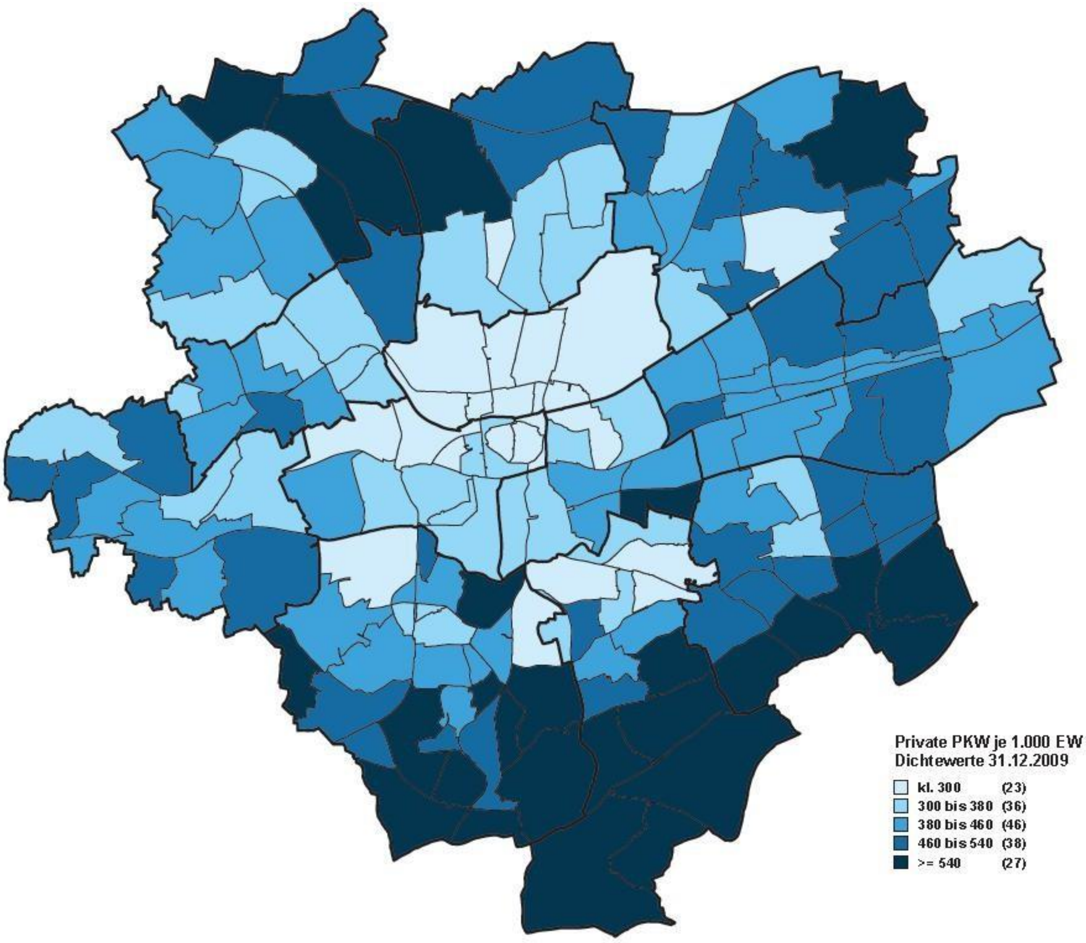


Figure 92: Private cars (PKW) per 1,000 inhabitants 31.12.2009 in the sub-districts Dortmund

Air quality and air pollution

The protection of human health was the starting point of the environmental protection movement. A correlation between respiratory diseases and air pollutants was established early on, so at first protective measures were directed at reducing the emission of air pollutants. However, air pollutants also damage ecosystems and species diversity, especially through acidification and eutrophication of the soil. Although the integration of desulphurisation units in power plants and the wide application of catalytic converter technology in petrol engines have served to reduce emissions in Dortmund and NRW significantly since the 1980s, further efforts are still needed. The National Strategy for Sustainable Development's indicator 'Air pollution' combines' four essential pollutants: sulphur dioxide (SO2), nitrogen oxides (NOx), ammonia (NH3), and the non-methane volatile organic compounds (NMVOC).

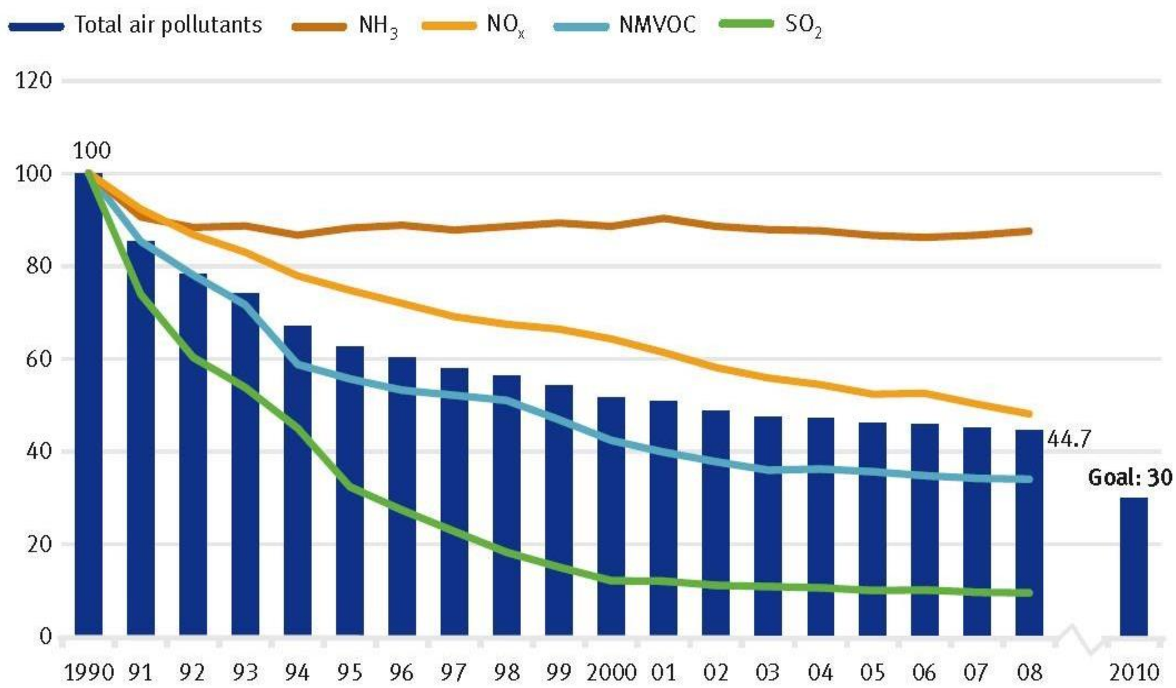


Figure 93 : Pollution index – Air quality

It is the aim of the Federal Government to reduce the emission of these air pollutants as a whole by 70 % compared with the base year of 1990 by 2010.

Air pollution decreased by 55.3 % until 2008; the indicator has thus been moving in the right direction. There were significant reductions in the first half of the 1990s.By 2000 the emission of air pollutants had virtually halved (– 48 %). In the last five years up until 2008, the index has only reduced on average slightly, by 1.2 % per year. This rate of change is insufficient to achieve the goal that has been set by 2010; only 80 % of the distance to the target would be covered.

CO2 scenarios

As part of the "action program climate Dortmund 2020 'were three different scenarios calculated. The results of the scenarios are possible Developments of energy consumption and CO2 emissions of Dortmund 2020 in the sectors of household, business, industry, transport, and Local Government. The differences lie in the activities of the city of Dortmund on climate change.

• The reference scenario includes statutory changes, general economic, social, and technological trends, but no active climate policy by the City of Dortmund

• The moderate scenario includes also reviewed in Dortmund already implemented and planned measures.

• The climate change scenario also includes the quantitative effect of the under action program of the newly proposed measures.

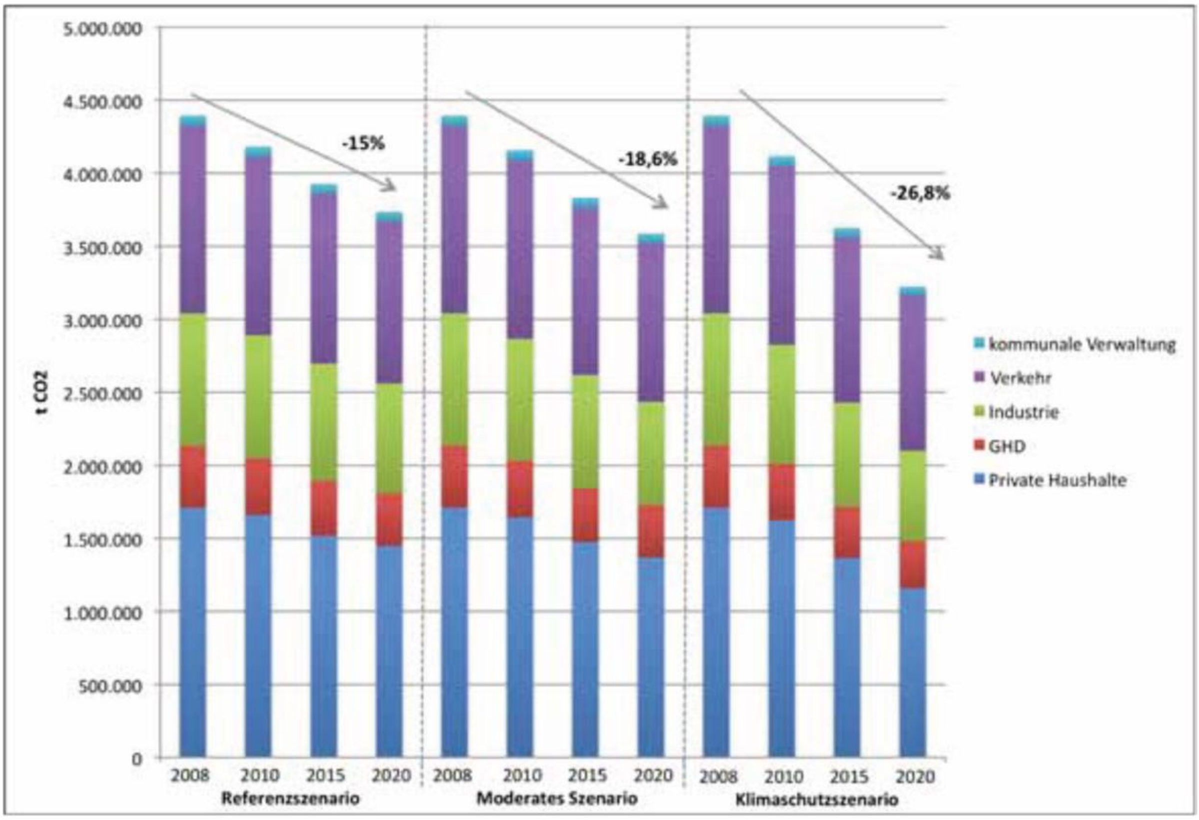


Figure 94 : Comparison of reference, moderate and climate change scenario: Development of CO2 emissions by sector in 2008-2020 (Wuppertal Institute, 2010))

The action program makes it clear that only the implementation of the mitigation scenarios (or with the realization of the packages of measures) climate change targets the city of Dortmund can be reached, at which the Federal Government orient. Germany continued in 2007 because of meseberg resolutions committed to a CO2 reduction of 40 % by 2020 (compared to 1990) to achieve. A different picture arises but if one further political climate targets considered.

The reduction of greenhouse gas emissions in Germany by 2050 at least 80-95 % according to the energy concept of the Federal Government requires more drastic Development paths. The possibility of reaching the reduction targets may therefore not obscure the fact that even beyond the year 2020, further efforts is necessary in climate protection. It is recommended that the City of Dortmund (not only concerning climate protection but also for economic Reasons) as early as possible on the long-term target path with a reduction of 80-95 % to wheel until 2050. This case, the local potential for expansion use of renewable energy, the development of decentralized combined heat and power promoted, and the end-use efficiency in the various Consumption sectors are achieved. (Handlungsprogramm Klimaschutz 2020 der Stadt Dortmund)

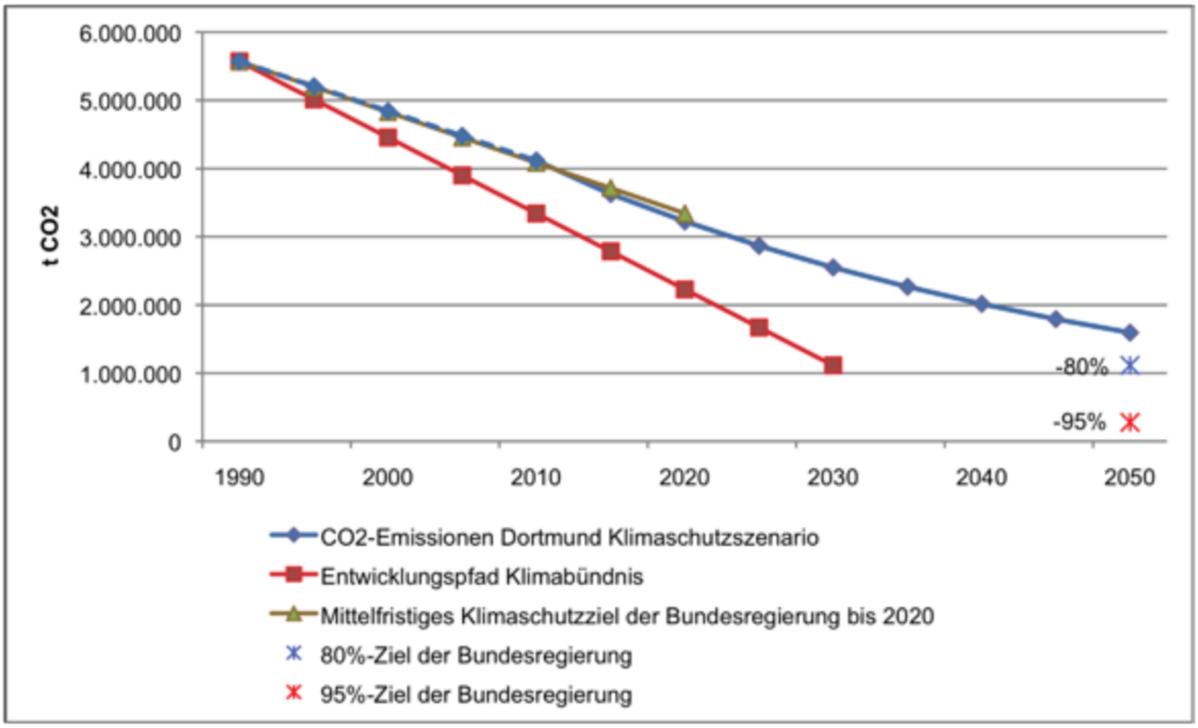


Figure 95 : Comparison of different objectives for the reduction of CO2 Emissions and the development in the city of Dortmund (Wuppertal Institute, 2010)