Analysing Synergies between Urbanization and Sustainable Development

Developing a Draft Theory through Historical Pilot Studies

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Abstract

Urbanization is an ongoing process all over the globe. People moving from rural to urban areas are the primary cause of urbanization, and history indicates that this movement of people is very hard to influence. The inflow of new residents to urban areas results in the need for more buildings and infrasystems, new institutions and often, new ways of life. How does this relate to the sustainability challenge? Given the ways in which most cities are currently developing, urbanization does not contribute to the achievement of sustainable development goals.

This thesis explores a new research strategy for studying the process of urbanization and how it may hold opportunities for addressing the long-term objectives of environmentally sustainable urban development. The research strategy: MAMMUT – Managing the Metabolism of Urbanization, is a methodological and conceptual framework, it is a dynamic and cross-disciplinary approach towards understanding urban sustainability.

The main novelty in this research strategy is to explore the use of situations of opportunity – instants when stakeholders have a possibility greater than average to guide and influence the urbanization process so as to contribute to more of environmental sustainability – as units of analysis. Political scientists have used concepts similar to this, however none is as wide in scope and time. Four aspects are analysed in a situation of opportunity: urban structure, institutional framework, new ways of life and environmental impacts – enhancing the cross-disciplinary approach of the framework. Also, in terms of time frame, the pre-history, the formative moment and the outcome of each situation are studied.

A cover essay and three papers compose this thesis. The papers apply and test the above-mentioned methodology in pilot studies about historical situations of opportunity created by the development of public transport systems in
Stockholm, Dar es Salaam and Curitiba. The cover essay discusses the lessons learned with the pilot studies and aims at: (a) discussing and further developing the MAMMUT methodological and conceptual framework; (b) analysing the relations and synergies between the four aspects of urbanization (as proposed by MAMMUT’s framework).

The main conclusion of the thesis is that the MAMMUT research strategy can be a useful tool for analysing the urbanization process and its relations to sustainable development. Suggestions for improvements in the framework are made. Also, the four aspects of urbanization suggested for the analysis of a given situation are confirmed relevant, however the analysis of the relations and synergies between these aspects is revealed to be as important as studying the four aspects per se.

*Key words:* urbanization, sustainable development, historical pilot studies, conceptual framework development
to Lindolfo

because your life inspires mine
Preface

When I was invited to carry out pilot studies to test a newly developed draft theory and conceptual framework about the relations between urbanization and sustainable development at KTH in 2003, I had no idea it would develop into a licentiate work. However, one project succeeded the other – and the end result is here! It was an enjoyable experience and I am thankful for the chance I was given.

Many people have walked by my side during this process of academic, professional and personal development – some where there for a long part of the way, some just for a few steps – and I am grateful to each of them for their unique contributions.

I am most thankful to my supervisor Örjan Svane for his enthusiasm, guidance, constructive discussions, helpful suggestions and constant support. Thanks also to Bernt Brikell, Anders Gullberg, Mattias Höjer, Rolf Johansson, Agnes Mwaiselage, Dick Urban Vestbro and Jonas Åkerman – they were among those who helped me in the process of data collection and gave valuable comments about my work. I would also like to thank Lars Orrskog for his constructive remarks during my final seminar. I should furthermore mention that this study would not have been possible without the financial support from KTH - Centre for Environmental Science and Formas.

For the enjoyable moments we had together, thanks to all my colleagues at KTH: Malika Bourennane, Ludigija Bulamile, Susanna Elfors, Ana Gren, Tigran Hasic, Tatu Limbumba, Assumpta Nnaggenda-Musana, Catharina Nord, Gilya Nsumbalimi, Tove Malmqvist, Markus Robért, Ian Senkatuka, Zeinab Tag-Eldeen, Inga Britt Werner, Pia Westford and Dorota Wlodarczyk. I would also like to thank the computer support group Adam, Björn, Katarina and Andrzej for all the technical help they provided me with.

My special thanks goes to Alice Hague for her great friendship and immense support. To Chris Peterson – thanks for the great memories we have built up together. Doug and Jodi: thanks for your nice and reassuring words. I am also indebted to all my friends from Immanuel Church and from Credo International: thanks for helping me to grow in grace, showing me your love and keeping me in your prayers.
Many other people made this period of my life enjoyable, and to name all would be impossible, but I would like to thank Carol and all my “Brazilian friends in Stockholm” and “As Costelas” for many a laughter and fun moments together.

Finally I would like to extend my deepest gratitude to my family. To Emanuel – who was always besides me – thanks for your patience and unending support and love. To my dearest relatives in Brazil – so far away, but so very close to my heart: Obrigada! To my parents, Ursula and Martin I am grateful for all the encouraging words and their ever present love. To my sisters and brothers: Cláudia, Daniel, Marcos, Diego, Lísia, Airton and Martina – thanks for your love and prayers. And yes, I promised to specifically thank Marcos and Diego for hopping on-and-off buses to help me with last-minute data collection for the paper about Curitiba. Valeu pela ajuda manos :-)  

Most of all I am thankful to God who has given me so much more than I deserved.

Carina Weingaertner

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Paper I

In this co-authored paper my main contributions are related to the pilot study itself and to discussions of the draft theory proposed by a group of senior researchers. An early version of this paper was presented at 2004 IAPS Conference, Vienna. This is a preprint of an article accepted for publication in Sustainable Development Copyright ©(2005) John Wiley & Sons Ltd and The European Research Press Ltd. Electronic version available at: www.interscience.wiley.com (EarlyView®)

Paper II
Brikell, Bernt; Svane, Örjan & Weingaertner, Carina 2004: “Daladala Buses Deregulated - Analysing Urbanization's Situations of Opportunity through a Tanzanian Example”.

My contribution in this paper is related to the empirical study. The discussions of concepts and the input from the viewpoint of political science are merited to the co-authors. Paper presented at the ENHR Conference 2004, Cambridge.

Paper III

Introduction

The debate about sustainable cities has been ongoing for a rather long time. Discussions about which urban structure has the qualities required to sustain human life in balance with nature are widespread. Is it the dense, traditional European city, or are other urban structures more suitable (European Commission 1996; Jenks et al. 1996; Williams et al. 2000)? In this thesis and in the appended papers, instead of analysing properties of urban landscape and its steady-state interchange with nature, we use a more dynamic approach towards understanding urban sustainability. The research strategy proposed by MAMMUT – a cross-disciplinary research programme at KTH, Sweden – is used, and with it we study “… an ongoing process – that of urbanization – and explore how it could contribute to another process of change – sustainable development. The former we see as a function of time, possible to influence but not to halt, the latter as a target oriented process with a set of long-term objectives guiding the direction that urbanization will take” (Svane 2005:2).

An Urbanizing World

In 1900 only 15% of the world’s population lived in urban areas (Graumann 1977 cited in Satterthwaite 2005). During the last century this figure has drastically increased and currently a large proportion of the world’s population lives in urban areas. In fact, in 2002 it was announced that for the first time half of the world’s total population lived in urban centres¹. This global trend is expected to continue, and according to UN predictions, by 2030 the world’s urban population is expected to amount nearly 5 billion people, representing about 61 per cent of the global population (Habitat 2001, UN 2004).

Alongside with natural growth within cities, migration from rural to urban areas also plays an important role in the increasing urban population. This migration is particularly strong in low and middle-income nations, accounting for 50% of the growth in their urban population (Habitat 2001). Mainly in these countries, people tend to move to urban areas driven by the lack of prospects in

¹ This figure may vary from 40 up to 55%. Among reasons for the uncertainty are: (a) the fact that countries use different definitions for what ‘urban’ and ‘rural’ areas are and (b) lack of recent census data, leading to the use of predictions for some countries (Hardoy et al. 2001:32).
the rural areas as well as the better economic opportunities and dreams of a better life in cities (Satterthwaite 2005).

The concentration of people and production in cities can provide opportunities for environmental gains at the same time as meeting human needs (Hardoy et al 2001; Mitlin & Satterthwaite 1994). Among benefits are the economy of scale in the provision of jobs, housing and services such as health care, water supply and public transport systems and other infrasystems (Moavenzadeh et al 2002). Nonetheless, the way in which most cities are developing today, does not contribute to sustainable development, in fact, it counteracts it. Cities depend on surrounding regions to sustain the life of its citizens: there is a constant exchange of resources and wastes between cities and their hinterlands. This unbalanced exchange creates heavy burdens and negative environmental impacts also in the hinterlands – further aggravating the problems related to environmental sustainability in cities.

The urbanization process, and thus the growth and development of cities, results in buildings and systems of infrastructure: new housing areas, roads, water and sewage systems, etc. These systems and buildings can be planned or emerge informally, they can be localised and constructed in many different ways creating an urban structure that is more or less dense, with linear or nuclear patterns of growth, and be more or less environmentally sustainable. Ways of life of people and the institutional structures in cities also influence the urbanization process, leading to more or less of urban sustainability. The above leads us to ask: Is it possible to manage the process of urbanization so as to contribute to achievement of long-term objectives of sustainable development? If so, to what extent can it be done? Are concepts such as “Factor 4/10” or “Fair Shares in Environmental Space” (Lovins et al 1998; Sachs et al 1998; Spangenberg 1995) feasible in the context of city development and growth?

Sustainable Development – the Urban Context

The report Limits to Growth published in 1974 (Meadows et al) was among the first publications that expressed concern about conflicts between ‘development’ - implying increased use of resources and generation of waste - and the ‘environment’ (Hardoy et al 2001). Drawing on that report the World Commission on Environment and Development (the Brundtland Commission) in 1987 formulated what is, perhaps, the most widely known and used definition for sustainable development:

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

However, in the last decades the concept of ‘sustainable development’ has been used with so many different meanings, that it has become rather ambiguous. Divergences range from different meanings for the word ‘development’ to
disagreements as to ‘what should be sustained’. There are also discussions related to local vs. global sustainability – what may be sustainable at the local level, is not necessarily so on the regional or global scale\(^2\). Sometimes the definition of sustainable development includes social, economical and ecological or environmental aspects, whereas in other contexts it is used as an equivalent for environmental sustainability only – adding to yet another source of ambiguity (Hardoy et al 2001; Sattherthwaite, 1997).

Despite all discussions, uncertainties and difficulties related to the concept of sustainable development, the main idea of reconciling ‘developmental’ goals with the need to recognize environmental limits (at local, regional and global scales) is relatively straightforward. Rather than looking into economical and social sustainability, in this research project stronger emphasis is laid on the environmental impacts caused by urbanization. As a result, to pursue sustainable development goals is understood as meeting people’s needs, while taking effective measures to reduce the transfer of environmental costs to other individuals, other ecosystems or global cycles – both now and in the future (Hardoy et al 2001).

In the cities quest towards contributing to sustainable development, priorities are going to vary. For some cities, the most relevant issue could be to reduce fossil fuel use and waste production. For others, especially in low-income nations, priorities may lay in more of social and political stability. Therefore it is important that each city, within their own context, should identify issues that can enable them to contribute to more of environmental sustainability. The MAMMUT research programme\(^3\) could aid in this search for ways to contribute to environmentally sustainable development in cities. One of MAMMUT’s chief ideas is to identify situations of opportunity: instants in the urbanization process when stakeholders have a greater chance of influencing the city’s development towards more of environmental sustainability.

**Achieving Environmental Sustainability in Cities**

Currently, in most cities of either high or low-income countries, urbanization does not contribute to the achievement of sustainable development goals. The present pattern of urbanization creates heavy burdens on hinterlands. Or, as Mike Jenks points out in the introduction of the book Compact Cities: Sustainable Urban Forms for Developing Countries:

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\(^2\) For a wider discussion of the concept 'sustainable development' applied to cities, refer to Environmental Problems in an Urbanizing World - Chapter 8 (Hardoy et al, 2001); Sustainable Cities or Cities that Contribute to Sustainable Development? (Sattherthwaite, 1997) and Sustainability is not enough (Marcuse, 1998).

\(^3\) The research programme is described to a further extent later in this chapter.
Environmental problems in urban centres are wide ranging, they can be related to both, renewable and non-renewable resources, and usually the use of these resources results in impacts that go far beyond the boundaries of a city (Habitat 2001). Cities depend on other regions to supply energy and matter to meet the needs of its citizens, but they also depend on these regions – the hinterland – for disposal of waste. Different studies have attempted to calculate the size of hinterlands for various cities (Wackernagel & Rees 1996), and it has been estimated, for example, that Stockholm has a hinterland of roughly 1000 times its own area (Folke et al, 1997). Among pressing issues that cause environmental degradation in cities and their hinterlands are the use of non-renewable energy sources and unsustainable land use patterns.

It has been estimated that cities are responsible for the use of seventy five percent of the global commercial energy (OECD 1995), and the source for about two thirds of that energy is fossil fuel – a non-renewable resource. A major portion of the energy used in cities relates to transport of goods and people and buildings – energy is needed to fuel vehicles, and in the buildings for heating, cooling, cooking, etc. The impacts of fossil fuel use on the environment can be divided into local problems such as air pollution leading to health hazards; regional problems such as reduced crop yields due to acid rains; and to global climate changes due to high levels of greenhouse gases’ emissions (Habitat 2001).

Land is a scarce resource, and competing land uses exist on local, regional and global levels (Sachs et al 1998). The expansion of cities may require the use of existing agricultural or forest land for development of new housing areas. The pavement and sealing off of large portions of the soil change the natural drainage systems and may cause problems such as land erosion. Regionally, changes in land use from agriculture/forestry to built up or landfills areas may cause contamination of soil as well as freshwater sources. With a growing global population, the competition between different land uses is likely to increase. While new built up areas are needed for the growing urban population, land is also needed for other purposes such as food production and biodiversity preservation (Eriksson 1998).

In some cities, pressing environmental problems are related to the use of firewood or coal for cooking, and its resulting air pollution may be a major negative impact on the local environment. In other cities the competition between different land uses might be more relevant. Cities need different approaches to contribute to sustainable development depending on their
priorities and problems. To exemplify this call for different approaches, let us briefly look into two different categories of cities: cities in high-income nations vs. cities in low and middle-income countries.

In high-income nations, urbanization is often slow and stagnant. From population growth statistics and forecasts (UN 2004) it is possible to conclude that due to low increase in urban population, in these countries urbanization will only slowly change the total urban fabric, and only a small share of new buildings will be annually added to the existing stock. The city of Stockholm is one typical example. Between 1985-95 population growth was 0.8% per year, but this is projected to diminish to 0.1% per year in the decade 2005-15 (Habitat 2001). In addition to that, people moving from rural to urban areas do not change much in their ways of life – rural ways of life in high-income countries tend to be more similar to the urban ones. Another characteristic of these cities is that local government and institutions guiding urban development are fairly stable and strong. It then seems relevant to ask: To what extent does the existing urban structure, the strong local institutions and the well-established ways of life of its households restrict the changes within cities in high-income countries? What freedom of action do the stakeholders have, if they want to guide the urbanization process to contribute to sustainable development? The first appended paper addresses these questions to some extent, while using the MAMMUT research strategy to study Stockholm’s Underground and the way it influenced the development of the city.

In contrast, rapid urban population growth is the norm in middle and low-income countries - three quarters of the global population growth occurs within the urban areas of these nations (Habitat 2001). Dar es Salaam, in Tanzania, is a typical example of such a city. It is projected that its population will increase by about five percent annually during the period 1985-2015, growing from 1.1 to 4.3 million citizens (Habitat 2001). In these cities most of the buildings and infrasystems are missing; people moving from rural to urban areas need to change their daily habits, adapting to urban ways of life; and although local governments of fast-growing cities differ widely, they are often characterized by weakness and increasing fragmentation (Habitat 2001). The questions that seem relevant in this case are: To what extent can the physical structure be influenced? Is it possible to make emerging urban ways of life become more sustainable? Which stakeholders and institutions could guide the seemingly unlimited freedom of action towards an urbanization that contributes to sustainable development?

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4 The book *Environmental Problems in an Urbanizing World* (Hardoey et al, 2001: 144-147) has an overview of main environmental problems in cities and how they typically affect them, according to the city’s level of income.

These questions are partly discussed in the two remaining papers: In the paper *Daladala Buses Deregulated*, the *situation of opportunity* for restructuring the public transport system in Dar es Salaam during the 70’s is analysed: The bus system that emerged at that time is analysed and followed by a discussion of the possible effects that a better structured and more institutionalized public transport system could have had on the future development of the city. In the paper about Curitiba – a Brazilian city that was among the fastest growing cities in Latin America during the last 50 years (Rabinovitch 1992) – the questions above are addressed through the study of yet another public transport system, studying a *situation of opportunity* that was taken by its stakeholders. The paper further analyses the ways the bus system influenced the growth of the city and how it impacted the environment.

**The MAMMUT Research Programme**

From the examples above it is possible to see that cities can differ widely from each other, having specific needs and limitations, but also assets that can be used in a variety of ways. However different cities are, one key question remains: *How can urbanization be influenced so as to contribute to sustainable development?* It seems rather straightforward that there is no single answer to this question – each city will have to look for unique ways of answering it.

At KTH, in Stockholm, a research programme entitled “MAMMUT – Managing the Metabolism of Urbanization” is being developed with the overarching aim of studying the process of urbanization and its relations and synergies with sustainable development. During the initial phase of the MAMMUT programme, a group of senior researchers from social, political and natural sciences met in a series of seminars and developed a draft theory, a cross-disciplinary conceptual and methodological framework. The papers in this thesis are part of a second phase of the same programme: I make use of the above mentioned draft theory as an input, and aided by it I collected data for the empirical studies about historical *situations of opportunity*. The aim of the pilot studies and of this dissertation is to test and further develop the methodological and conceptual framework. In other words, my dissertation has an input: the MAMMUT conceptual and methodological framework. My contributions, through pilot studies, have been to test and further develop this framework.

In a third phase of the research programme, full-scale studies are planned, and those are to deal with the future development, looking two-generations ahead, of a few selected urban areas and thus to analyse how their urbanization process can be used to achieve more of environmental sustainability. In that context, the historical *situations of opportunity* studied in this thesis are used to gain

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new knowledge for the study of future synergies between urbanization and sustainable development.

Let us now briefly look at the reasoning behind the draft theory proposed by the MAMMUT programme. The question: ‘How can urbanization be influenced so as to contribute to sustainable development?’ is here subdivided into ‘What, When, By Whom and How much’ questions – their tentative answers indicate the path chosen for MAMMUT’s research strategy (Svane 2005):

- **What can be changed?**
  The physical structure of the city, in other words, its buildings and infrastructure systems, including the transport infrastructure; additionally the ways of life of its citizens can also be influenced.

- **By whom is change guided?**
  By the cooperation of institutions of city governance, represented by local authorities, private enterprises and NGOs; and also by the city’s households;

- **When can conclusive change best take place?**
  During the situations of opportunity of the city’s urbanization process;

- **How much – which is the possible extent of change?**
  Within a field of options that is unique for each city’s every strategic situation of opportunity.

![Figure 1](image-url)

**Figure 1:** Illustration of the field of options available to stakeholders in a situation of opportunity. Source: Svane 2005:4 & 15

The MAMMUT research programme aims at analysing the dynamics and synergies between the ongoing process of urbanization and how it could contribute to sustainable development. Because the processes in focus are complex ones, they require input from different fields of science. The framework suggests focusing on four aspects: urban structure, institutions, social and environmental aspects.

Researchers from natural and technical sciences study the urban metabolism – i.e. they assess the extent to which environmental sustainability is attained whilst studying the exchange of resources and waste between the city and its hinterlands. Researchers from architecture and planning, political science,
and sociology study the extent to which urbanization can be managed – i.e. guided by its stakeholders – to contribute to sustainable development. Thus, MAMMUT is a conceptual and methodological framework that calls for cross-disciplinary co-operation. It is furthermore a strategy for trans-disciplinary co-operation with practitioners, an action research programme producing a set of tools for improving practice.

Two main assumptions are embedded in the MAMMUT approach:

- Urbanization can be influenced by its stakeholders so as to contribute to sustainable development at least in some moments – during the situations of opportunity – and within a field of options.

- If the stakeholders of urbanization can identify a situation of opportunity well in advance, they will be able to analyse and utilize as wide as possible a field of options.

In the papers and throughout this thesis the MAMMUT research strategy is explained to a further extent. For the time being it suffices to say that it is a framework for cross-disciplinary research that offers tools for analysing the field of options of urbanization’s situations of opportunity, aiming at, through cases studies, analyse the synergies between the processes of urbanization and sustainable development.

Purpose of the Thesis

The MAMMUT programme has been briefly explained above to enable the reader to understand the broader context within which this thesis has been carried out. But the purposes of this thesis are not as broad as the ones of the research programme itself. Initially this thesis aimed at:

- **Discuss and further develop the MAMMUT methodological and conceptual framework aided by pilot studies in different cities;**

This objective is discussed in the chapter entitled *The Research Strategy*. There, the main features of the MAMMUT conceptual and methodological framework are presented, showing the input it provided for this thesis. The framework is then discussed with the aid of illustrations taken from the pilot studies from Stockholm, Dar es Salaam and Curitiba. Four distinct aspects of the urbanization process are in focus, namely: urban structure, institutional framework, new ways of life and environmental impacts. These aspects are used to analyse a specific situation of opportunity, from different perspectives.

However, as the research developed, and mainly as a consequence of the pilot studies, another important objective for this thesis emerged. It became clearer

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7 These pilot studies are part of the appended papers I, II and III.
then, that the focus of the research strategy should not lie on those four disciplinary aspects as separate entities alone. Instead, to understand the process of urbanization and its relations to sustainable development, it is also important to analyse the complex interplay between urban form, institutional setup, and people’s ways of life; and the resulting urban metabolism and its environmental impacts are also involved in these interactions. From the realisation of the importance of the relations between the disciplinary aspects, a new objective emerged:

• **Analyse the synergies and relations between the different aspects of urbanization, as defined in MAMMUT’s conceptual framework.**

The discussion and analysis of these interactions, i.e. the relationships between the four aspects of urbanization, are in focus in the chapter *Synergies and Relations* and once more the pilot studies are used to illustrate and support the discussion.

This work has a multi-disciplinary approach, touching on issues from social, political, natural and technical sciences. While there has been some degree of collaboration with senior researchers from various fields of science through discussions and seminars, much of the analysis of the cross-disciplinary issues discussed in this thesis could certainly be explored to a further extent by experts within each specific field of science. In other words: The research front in each of the disciplines above lies ahead of my own work. However, the analysis in this thesis, which dips into specialities of others, was necessary and is believed relevant in relation to the problems addressed. It aided in gaining understanding about the relevance of cross-disciplinary work to study the relations between urbanization and sustainable development. In a full-scale study there will be scope for a more extensive cross-disciplinary collaboration with researchers from different fields of science.

Before we continue, just a few words related to the structure of this thesis are adequate. The next section will briefly position my research within the Built Environment Analysis research tradition. Following that, the chapter entitled *Papers & Pilot Study Cities* presents an overview of the three appended papers and their respective pilot studies. The two subsequent chapters, namely *The Research Strategy* and *Synergies and Relations*, discuss the purposes of this thesis. Finally, in *Concluding Remarks*, a retrospective analysis of lessons learned and topics for future research are pointed out.
Relation to Built Environment Analysis

Built Environment Analysis (BBA) is a discipline within the Department of Urban Studies at the Royal Institute of Technology in Stockholm. It’s formal definition reads: “…the discipline deals with the relations between people, society and the built environment with the aim of developing knowledge for physical planning and design of the built environment”. This definition is often illustrated with a triangle:

![Figure 2: The classical Built Environment Analysis triangle](image)

A former professor of the discipline (at that time called Building Functions Analysis), Sven Thiberg (1995) has discussed the triangle and its three concepts at length, and he understands the “society” concept to contain the other two, namely “people” and “built environment”. In other words, the concept of society describes the total, within which people and the built environment are included.

However this view has been discussed, and professor Rolf Johansson, in his dissertation about case studies as research methodology for evaluation of the built environment (1997), has further developed the “triangle definition”, substituting built environment for place, people for agents and society for culture. In doing that he gives the triangle a geographical and temporal dimension: in a case study about a housing project (place) it is possible to identify residents, developers (agents) and the society is expressed as the culture brought by the agents into the study area. He further develops his model and distinguishes between focus and context. If the housing project and its agents are the focus of the case study, society and the built environment in general are the context. And the latter influences the focus in various ways.

My research can be understood as an example of the people-environment studies and is close to the discipline of Built Environment Analysis. Aided by a conceptual framework and pilot studies of different public transport systems I look at the process of urbanization and its relations to sustainable development. Instead of analysing built environment and people as part of the society (as suggested by Thiberg), my research approach is closer to Johansson’s discussion of the “triangle”, and the distinction between focus and context, while conducting a case study. The focus in my studies is the situation of opportunity, and embedded in it are four aspects: urban structure, institutions, ways of life and the environment.
The context I defined by the pre-history that led stakeholders to take a certain decision during the situation being analysed.

As in the triangle figure, this dissertation includes the analysis of aspects about the built environment (or urban structure), people and society (or institutional structure). However, it is neither entirely focused on people: their habits, attitudes, organization, etc. nor does it focus solely on the built environment or the society. Rather, in my research I look at relations between them. Additionally, the environmental aspect, which is not included in the original triangle, has also been included in my analysis.

**Summarizing:** my research, which is part of a larger project – MAMMUT – looks for opportunities for reducing negative impacts on the environment, and thus promote environmental sustainability in urban areas. These opportunities could lie within physical planning decisions, but may also be related to changes in people’s ways of life or in the ability of stakeholders to take key decisions. It is therefore important to analyse the relations between the built environment (places), people (or agents, households) and the stakeholder’s; and the way these affect the environment.
In the previous section two core objectives for this thesis were pointed out, and for the discussion and development of these purposes, I will draw on knowledge obtained from three papers written to support the MAMMUT programme development – and their respective pilot studies.

The MAMMUT methodological and conceptual framework was used in all three pilot studies as a tool for identifying synergies between the processes of urbanization and that of sustainable development; at the same time, the framework was also being further developed with the empirical material. From this follows that, in these pilot studies, the purpose was neither to apply a fully developed theory to a real-world event to gain new knowledge, nor was it to develop new theory using empirical data. Instead, the pilot studies were used to test the assumption that the concept of situations of opportunity, proposed by MAMMUT’s draft theory, can define a relevant unit of analysis for studying synergies between urbanization and sustainable development.

To give the reader a taste of what each of the papers deals with, this section will briefly point out their main features. Every paper is the result of the analysis of one situation of opportunity – in three different cities: Dar es Salaam, Curitiba and Stockholm. Coincidentally the situations in all three papers are related to public transport system, the papers are however rather different in their scope and focus. The first one contains a more general overview and discussion of the MAMMUT research strategy, the second focused on the “institutional” aspect of urbanization and the last paper deals with the “environmental” aspect of urbanization.

In the first paper Stockholm’s Underground development is the situation of opportunity used to test the possibilities and limitations of the MAMMUT research strategy. The pilot study and the paper developed while the discussions about the research strategy were ongoing, and in that way, it aided to the discussions about the relevance of the proposed conceptual framework. The main contribution of this paper is the analysis of the research strategy in general as well as a discussion of its key concepts. The usability of the research strategy and its conceptual framework is tested in the pilot study of Stockholm’s Underground, and discussions profited from seminars with a cross-disciplinary group of senior researchers. This paper is co-authored with Örjan Svane – one of the senior
researchers that proposed MAMMUT’s draft theory, and my main contributions lies in the pilot study itself and the discussions about the draft theory.

The need for a wider discussion about the main concepts proposed by MAMMUT arose, and in the second paper - which includes the pilot study of the bus system in Dar es Salaam - the concepts of situation of opportunity and field of options are discussed further with the aid of theories from political science. The MAMMUT project proposes the study of the urbanization process through situations of opportunity. Four aspects are analysed in each situation: urban structure, institutional, social and environmental. In this paper the discussion focuses on the ways in which theories from political science can assist in the identification and analysis of the institutional aspect of a situation of opportunity. This is also a co-authored paper: with political scientist Bernt Brikell and Örjan Svane. My major contribution in this paper is related to the empirical study, while the co-authors elaborated on the discussions of situations of opportunity (Svane) from the viewpoint of political science (Brikell).

The two first papers used pilot studies to test, discuss and further develop the conceptual framework proposed by MAMMUT. In the third paper the aim is to continue in the same line, through the pilot study of Curitiba’s bus system. However the main focus in this paper lies on the environmental aspects of urbanization. Methods for the analysis of environmental impacts are explored in the paper. Energy use for operating the transport system is used as an indicator of environmental impacts, and the same methods for assessing energy use are applied to transport systems of Curitiba and Stockholm to indicate the possibilities and weaknesses of the methods. As in the previous papers, rather than producing highly relevant and novel empirical results, the focal point of the study is to discuss MAMMUT’s research methodology and conceptual framework.

To summarize: In all three papers the draft theory proposed by MAMMUT’s research programme is used as a starting point for the pilot studies. The empirical material aided in the discussions and lead to conclusions about the conceptual and methodological framework.

For the person who already read the full papers the information presented in the next pages might, to some extent, be repetitive. However, in the papers there was no scope for a more wide-ranging description of the cities and how they differ from each other. To compensate for that, the cities and their commuting regions are briefly described at this time. The city profiles presented are not all-inclusive, but contain a brief history of their urban development, main geographic and demographic characteristics as well as some maps.

This overview of the papers and the city profiles will hopefully aid in the understanding of the discussions in the following sections.
Paper I & Stockholm, Sweden

The first paper is entitled "MAMMUT – Managing the Metabolism of Urbanization: Testing Theory through a Pilot Study of the Stockholm Underground". This paper outlines the draft conceptual framework developed in the MAMMUT project and applies it to a pilot study in Stockholm. The concept of situations of opportunity – i.e. moments in time when stakeholders have a possibility greater than average to influence the urbanization process – is used as a research tool for delimiting and defining the relevant unit of analysis in the pilot study. The situation of opportunity analysed is the development of the Underground system in Stockholm in the from 1940s onwards.

In the urbanization process, stakeholders face different alternatives while seeking to shape the city’s urban development. The analysis of these options shows the extent to which – guided by objectives of sustainability – the process can be managed. Assessment of environmental impacts originating from the exchange of resources and waste between the city and its hinterlands – its metabolism – indicates to what extent sustainability is attained.

The MAMMUT research strategy proposes four aspects that are relevant for the study of the managerial and metabolic perspectives of urbanization: urban structure, institutional framework, new ways of life and environmental impacts. The Underground Situation is used to test the possibilities and limitations of this research strategy. The Underground is a historical situation that has a factual outcome, which can be analysed through the ways the city developed. However, there were alternatives to this outcome – what if instead of Underground the city had developed a Roads and Highways alternative? This illustrated in the field of options that was available to stakeholders.

In the paper the factual outcome and the alternative scenario are analysed and a short description of the resulting physical urban structure, the institutions needed for development and operation as well as the resulting ways of life of the households is outlined. A brief qualitative assessment of main environmental impacts in both alternatives is also presented, to illustrate the extent to which environmental sustainability is achieved. The conceptual framework is discussed and further developed throughout the paper, aided by the empirical material.

The city highlighted in this paper is Stockholm, the capital of Sweden and its main commercial, transport and service centre. Compared to Dar es Salaam and Curitiba, Stockholm is a rather old city. It was founded 1252 and is the largest urban area in the country with more than 765,000 inhabitants in the city proper. Stockholm is located between the Baltic Sea and the lake Mälaren, and formed by a combination of islands and mainland. Water and nature are strong features of the city, which occupies an area of 187 km². Stockholm’s metropolitan region is formed by 26 municipalities in an area of 6,519 km², and with a population of nearly 1,9 million people. The public transport system in
focus in this paper serves a ‘commuting region’ (in this thesis this term is used to indicate the area where the public transport system operates) that coincides with Stockholm’s metropolitan region.

By the late 15th century population in the city amounted to 6,000 people. Two hundred years later it had tenfolded and in 1630’s the first street grid beyond the medieval city centre was laid. Mainly due to migration, Stockholm, which had roughly 100,000 inhabitants in 1850, grew to about 300,000 people in 1900. Town planning in that period created many of the still existing wide avenues and apartment blocks. The city’s population continued to grow rather rapidly, and in 1941 – at the time when the Underground Situation happened – there were around 600,000 people living in Stockholm. In the post war period new housing policies came to place and a number of new suburbs were built. Currently the growth rate in the city is almost stagnant, but the commuting region as a whole is growing at 0,6% per year (RTK 2005).

The maps in Figure 3 show Stockholm’s geographical position in relation to Sweden and to its metropolitan region (also known as Stockholm Län). The larger map shows the main features of the public transport system that currently serves Stockholms’ commuting region.

Paper II & Dar es Salaam, Tanzania

Daladala Buses Deregulated - Analysing Urbanization’s Situations of Opportunity through a Tanzanian Example – in this paper the extent to which theory form political science could contribute to the development of the MAMMUT research programme is explored. The concept of Formative Moments, as elaborated for example by political scientists Rothstein and Ostrom, is applied to the empirical material of a pilot study about the development of the “Daladala” bus system, the main means of public transport of Dar es Salaam from the 1970s on.

As in the former paper, it is argued that in the development and growth of cities, certain segments in time are considered more important than others: the situations of opportunity, “formative moments” or “policy windows” present stakeholders with a unique opportunity to implement change. How can such situations be identified and analysed? In historical studies, when did these moments open up and what did they consist of? Was the process intentional, accidental or the effect of an evolutionary process? Furthermore, which was the field of options available to the stakeholders?

During the 1970s the government in Dar es Salaam began issuing licences to private bus owners, allowing them to operate parallel to the existing public bus system. This was done as the existing system was struggling to provide an adequate level of services to the population. During this situation of opportunity, instead of investing in a new public transport system, the government opted to open the market to private operators that owned mini-buses with capacity for 15
to 30 people (usually one-man one-bus). Currently the informal sector constitutes about 90% of the fleet used for public transport in Dar es Salaam. The paper explores the ways in which the “Daladala” system influenced Dar es Salaam’s development, and looks upon the decision to open the public transport market as a “chance lost” during that situation of opportunity. It is argued that a different decision – namely to develop a well-organized and functioning public transport system – could have influenced the city’s development towards more of environmental sustainability.

The focus in this paper lies on finding methods for analysis of the institutional aspect of situations of opportunity. The means for identifying formative moments in institutional processes of decision-making, as suggested by Rothstein (1996), are applied to findings from the pilot study. Elinor Ostrom’s (1990, 1999) theory is also used in the analysis of the institutional aspect of situations of opportunity.

The pilot study takes place in Dar es Salaam, the largest city in Tanzania and the country’s major economic, commercial and industrial centre. It is situated in a coastal plane, bordered by the Indian Ocean at the east and slopes to the west. The city covers an area of 1.350 km², and one-third of it is reserved for urban development (the remaining is for agricultural and forestry purposes). The spatial structure of Dar es Salaam is “finger-like”, with land development patterns concentrating along the major roads connecting it to neighbouring towns. The existing natural harbour has been developed into a modern port that serves Tanzania as well as other countries.

The city was founded in the 1860’s for trading activities. In 1881, when German colonization took over, it was a small settlement with about 4.000 inhabitants. Dar es Salaam then started a rapid process of growth, being among the most rapidly urbanizing cities in the sub-Saharan Africa. More recently both natural growth and rural-urban migration contribute to the city’s growth, and during the last fifty years population increased more than twenty fold. In 1957 population in Dar es Salaam was about 128,700 people; currently it is estimated to be close to three million people. Annual population growth reached its peak in the 80’s (9,1%), but it has eventually slowed down, and currently it is estimated at 3,5% (Lupala 2002).

Dar es Salaam’s city planning started with the zoning plan developed by the German administration in 1891, which guided the city’s growth until 1949, when the first Master Plan was prepared. Its main features included the demarcation of low, medium and high-density residential areas and allocation of areas for industrial development. In 1968 another Plan was made, but its implementation failed mainly due to lack of funds and political will. Yet another Master Plan was prepared in 1979, with similar features to the 1968 Plan, but “less radical” in terms of resettlement and redevelopment of slums and informal settlements.

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8 This section draws on the following sources: Lupala 2002, Nguluma 2003 and Mwaiselage 2003
Despite the efforts to guide Dar es Salaam’s development with plans and zoning regulations, since independence (1961), most of the city’s expansion is taking place informally, and it is estimated that currently 70% of the population lives in unplanned settlements with only marginal access to water, sanitation, transportation and social services (Nguluma 2003).

The maps in Figure 4 show Dar es Salaam’s geographical position in relation to Tanzania, its neighbouring municipalities and the larger map shows the main streets and roads leading to other cities.

**Paper III & Curitiba, Brazil**

*Developing Methods for Analysis of Public Transport Systems to Promote Environmentally Sustainable Urban Development – Learning from historical Situations of Opportunity in Curitiba and Stockholm.* This paper explores the public transport system developed in Curitiba, Brazil during the 70’s as a historical situation of opportunity. It has been argued that public transport systems can create opportunities for cities to influence their growth as well as reduce energy use, and possibly minimize negative effects on the environment such as greenhouse gas emissions. In Curitiba the city’s prehistory restricted the field of options available to stakeholders, and the choice of bus transport system eventually made in that formative moment influenced the city’s future development, affecting its urban structure, institutional setup and people’s ways of life.

In relying solely on buses, Curitiba’s transport system is somewhat contrasted to that of Stockholm: underground plus trams and buses (i.e as presented in Paper I). The two systems are compared to further discuss and develop MAMMUT’s research strategy. The paper also explores methods for the assessment of environmental impacts created by transport systems. Energy use for operating the public transport systems during one year in the two cities is calculated and used as an indicator of environmental impacts. The results *per se* are not the main focus of this paper, but rather the development of methods for analysing the extent to which environmental sustainability is attained in cities.

Curitiba is the capital of the state of Paraná, situated in southern Brazil, about 100km from the coast. The city’s economic activities are predominantly industrial and commercial, with a large service sector. Curitiba was founded in 1694 and it started to grow significantly only with the European immigrants that arrived in the late 19th and early 20th century. In the 1930s the city had 127,000 inhabitants, and annual growth rate of 3,5%. Largely due to rural-urban migration the population in Curitiba increased drastically from the 1950s onwards, growing up to 5,3% per year during the 1970s - one of the highest growth rates in Brazil. Curitiba’s population is currently close to 1,6 million and the annual growth rate is about 1,8%. Even though Curitiba’s growth rate has
diminished considerably, the Metropolitan Region is among the fastest growing regions in Brazil, with close to 2.8 million people and an annual growth rate of 4.4% (IPPUC 2004).

The city of Curitiba occupies an area of 432 km² and its planning history coincides with the periods of large population growth. In 1934 the first urban plan for the city was prepared, based on radial development. In 1965, with nearly half a million people, the city adopted a new Master Plan. Among the goals pursued by the Plan was linear growth radiating out from the city centre – integrating transportation, street network and land use. The 1965 Master Plan has been updated to accommodate new needs that arose in the city, but most of its main features continue the same. As the city grew, densification occurred (and still occurs) along the pre-defined structural corridors (in Figure 5, marked in red), and the street network, alongside with public transport and land use regulations have ensured a linear pattern of growth.

Curitiba is part of a larger Metropolitan Region of 26 municipalities (15.622 km²), and in recent years it has considerably expanded into the neighbouring cities. The lack of coordination in planning efforts of the different municipalities has caused problems; however slowly some actions have been coordinated. One example is the expansion and integration of Curitiba’s bus system (RIT) into eight surrounding municipalities. Differently from Stockholm, Curitiba’s commuting region is included but does not fully overlap with the city’s Metropolitan Region. The commuting region is considerably smaller than the latter: it covers an area of about 3,900 km² and serves a population of approximately 2.4 million people.

The maps in Figure 5 show Curitiba’s geographical position in relation to Brazil, the State of Paraná and its Metropolitan Region. The larger map shows the main bus routes and how it is expanding into neighbouring municipalities.

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9 The municipalities included in the RIT area are: Almirante Tamandaré, Araucaria, Campo Largo, Campo Magro, Colombo, Curitiba, Fazenda Rio Grande, Pinhais and São José dos Pinhais.
Stockholm, Sweden

Figure 3: Map of Stockholm’s commuting region with main train and underground lines

Source: RUFS webpage
Figure 4: Map of Dar es Salaam, highlighting main streets

Source: Scanned from paper version
Figure 5: Map of Curitiba and commuting region with main bus routes

Source: IPPUC 2004, URBS 2004
The Research Strategy

One of the purposes of this thesis is to “discuss and further develop the MAMMUT methodological and conceptual framework”. In this chapter a brief discussion of some key concepts as well as a more detailed discussion of the four aspects of the urbanization process as proposed by MAMMUT is made. The pilot studies from Stockholm, Dar es Salaam and Curitiba are used to illustrate and highlight some features of the conceptual and methodological framework.

The chapter is structured as follows: first, the input draft theory and the conceptual framework proposed by MAMMUT is presented, second I illustrate how the draft theory can be used, telling about the empirical findings in the pilot studies, and third I conclude from the above about the relevance of the theory originally proposed by the cross-disciplinary group of senior researchers in MAMMUT and how it could be further developed.

It should also be said that, the methodological and conceptual framework used in this work has changed over time, and that this framework was under constant development at the time when the pilot studies were carried out. I am presenting the “latest” version of the framework. It has however changed, not least because of the input provided by the pilot studies (for earlier versions refer to Svane 2003).

This thesis deliberately deals only with historical situations of opportunity, looking two generations back, and analysing relevant moments in the historical development of three cities – the factual outcome of decisions taken in those formative moments are analysed in terms of urban form, institutional framework, new ways of life and environmental impacts. But at least as seen from the perspective of today, there were alternatives to that outcome, and those alternatives are analysed in counterfactual scenarios. The factual outcome and the counterfactual scenario illustrate the field of options available to stakeholders at the formative moment.

The study of historical situations of opportunity and the analysis of the field of options is important as a means to learn about future situations of opportunity and the possibilities they provide for guiding and influencing urbanization towards achieving sustainability goals. Thus, the main focus of the historical studies in Stockholm, Curitiba and Dar es Salaam lay in methodological development rather than empirical findings. The MAMMUT programme has the ambition to,
using knowledge gained from historical studies, look fifty years into the future\textsuperscript{10} and identify a set of strategic situations of opportunity that could be used to contribute to sustainable development. These studies of the future are planned as a next step in the research programme and include full-scale studies of selected cities using techniques such as backcasting and scenario building.

**Situations of Opportunity**

In MAMMUT’s conceptual framework situations of opportunity refer to instants when stakeholders have a possibility greater than average to guide and influence the urbanization process so as to contribute to sustainable development. From a historical perspective, some moments in time are considered more important than others. These relevant moments have also been called “formative moments”, “policy windows” and “windows of opportunity” by political and social scientists (Kingdon 1995; Ostrom 1990, 1999; Rothstein 1996).

To investigate the relations between these concepts, a comparative analysis was carried out in the paper that explores the public transport system in Dar es Salaam (Brikell et al 2004), and from there we learned that the concept of situations of opportunity used in MAMMUT is similar, but is not equal to the ones used in political and social sciences. Situation of opportunity differs because it is a wider concept in scope and time. Whereas “formative moments” are a political scientist understanding of actors seizing an opportunity in a specified situation, situations of opportunity is understood to have a temporal dimension with a pre-history and a formative moment (when the decision is actually taken), and its scope includes the analysis of contrasting factual and counterfactual outcomes that are discussed from a cross-disciplinary perspective.

The MAMMUT draft theory suggests that, in the process of understanding the concept of situations of opportunity it is useful to reflect upon the contrast between goal-oriented rationality versus determinism. Political science, and to a even larger extent "economics", tend to argue in rationalistic terms, normally assuming that individuals are well informed and have a large freedom of action (“economic man”). Hence, formal rationality claims that it is possible to apply rationally chosen actions to attain pre-defined goals (Elwell 1996). Applied to urbanization, rationality can be understood to mean that it is possible to achieve a set of goals for sustainable development in the urbanization process through rationally chosen actions. Environmental and quality management systems (i.e. ISO 14000) are based in such underlying assumptions.

In contrast to formal rationality, political economist Charles Lindblom introduced the concept of “muddling through”, which is close to what in everyday language is known as determinism. This concept is used to indicate that

\textsuperscript{10} More details about the studies of the future can be found in: Svane 2005 p. 14-15
the decision making process is incremental and that freedom of action, and subsequently the outcome of future events, is normally strongly restricted by past actions (Lindblom 1959, 1977). Lindblom went further and stated that this process of gradual improvement and change is much more common than the full rationality often assumed in theories from political science or environmental management.

In MAMMUT it is argued that the concept of situations of opportunity rests between determinism and formal rationality. It accepts that there are limits to rationalism, and these limitations are described and analysed as the prehistory of a situation of opportunity. On the other hand it is argued that the process of forever muddling through can be avoided, at least in certain strategic moments – the situations.

In the pilot studies presented in the appended papers, historical situations of opportunity in Stockholm, Curitiba and Dar es Salaam have been identified, and coincidentally they are all related to public transport systems. In Stockholm, the formative moment happened in 1941, when the formal decision to build the Underground system was taken. This choice however, was shaped by a pre-history of more than a decade of discussions. As will be shown later, the Underground system affected the city in several ways (urban structure, institutional setup, ways of life of citizens and ultimately the environment), supporting the argument that situations of opportunity, when used as a tool for analysis of urbanization and sustainable development, need to be multidisciplinary.

In Curitiba the formative moment happened in 1971, with the decision to expand and restructure the city’s bus system, creating an integrated policy for public transport, land use and road network. As was the case in Stockholm, Curitiba’s situation of opportunity also had a pre-history and the outcome of the decision taken at that point in time had effects on the urban structure, but also in citizens ways of life, institutional setup of the city and ultimately impacts on the environment.

The study in Dar es Salaam is an example of a “chance lost”, a “situation missed” – at least from the perspective of the formal institutions and stakeholders. During the 1970s governmental stakeholders had the possibility to restructure the city’s public transport service, but this chance was lost, and as a consequence the informal sector “took the chance” and developed its own solution: the informal Daladala bus system. That missed opportunity is analysed contrasting the factual outcome of how the city developed, and a counterfactual scenario of how it might have developed, had the chance of creating a formalised transport system been taken. In the paper the perspective that this was a missed opportunity for the governmental stakeholders is emphasised. On the other hand, we now see that the informal sector took the opportunity and developed its own solution, and if compared to commuting by car (which is a
common development in other cities that lacked public transport) the Daladala buses probably create less negative impact on the environment in terms of energy use.

As can be observed in the examples above, situations of opportunity have stakeholders who identify the situation (or not), see its potential, and take action. Possible stakeholders include well-established institutions, private enterprises or individuals. In the case of Stockholm such stakeholders included the City Planning Office and the “1930s Traffic Committee”. In the pilot study of the Daladala buses in Dar es Salaam the stakeholders were a few private companies and a large number of “one-man one-bus” enterprises that took over the public transport system when the national transport company (UDA) lost control in the early 1970s.

Besides the three pilot studies presented in this thesis, other two studies of situations of opportunity were carried out. The first dealt with the situation that emerged when Sweden changed its energy policy in the post-war period: At that time a move from a “low energy-use” to a “production-supply” strategy was decided – supporting and encouraging rapid increase in energy use. This study differs from the others because it deals with a situation related to a political decision rather than change in the urban structure. The other study dealt with an ongoing opportunity in Bagamoio (Tanzania) – where the municipality is currently seeking solutions for a new water and sanitation system for the city.

The concept of situation of opportunity was used in the pilot studies to test whether it is possible to identify such moments and if this is a relevant concept to analyse the synergies and relations between urbanization and sustainable development. One of the findings from the pilot studies indicates that situations of opportunity tend to occur in connection to major investments (e.g. transport and sanitation systems). However, this is not always the case: In Stockholm, the decision to implement a new waste recycling and separation system was a situation of opportunity with considerable environmental gains, however with no need for large investments.

The pilot studies have shown that in the historical development of cities it is indeed possible to identify events that fit the definition of situations proposed by MAMMUT. In Stockholm one example was the Underground, in Curitiba the bus system and in Dar es Salaam a missed situation was the “chance lost” to develop a organized public transport system instead of the informal Daladala buses. The Daladala study has also shown that there is a difference in scope and time between the concepts suggested by political and social sciences and the concept of situations of opportunity. Through the empirical material I have furthermore found that the concept of situations provides a relevant unit of analysis for studying the synergies urbanization-sustainable development. This is further clarified and illustrated in the next sections of this chapter, when I
discuss each of the managerial and metabolic aspects that compose a *situation of opportunity*.

### Field of Options

From the draft theory in MAMMUT the alternatives accessible to stakeholders in a *situation of opportunity* reveal the situation’s *field of options*. The differences, in terms of environmental impacts, between possible alternative outcomes of a *situation of opportunity* - and in particular the contrast between extremes - indicate how wide the *field of options* is (see Figure 1).

In historical situations, there is a factual outcome with a resulting urban structure and certain ways of life. During the first pilot study (Stockholm Underground) it was realised that, to better understand the *field of options* available to stakeholders of a *situation* it was necessary to contrast the factual outcome to a counterfactual scenario – illustrating in that way the *options* that were, at least in principle, available to the stakeholders. This counterfactual scenario deals with what might have been – it represents alternative realities for past events. The counterfactual scenario takes into account solutions and technologies available at the *situation*’s formative moment, but it also strives for contrast.

To exemplify: in the empirical study of Stockholm’s Underground the *field of options* available to stakeholders is illustrated through a counterfactual scenario with highways, roads and a bus system. This alternative scenario was based on urban development ideas that were rather common in cities in the USA during that time. In that scenario the development of Stockholm is based on a car-dependent urban structure, and differs from the real outcome in its institutional structure, urban ways of life and environmental impacts. In the Dar es Salaam study the counterfactual scenario suggests a public transport solution that includes trams and buses and a more dense urban structure.

According to MAMMUT’s conceptual framework, ideally the *field of options* is quantified and illustrated looking at the accumulated environmental impacts between the contrasting alternatives over the entire period of time from the formative moment to an outcome date. In the pilot studies this is, however, not fully explored. Instead, in the Daladala buses and the Stockholm Underground studies the contrast between the environmental impacts is not quantified and just a reflection as to how this could be done is indicated. Yet, in Curitiba’s pilot study an attempt to partially quantify environmental impacts is presented, and environmental impacts related to the use of energy are assessed – not for the entire period of time between the formative moment and an outcome date – but instead it refers to the energy use for operation during one year.

The pilot studies of historical *situations* in the three cities mentioned above have shown that, to better understand the concept of *field of options*, it is helpful to study the factual outcome alongside with a contrasting “counterfactual”
It is also argued that, even though it may be controversial to use counterfactual scenarios to illustrate what “might have been”, the concept is still useful in relation to historical studies: It shows how different choices in a given moment – the situation – may result in contrasting outcomes with regards to impacts on the environment. The “counterfactual” concept, however, needs to be further developed, and its relevance should become clearer especially when the MAMMUT research moves into studying future situations of opportunity – when there will be no “factual outcome” to begin with.

Managing Urbanization

In order to analyse situations of opportunity and the field of options available to stakeholders, two main perspectives of urbanization are proposed by MAMMUT: metabolism and management. Metabolism – the exchange of resources and waste between the city and its hinterlands – indicates to what extent environmental sustainability is attained. The degree to which urbanization can be managed – guided by the objectives of sustainability – is analysed as the field of options accessible to its stakeholders in the situation of opportunity.

MAMMUT’s cross-disciplinary research approach proposes that the management of the process of urbanization is studied as a complex interplay between three aspects: urban structural development, changes in the institutional setup and changes in people’s ways of life. These aspects, when observed in the formative moment of a situation of opportunity, are structures with their own fields of options; in their development over time they are parallel and interacting sub-processes. Stakeholders of urbanization can influence the three management aspects, in their situation of opportunity, within each situation’s field of options.

Examining the aforementioned management aspects per se as well as the complex multi-directional interactions between them is how we study the management of urbanization. These interactions are exemplified through the ways in which powerful institutions (e.g. planning offices) guide the development of the urban structure; or in how physical structures can facilitate certain ways of life while, for example, limiting households choices for transportation, energy use, etc. At the same time citizens can change their own ways of life and also indirectly influence the local government’s institutional setup as well as changes within the urban structure.

Urban structure – geography, infrasystems and buildings

In MAMMUT the urban structure is the new buildings, roads and other infrastructural systems that develop in the urbanization process. The location and type of buildings and infrastructure guide the performance of the resulting built environment for a long time: they typically have a service life of at least a few decades, and up to a century in high-income countries. The ensuing urban
pattern normally lasts even longer, guiding changes within itself as well as further urbanization.

The relation between urban structures and their long-term impact on the urban development pattern can be exemplified through the impact of transport systems. While transport systems shape the built environment – as was the case of the densification along structural corridors next to the express bus routes in Curitiba – it is also true that some building types go together with certain transport systems: in Stockholm high-density housing areas developed surrounding the Underground stations. On the other hand, low-density areas make undergrounds and also other types of public transport economically unfeasible.

The urban or physical structure of a city also, to a large extent, depends on the natural characteristics of the region – its access to water, its topography, natural resources, forests, etc. The existing and future physical structure of a city is overlaid on, and limited by its natural geography.

The physical structure directly influences the environment through land use patterns, but it also indirectly affects it through the use of other resources, for example energy. In a dense city it is viable to achieve high rates of public transport use, and this is likely to use less energy than commuting with car in cities characterised by sprawl. Energy use for heating can also sometimes be minimized with the use of district heating – which is not viable in low-density housing areas with one-family units.

If, as it has previously been argued, population growth and consequently the urbanization process in most high-income cities is close to stagnation then it is also possible to say that most of the physical structure needed in a two-generation perspective in those urban centres is already there, and changes will only add on the margin to the existing urban structure. For Stockholm, seen in a perspective of thirty years, it has been estimated that the average annual construction will add at the most one percent to the existing urban structure (Energimyndigheten 2000).

On the other hand, in rapidly urbanizing cities (located mostly in low and middle-income countries), the urban structure is growing and changing rapidly, and there is lack of infrastructure systems: most buildings are not yet there. In Dar es Salaam, a rapidly growing population requires and results in speedy construction of new buildings and new infrasystems. A proportion of these new buildings, however, consists of structures with a short service life and therefore calls for further development (Lupala 2002).

The MAMMUT framework proposes that situations of opportunity within the physical aspect of urbanization can emerge in two ways: one set of opportunities happens when the basic proprieties of the urban structure is being defined, for example the construction of tunnels and railway for the Stockholm Underground system, or the restructuring of Curitiba’s growth along the express bus lanes.
The other set of opportunities comes with technological improvements and changes within existing systems, as for example the possibility to use hydrogen and fuel cells for private transport.

The cases of Curitiba and Stockholm investigate the situation of opportunity that emerged when the public transport systems in those cities were defined. The changes that these systems brought to the physical structure of the cities have affected and simultaneously been affected by changes in the institutional setup as well as on the ways of life of their citizens. In Dar es Salaam’s pilot study we look at a missed situation of opportunity and how a different decision in the formative moment could have affected the city’s urban structure.

The empirical studies have shown that the structural aspect – i.e. the development of infrasystems and buildings – can indeed create opportunities for stakeholders to guide the urbanization process towards more of environmental sustainability and is therefore an important aspect to be included in the study of situations of opportunity. With the pilot studies we also learned that the situations within the urban structural aspect often emerge linked to major investments (e.g. transport systems, water networks, etc). In full-scale studies researchers from the fields of architecture and planning will be responsible for further analysis of this aspect.

The institutional aspect

The conceptual framework in MAMMUT proposes that the institutional aspect of urbanization refers to organised co-operation between people. This cooperation between stakeholders is often restricted to projects limited in time, however there are some institutions that have a longer-lasting influence. In a country such as Sweden, developers, consultants, contractors, local authorities, banks and insurance companies are separate and long-term stakeholders of urbanization. In low-income countries as for example Tanzania, stakeholders often include informal institutions: individuals, community organizations (NGOs, CBOs, etc) and other forms of less-formalized organizations that play important roles in the process of urbanization.

One set of stakeholders is involved with the production of new infrasystems and buildings: the urban structure. Once production is finished, users and managers take over as main stakeholders, while local authorities retain a field of influence. Users and managers often negotiate and co-operate, mainly in long-lasting institutions like tenants’ associations, community based organizations or housing co-operatives.

The stakeholders mentioned above and their forms for co-operation are the institutional structure of urbanisation, their emerging, developing and vanishing the institutional sub-process of urbanization. In Stockholm, the institutional structure is strong, probably governed by stiff power orders. There, situations of opportunity could be the phases of weakness in the city building regime (Gullberg
& Kaijser 1998; Gullberg 2001), recent examples of such situations of opportunity being the reorganisations of the electric distribution and the municipal waste handling.

In the empirical studies of the situations of opportunity in the Underground in Stockholm as well as the Bus System in Curitiba the influence of strong and long-lasting institutions such as the city planning office and the public transport company are rather evident. In low-income countries like Tanzania however, formal institutions for guiding urbanization are weaker and have scarce economic resources. Consequently urbanization takes, to a large extent, the form of informal development where people get together and organize a minimum of institutional framework among themselves to built and maintain the basic infrasystems needed.

The paper about the Daladala buses makes a deeper analysis of the institutional aspect of urbanization in the development of the mini-bus transport system in Dar es Salaam. In that case the main formal institutions involved were the Ministry of Communication and Transport and Ministry of Home Affairs at the national level and Dar es Salaam Regional Transport Licensing Authority along with UDA representing the local government. However, those formal organizations failed to take advantage of the situation of opportunity provided by the need to restructure the public transport system during the 1970s. Instead a group of less-formalized stakeholders, namely the bus-owner and their organizations, took advantage of the situation and developed the informal Daladala bus system.

In the paper these institutional processes are studied with a political science approach – for example in terms of local power structure, participation and governance and commons’ dilemmas (Fudge & Rowe 2000; Ostrom 1990; Peters 1999). The concept of governance is used to indicate new forms of public-private collaboration and network to provide services (Martinson 2005). It has also been used to describe the processes of governing urbanization in cities (Habitat 2001). In the UN report the concept of governance is defined to include market-based strategies from the private sector, hierarchical strategies from the public sector and network strategies from the civil sector.

In MAMMUT, and consequently also in the three historical pilot studies this wide definition of governance that considers stakeholders from private enterprises, governmental institutions as well as the civil society as a whole, is used. In the case of Curitiba and Stockholm the various institutions from the public sector are the strongest stakeholders, whereas in Dar es Salaam the informal and civil organizations play a major role.

MAMMUT’s draft theory was used to analyse the empirical material in Stockholm, Curitiba and Dar es Salaam. In the latter a deeper analysis of the institutional aspect of urbanization is discussed and its relevance for achieving the aim to study relations between urbanization and sustainable development is explored. Furthermore, following the work presented in these three papers,
political scientist Bernt Brikell has published a work that goes one step further and analyses the institutional aspect of urbanization using concepts from political sciences (Brikell 2005).

The social aspect - households and urban ways of life

The social aspect, as put forward in MAMMUT’s draft theory, is people’s urban ways of life, for example the everyday habits of cooking, cleaning or travelling. Urban environmental sustainability is not just dependent on urban form and the institutional setup. Shifts in peoples’ behaviour and attitudes are also required (Williams et al 2000). Within limitations imposed by the urban structure and the institutional setup, the individual or household has alternatives and can choose between more or less environmentally sustainable ways of life. Thus, the primary agent of change is the household itself, and the object of change: the household’s ways of life.

To exemplify: once built, the properties of buildings that define its level of energy use are locked in and will influence its performance for a rather long time. However, residents still have the choice of using more or less resources such as energy and water for cooking, cleaning, etc – and depending on the choices made by households, it has been argued that the impacts on energy use can be reduced by as much as factor of four (Gram-Hanssen 2003). Another example, taken form the empirical studies: In Curitiba once the RIT bus system was put in place many people that previously commut ed by car were given the opportunity to choose between continue to use private cars and thus contribute to increasing fossil fuel consumption and problems related to traffic congestion, or use a more environmentally sustainable way while commuting with buses.

Situations of opportunity for households could be related to migration itself or moves within the city. Moving from rural Tanzania to Dar es Salaam will normally require people to adapt to new ways of life. It seems reasonable to presume that this move might increase impacts on the environment – the chains of supply are longer and the feedback on individual behaviour less manifest. However, as mentioned in the introduction, the urban concentration of people also opens up for efficiency gains. In high-income countries, like Sweden, the changes in ways of life from rural to urban areas may not create as significant situation of opportunity as in low-income countries, because ways of life in terms of resource use in rural Sweden are very similar to the ones in urban areas.

Another set of opportunities can arise with the renewal of houses or infrasystems. In Stockholm many buildings will need to be renovated in the next few decades. In the section that discussed the physical aspect of urbanization I drew attention to the fact that in high-income countries most buildings “are already there”, whereas in middle and low-income countries buildings and infrasystems are “still missing”. As a result I here argue that the situations of opportunity arising from renewal and gradual improvements are larger and more
evident in high-income countries. However, perhaps to a smaller extent, the need for renewals also applies to houses and infrasystems in cities like Curitiba and Dar es Salaam.

The refurbishment of buildings creates *situations of opportunity* while facilitating more environmentally sustainable ways of life for its users. In these cases the agent of change is not necessarily restricted to the individual household, it could include real estate owners and managers or a co-operation between households. This co-operation can originate from the need to improve sanitation conditions in an informal settlement in Tanzania, or in a housing renewal project in Stockholm.

Moving from empirical examples back to MAMMUT’s theory development, it is possible to conclude that the analysis of the social aspect of urbanization seems relevant, but is not yet fully explored. Households’ changing ways of life and the *opportunities* they may entail, could further benefit from the use of concepts such as “social capital” (see e.g. Coleman 1988, Fukuyama 2001, Putnam 1993) to better understand the relations between various stakeholders. The notion of “life style” and “life form” (Bergman 2002; Höjrup 1983; Lindén 1994) could also be useful to understand households’ values, attitudes and habits as well as incentives and obstacles for change. However, to adapt and further develop these concepts in the context of MAMMUT’s research programme remains to be done.

**To summarize:** the empirical material confirms that the draft theory in form of conceptual and methodological framework proposed by MAMMUT is indeed a fruitful tool for analysing *situations of opportunity*. Some of the concepts were further developed aided by the feedback from the pilot studies (i.e. *field of options*). The pilot studies have also demonstrated that the three managerial aspects of urbanization are relevant in the discussion of urbanization and its relations to sustainable development. The institutional aspect was the only managerial aspect studied in more detail in the pilot studies, whereas the analysis of the other two aspects (urban structural and social) needs to be further explored, although some suggestions for their development have been put forward. Also, the pilot studies have tested the draft theory in a historical perspective. Applying the same concepts to studies of the future should entail new challenges.

**Metabolism – the Environmental Aspect of Urbanization**

Urban metabolism is the exchange of resources and waste between the city and its hinterlands; assessing it in terms of environmental impacts indicates to what extent sustainability is attained. Any city is dependent on a large exchange of resources and waste with its surrounding hinterland. In MAMMUT, the urban metabolism is an overarching theory for understanding and assessing
environmental impacts. The urban metabolism is used to describe relationships and dependencies between a city and its hinterland (Baccini & Brunner 1991).

The development of new urban areas means new buildings, roads and other infrastructural systems, calling for large amounts of construction materials and energy. This material becomes waste when eventually the buildings are torn down, perhaps a hundred years later. The construction materials are the slow flows of the urban metabolism. Once construction is finished, people start using the area. This, in its turn, calls for an inflow of other kinds of resources – energy for heating, cooling, cooking etc., as well as food, water and other daily goods. Sooner or later the activities of the area transform these resources into waste that needs to be taken out and processed. These are the quick flows of the urban metabolism.

Through analysing these slow and quick flows of energy and matter, resources and waste as well as their societal stocks, we learn about the metabolism of urban life (Baccini & Brunner 1991). In comparing the flows to objectives of environmental sustainability, we can assess whether urbanization contributes to sustainable development or not.

The urban metabolism can be quantified and its environmental impacts estimated through modelling based on systems’ theory and with the aid of computerised tools (Ingelstam 2002; Finnveden & Moberg 2004, Baccini & Baader 1996). For the quantification and analysis of the urban metabolism a theoretical basis is Material Flows Analysis (MFA)\(^{11}\). A wide range of indicators could be used to assess environmental impacts in cities. In MAMMUT, within a given situation and its field of options, indicators of environmental impacts have been restricted to land use and the assessment of energy use in the management (operation and usage phase) of the built environment and urban transport systems.

This restriction is, at least in part, a development that followed from the pilot studies: it was realised then that it would be very demanding to assess all the possible impacts that a given situation and its field of options have on the environment, and a restriction as to what should be studied was needed. The reason for choosing energy use in buildings and transport systems to assess environmental impacts in cities is related to, as mentioned in the introduction, the fact they are responsible for a large proportion of the total commercial use of energy in cities, and this energy causes society’s main impacts.

One of the most well-known effects on the environment impacts arising from fossil-fuel energy sources, and thus strongly related to transport, is the emission of carbon dioxide and other greenhouse gases. In 1996 the US, Canada, EU, Japan and Australia – with 16.7% of the world’s population – accounted for 53.6% of global carbon dioxide emissions. Over three quarters of these

\(^{11}\) Ahlroth et al. 2003 contains a general overview of methods for environmental analysis including MFA.
emissions were derived from urban activities with transport-related emissions increasing rapidly (Jenks & Burgess 2000:12). As of now, within MAMMUT, the assessment of energy use for transport has been carried out – to some extent – in a pilot study for Stockholm and Curitiba. The analysis impacts of land use and energy used in the built environment remains to be done.

**Transport systems and environmental problems**

In recent Habitat reports (1996 & 2001) public transport systems are pointed out as opportunities for cities to influence their growth, as well as reduce energy use, and possibly minimize negative effects on the environment. In his well-known paper “Transport: Reducing Automobile Dependence” Peter Newman (1996) also indicates that investments in transit infrastructure can help shape the city and reduce automobile dependency, bringing advantages such as reduced energy use, greenhouse gas emissions and air pollution.

Newman and Kenworthy (1989) report a strong relation between the city’s urban structure (low vs. high density) and energy use for transportation. In their study of 32 cities worldwide they show that cities characterised by sprawl use more of fossil fuel for transportation, in part because of the strong reliance on private cars. In countries such as the United States and Canada urbanization commonly is characterized by urban sprawl and thus fossil fuel consumption for transport is higher, if compared to for example some European cities such as Amsterdam, which have high densities. In cities with higher densities public transport systems tend to be more efficient. While comparing transport for commuting in different cities Brown (2001) observed that in Atlanta (US) 95% of commuting was done a using private car, whereas in Amsterdam this figure was 40%, in Singapore 22% and in Curitiba 14%.

The energy use and the impacts on the environment related to public transport can be assessed with tools of varying complexity (Jonsson 2003), and the papers about the public transport systems in Stockholm and Dar es Salaam some methods and tools are suggested, however no quantification is made.

The third paper appended in this thesis is the first attempt to further test MAMMUT’s theory, more specifically with regards to the quantification of impacts on the environment. There, a simplified calculation of energy use for operation of the bus system in Curitiba for the period of one year has been made. A similar calculation was also made for Stockholm’s public transport system. The two cities are, to some extent, contrasted. The overarching aim in that paper is methodological development. Hence, the main contributions of this study is less about the quantification of energy use per se, and more about identifying possibilities and weaknesses of the methods used to quantify it.

From the energy use quantification in the two cities it was possible to realize what kind of measures are more relevant. From the empirical material I concluded that to use a single indicator for total energy use (GWh) is rather
simplistic. Instead it is important to relate the total energy use to indicators that measure how efficiently the energy is being used. Besides discussing some possible ways of assessing energy use (e.g. KWh per person-kilometre), in the paper I have also discussed some broader problems that emerged while assessing environmental impacts in transport systems, namely: energy sources and conversion factors, quality of services, etc. These issues need to be explored further in a full-scale study.
Synergies and Relations

While exploring and discussing the four aspects of urbanization (i.e. urban structure, institutional, social and environmental) in the pilot studies, we realised that: In order to understand the process of urbanization and how it relates to sustainable development not only the four aspects themselves as separate entities are relevant, but equally important are the relations and synergies between these aspects. In other words: we need to study how the physical structure supports and restricts certain ways of life, or how powerful institutions guide the development of the urban structure, and so forth. From this realisation the second objective for this thesis is born: “analyse the synergies and relations between the different aspects of urbanization”.

In the initial stages of the process of developing MAMMUT’s methodological and conceptual framework, there has been some discussion about the relations between the managerial and metabolic aspects of urbanization. Early on it was assumed that these relations are not of the cause-effect type, yet further development of this line of thought was not pursued at that time. During the pilot studies however, it became clearer that there is a complex web of interchange between the managerial and metabolic aspects, and that these relations are important in order to understand the process of urbanization and how it can contribute to more of environmental sustainability. Findings from the pilot studies also indicate that the relations between these aspects are those of mutual dependency or interchange, rather than of cause-effect type.

To illustrate the relations between separate aspects of urbanization, let us look at the case of Stockholms’ Underground: There the decision of stakeholders (institutional aspect) to build an Underground system (structural aspect) influenced people’s everyday ways of life, changing, for example, their commuting habits (social aspect). On the other hand, the commuting options available allowed people to live in suburbs, farther from the city centre. This, in its turn, created incentives for the development of new neighbourhoods, and more changes in the urban structure. While the Underground system guided the development of the city’s built environment, there was also an influence in the opposite direction. The urban structure of neighbourhoods affected the development of the Underground system creating a web of influences. Thus, there is no simple cause-effect relation here, but rather relations of mutual dependency.
Urbanization can be characterized by the complex interplay between urban form, institutional setup, and people’s ways of life. The resulting urban metabolism and its environmental impacts are also involved in this interplay. From the pilot studies we have learned that individual aspects play distinct roles in the process of urbanization: The institutional aspect (and sometimes also households) is the “agent for change” – it is through institutions and stakeholders that decisions related to a *situation of opportunity* are taken and change is initiated. The urban structure and the social aspects are “objects of change” – these aspects are the ones affected by the decisions taken by stakeholders, and they will therefore be the ones undergoing change. The environmental aspect of urbanization is the “outcome” of the whole process: once change is implemented, there is an outcome in terms of environmental impacts. In MAMMUT’s research programme the main impacts are studied in relation to land and energy use.

To exemplify the role of different aspects, let us briefly go back to the Daladala bus system in Dar es Salaam: There the individual bus owners were among the main stakeholders (agents for change) who took the *opportunity* provided by the lack of public transport and initiated the change by providing alternative public transport – the Daladala buses. This initiative affected the ways of life of people (object of change) that depend on the bus system – in terms of service availability and commuting options. In the second appended paper we argue that, at least to some extent, the urban structure (object of change) of Dar es Salaam was also affected and changed by the informal bus system. The environmental aspect (outcome) in this example can be illustrated through the amount of energy used to run the existing system.

The roles of the institutional and the environmental aspect are seen as special in our research. The institutions are seen as the initiators that can (or not) take advantage of a *situation of opportunity* and start a process of change that will lead to more of environmental sustainability in the urbanization process. Stakeholders are considered as “agents of change” and thus in our future research, once a possible future *situation of opportunity* is identified, it will be crucial to also identify the stakeholders that can initiate the change in that *situation*.

Within a *situation of opportunity* the relations between certain aspects may be more relevant than others. Whereas in some cases the relations between institutional and urban structural aspects may be rather relevant (as in the case of Curitiba), in a different *situation* other relations may be more significant. Let us look at the different relations that could exist between the urban structural, institutional, social and environmental aspects of urbanization. I start the analysis of these relations with the environmental aspect, and discuss its synergies with the other three, proceeding in that way until a web of relations between the aspects is composed. Examples from the pilot studies are used to illustrate the points. This discussion is far from complete – and in many cases the relations between aspects will be unique for each *situation of opportunity*, thus making it hard to generalise.
From the pilot studies we conclude that all three management aspects of urbanization create impacts on the environment. Some may have a stronger impact than others, but all contribute to some extent to the degradation of the surrounding environment. Furthermore, there are two kinds of impacts on the environment: direct and indirect. The direct influences can be exemplified by the sealing off of land for buildings and infrasystems affecting the natural drainage characteristics of the city, waste disposal that contaminates soil and water bodies, different transport systems creating more or less of air pollution, and so forth. The indirect impacts include ways in which the density and organization of the urban structures contribute to higher or lower levels of resource use: in low-density housing areas there is an increased energy use related to longer commuting distances, absence of district heating, etc – these are but a few examples of how the physical structure of a city affects the environment.

As we have seen, people’s ways of life can also result in more or less impacts on the environment: depending on people’s choice of transport for commuting, or the amount of resources such as energy and water they use for their daily activities, significant reduction in resource use within a given urban structure is possible. This reduction is applicable especially in high-income countries, and among the high-income groups in low-income countries.

The institutional setup also influences the environmental aspect of urbanization. Governments and other stakeholders create indirect environmental impacts while taking decisions about city planning, location and need for new infrastructure, etc. These decisions, when implemented, will further affect the city’s structure, and thus also affect the environment. In a more direct way, institutions can influence impacts on the environment through laws or other policy instruments such as taxes, financial incentives, subsidies, information dissemination, etc. To illustrate the role of government: If emission regulations, which governments set, are too lax, air pollution would significantly increase. Consequently, for example more acid rain and soil contamination could further affect forests and agricultural land in the region.

Less obvious may be the relations between the management aspects themselves. As mentioned above, the Underground study in Stockholm shows how the urban structure affected ways of life of people as well as institutional setups. Curitiba’s bus system had a similar effect: new buildings/housing developed near bus services, and people changed their habits from commuting by car to using the buses – this in its turn reduced the fossil fuel emissions and traffic congestions and thus reduced impacts on the environment.

In the case of the Daladala buses in Dar es Salaam the lack of ability from governmental stakeholders to enforce the regulations and provide a comprehensive public transport service encouraged the development of a alternative bus service that has very little of institutionalized organization. People who once were used to the public service provided under the colonial regime
adapted their ways of life to the Daladala system – in part due to lack of options. In the counterfactual scenario in paper II, it has been suggested that the use of a different transport system, namely commuter trains, could have encouraged a different and more dense urban structure – which in its turn would reduce commuting distances and time for the citizens. On the other hand, the existing Daladala system, if compared to commuting by car (which is a common development in other cities that lacked public transport), created less negative impact in terms of energy use: it most likely uses less energy than private cars would use.

In order to summarize the discussion above, a tool in form of a table has been developed. This table should be seen as a device to illustrate and facilitate the analysis of relations between the different aspects of urbanization in a given situation of opportunity.

Table 1: Illustrating the relations between different aspects of urbanization

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Structural Aspect</th>
<th>Institutional Aspect</th>
<th>Social Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Environmental impacts creating chains of impacts: waste contaminates soil, which contaminates water, and this further creates problems to those using the water source.</td>
<td>- Urban structure creates impacts on the environment during construction, use and maintenance. - Environmental and geographic characteristics of a city create restrictions for urban development.</td>
<td>- Regulations and incentives from governments can result in more or less impact on the environment. - Some new institutions may result from the need to e.g. protect biodiversity in a city.</td>
<td>- Different ways of life create more or less negative impact on the environment. - Scarce natural resources may lead to changes in people’s ways of life. - Pollution can affect citizen’s health and change their habits.</td>
</tr>
<tr>
<td>Structural Aspect</td>
<td>- Certain urban forms encourage the development of some urban structures: rail transport systems can lead to higher density in land use patterns, whereas low-density housing areas do not usually support rail based transport.</td>
<td>- Government and informal organizations play important roles in decisions about the urban form of a city: location of new housing, roads, etc. - Privatization of structures (e.g. public transport, water distribution networks) creates new institutions (privately owned companies).</td>
<td>- Commuting habits are related to available urban structure &amp; services. - Urban structures can facilitate certain ways of life: underground and dense housing areas in suburbs facilitate commuting mentality.</td>
</tr>
<tr>
<td>Institutional Aspect</td>
<td>- Existing stakeholders in a decision-making process may influence the participation or not of other stakeholders/institutions.</td>
<td>- Needs arising from people’s ways of life may influence institutions – directly through CBOs, or indirectly while influencing the government. - Governments as well as other stakeholders can use different policy instruments to influence people’s ways of life.</td>
<td>- People influencing each other’s ways of life (“peer-pressure”). E.g. People in a given housing development agree to recycle waste, the group-pressure may lead households that initially were not in favour to participate in the process, and thus change their ways of life.</td>
</tr>
</tbody>
</table>
The examples in the table are a few random illustrations, and they serve the purpose of showing possible relations between different aspects. The table, when used to analyse a specific situation of opportunity, aims at aiding in the identification of a unique web of relations between the different aspects of urbanization. In some cases these relations may be of a cause-effect type with one aspect having a strong and direct influence over another, or vice-versa. In other cases the arrow of influence between two or more aspects does not exist, and instead there is a relation of the mutual dependency type. In future research the analysis of the relations exemplified in each of the boxes could be extended to include the use of concepts such as problems and conflicts, synergies and solutions, etc.

Another improvement in the table would be to analyse each aspect in relation to the two main environmental impact categories proposed by MAMMUT – namely land and energy use. In a full-scale study this table could be used as a starting point for a more comprehensive analysis of the relations between the management and metabolic aspects of urbanization in a given situation.

The lessons learned in the empirical studies and the discussion in this chapter show that, although it is important to study the four aspects of urbanization proposed by MAMMUT’s framework in isolation, it is even more important to analyse the synergies among them to better understand the relations between the processes of urbanization and sustainable development.

Therefore, even though different disciplines – namely architecture and urban planning, political science, sociology, and natural science and technology – may be able to make more specific contributions to each aspect, in future studies it will be equally important that researchers from different disciplines work together moving from multi-disciplinary to cross-disciplinary results. In that way the complexity of both processes: urbanization and sustainable development will hopefully be understood to a further extent – creating possibilities for better guiding urbanization towards achieving environmental sustainability goals.
Concluding Remarks

In the beginning of this dissertation two main objectives were pointed out: to discuss and further develop the MAMMUT methodological and conceptual framework and to analyse the synergies between the different aspects of urbanization proposed by this research strategy.

Various concepts from the MAMMUT draft theory were discussed and further developed aided by the empirical material from three historical pilot studies in Stockholm, Dar es Salaam and Curitiba. We concluded that there are indeed moments that fit the definition of situations of opportunity and that the concept of situations provides a relevant unit of analysis for studying the synergies urbanization-sustainable development. In the Daladala study the concept of situations of opportunity was compared to similar concepts from political science (formative moments, windows of opportunity) – and we learned that, though similar, the concept of situations is wider in scope and time, including the analysis of pre-history, formative moment and an outcome.

The empirical studies also aided in the development of the concept of field of options. The idea of counterfactual scenario was added and it has helped to illustrate the concept of field of options, showing how different choices in a given moment – the situation – may result in contrasting outcomes with regards to impacts on the environment.

A discussion about the management and metabolic aspects of urbanization followed. From the empirical studies it was confirmed that the analysis of urban structural, institutional, social and environmental aspects of urbanization are a fruitful tool for analysing situations of opportunity. We also concluded that all four aspects are relevant in the discussion of urbanization and their relations to sustainable development.

From the three managerial aspects, only the institutional aspect was studied to a deeper extent (in the Daladala pilot study). Ways to study this aspect in the context of MAMMUT’s approach were further explored by political scientist Bernt Brikell. Some suggestions for further development of the methodology to analyse the other two aspects (i.e. urban structural and social) have been made. However they could still benefit from contributions from researchers such as architects, planners and social scientists.
One of the major contributions from the pilot studies regarding the environmental aspect of MAMMUT’s conceptual framework was the realisation that it would be too demanding to assess all possible environmental impacts related to a given situation of opportunity and its field of options. Instead, only the impacts related to land use and energy use in buildings and transport systems were chosen as indicators of environmental impacts in the MAMMUT project.

Furthermore, the case of Curitiba and Stockholm were used to explore a methodology to quantify energy use in public transport systems. The main conclusion from that empirical study is that to use a single indicator for quantifying energy use in transport systems is rather simplistic, and it is important to relate the total energy use to indicators that also measure the efficiency of the system. Additionally some broader problems related to energy use in general were pointed out. The pilot studies only analysed ways to quantify energy use related to transport systems. In a full-scale study researchers from natural sciences should be able to further develop the methodology to include impacts from land use and energy use in buildings.

In the chapter, Synergies and Relations, the second purpose of the paper was discussed. There we concluded that the management and managerial aspects of urbanization are interrelated and influence each other, and therefore should be studied as such. The relations are, however, not of the cause-effect sort and learning about the complex interrelations between the urban structural, institutional, social and environmental aspects of urbanization should enable a better understanding of the process of urbanization and how it could contribute to more of environmental sustainability. A tool in form of a table was proposed to aid the analysis of the relations between managerial and metabolic aspects within a situation of opportunity.

The papers and the discussions in this dissertation aimed at testing and further developing the conceptual framework proposed by MAMMUT. The next step should lead to a full-scale study: in it, using the knowledge gained from the study of historical situations, researchers from different fields of science will pool together in the analysis of future situations of opportunity.

As of now, the MAMMUT research strategy has deliberately not included the analysis of the “economic aspect” in the urbanization process and how it influences the achievement of a more environmentally sustainable development. This aspect is relevant, and could be included in future studies, adding yet another perspective in the discussions. The economic aspect could be incorporated in the project in two ways, one of which was already mentioned earlier on: situations of opportunity often are connected to major investments, and thus it could be relevant to consider the financial aspects of it. Also, when looking at the field of options available during a situation it could be beneficial to evaluate costs of projects in contrasting scenarios, and thus evaluate how realistic/likely the different alternatives are.
In the next phase of the MAMMUT research project a full-scale study in one or two cities is planned. In it the coordinated work of researchers from different disciplines and possibly the involvement of stakeholders of urbanization such as city planners, CBOs, etc (e.g. through action research) in the analysis of future situations of opportunity will strengthen the cross-disciplinarily aspect of the research programme. The aim with such future study is to identify well in advance and create awareness among stakeholders about a few opportunities that will lead the process of urbanization towards the fulfilment of sustainability goals.
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