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Sustainable City Development - Indicators and their use for transforming cities
- A methodical proposal for a paradigmatic application in Piura, Peru

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Dissertation submitted as partial requirement for the conferral of
Master in Development Studies

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June 2019

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Acknowledgements

I want to thank my mom for always trusting in my decisions, taking the biggest challenges and making me go, wherever I feel like going.
I want to thank my dad for giving me my roots, to stay and to speak up for what I think and to be courageous.

I want to thank my siblings Maryam and Junes for their unlimited belief in whatever I do and for always having my back.

I want to thank Teresa for making my time in Lisbon the best time of my life and joining me on the way to discovering a new language and hereby a new world.
I want to thank Zé Maria for motivating me, to take the steps into the direction I want to go and for being a great friend.
I want to thank my friends for their endless patience.

I want to thank Professor Amaro for giving me courage and support throughout my course, helping me to find my spot in a surrounding, where I did not initially fit in.
I want to thank Eliseu Sequeira, who helped, wherever he could without hesitating for a moment.

Resumo

O estudo apresentado é composto pela investigação actual de metodologias que medem o crescimento sustentável em diferentes contextos globais.

As cidades terão um papel essencial no Desenvolvimento para um futuro resiliente e neutro a nível climático.

Em 2030, aproximadamente 5 biliões de humanos estarão a viver nas cidades, sendo que uma grande maioria deles estará a habitar nos que são hoje considerados os países desenvolvidos e emergentes. Este crescimento na importância do espaço urbano é acompanhado pelas rápidas mudanças tecnológicas e sociais. A importância deste campo despoletou um número significativo de iniciativas e estudos por todo o mundo, com a intenção de reunir e organizar dados relativos ao Desenvolvimento e sustentabilidade. Do ponto de vista científico, são escassos os métodos e modelos que possam quantificar a eficácia das cidades ao nível da sustentabilidade.

Ao longo da tese, o foco predomina na abordagem do método desenvolvido no âmbito de Morgenstadt, desenvolvida pelo Instituto Fraunhofer na Alemanha.

O objectivo da tese é a identificação das fraquezas que podem ou não ser reconhecidas através dos sistemas indicativos standard.

Adicionalmente, pretende-se identificar metodologias fortes e fracas no contexto da próxima iniciativa climática internacional. A metodologia apresentada será aplicada em Piura, Peru, de forma a avaliar a prontidão de uma cidade Sul-Americana, tendo em conta o seu complexo sistema enquanto cidade.

Palavras-chave : Cidades, Desenvolvimento Urbano, Desenvolvimento Sustentável, Inovação

Classificação JEL: O19; Q01

Abstract

The present research consists of the current research on methodologies to approach the measurement of sustainable development in different global contexts. Cities will be taking over an essential role in the Development towards a climate-neutral, resilient future.

By 2030, nearly 5 billion humans will be living in cities, a vast majority of them in today's emerging and developing countries. This increase in importance of urban space is accompanied by rapid technological and societal change. The importance of this field has sparked a significant number of initiatives and studies worldwide, intending to gather and organize data related to Development and sustainability. From the scientific point of view, proven methods and models for measuring the efficiency of cities in terms of sustainability are lacking.

Throughout the thesis, the focus is being set on the Morgenstadt approach, developed by the Fraunhofer Institute in Germany. The purpose of the thesis is to identify the weaknesses that can or can not be identified through the standard indicator systems. Furthermore, the aim is to define the methodologies strengths and weaknesses in the context of the upcoming international climate initiative. The methodology is going to be applied in Piura, Peru, in order to assess a southern American cities readiness while considering a city as a complex system, impossible to be predicted or foreseen.

Keywords: Cities, Urban Development, Sustainable Development, Innovation

JEL Classification: O19; Q01

List of Abbreviations

BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CAS	Complex Adaptive Systems
DPSIR	Drivers Pressures State Impact Response
DSR	Driver State Response
EEA	European Environment Agency
GCIF	Global Cities Indicators Facility
GIZ	German Corporation for International Cooperation GmbH
ICT	Information and Communication Technology
IKI	International Climate Initiative
INEI	Instituto Nacional de Estadística e Informática
ISO	International Organization for Standardization
m:ci	Morgenstadt City Index
MDG’s	Millennium Development Goals
NGO	Non-Governmental Organization
OECD	Organisation for Economic Co-operation and Development
PSR	Pressure State Response
SDG’s	Sustainable Development Goals
UN	United Nations
UNCSD	United Nations Conference on Sustainable Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCED	World Commission on Environment and Development

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Introduction

While writing the thesis, I was mainly involved in the Morgenstadt City Index development or reframing looking onto the topic of Piura, Peru under the framework of the by the Bundesministerium für Umwelt (Federal Ministry for the Environment) tendered IKI (International Climate Initiative). Through research on the City itself, as well as through the research on the various examples of other Indicator based tools, I studied the probable best approach in this case. Looking into this, I reviewed the in previous phases developed Morgenstadt Tool on its flexibility and its applicability

.

Until today, several methodologies and tools directing themselves onto the evaluation of sustainability and resilience of a city were developed. Supposedly they apply globally to various cities in order to support international decision-makers. Each tool has got different approaches as well as a different focus; therefore, I will look into some approaches, including the very renowned SDG's, as well as the by Fraunhofer developed Morgenstadt Index.

The current level of development of tools, looked at from a holistic point of view seems to be an approach to the topic of rating the cities development on a fundamental point of view. Current research on indicators has been done by several international institutions such as the United Nations, the World Bank and the ISO, the International Organization for Standardization. Looking at the different level of development of Cities, which are never comparable to each other, an evaluation system is not easy to apply in the same way on each City. Current research has been seeking to unite the most relevant indicators in order to develop a generally adaptable framework, but approaching the method of applying a developed tool will not be the appropriate approach when looking at cities as CAS (Complex Adaptive Systems).

I want to discuss, if applied to the case of the current IKI (International Climate Initiative) in Piura, Peru, an approach through one of the yet developed models is possible and if so, if it can spot and target the currently weak sectors within the City. Is it possible to deliver, as Morgenstadt Proposes with its set of indicators, a measurement of the future proofness of a city, the level of development in the areas of liveability, resilience, innovation and the aspect of a green city?

The research is aiming to evaluate urban development indicators in terms of their utility and palpability; to find out the necessities for an indicator-based tool that can be used by real-world decision-makers to inform their strategies for sustainability and developmental goals.

Recent research has addressed the question of how complex socio-technical systems can be transformed towards sustainability over a long-term time frame. In addition to technologies, "socio-technical systems" combine economic factors, human behaviour, the interests of actors, and regulatory references of the political system in an approach that builds particularly on the complexity of urban systems. Socio-technical systems can be described as historically grown structures and processes in which technologies are embedded in a complex mixture of grown infrastructure, economic structures and interests, political & regulatory structures as well as human behaviour and preferences for action.

A probable obstacle will be, to evaluate whether a set of indicators can be chosen and afterwards applied without the need for adaptation or modification. In case of the decision of a need for adaptation, is there a method to define the approach on which basis the level and area of modification shall be chosen?

I will describe how the Morgenstadt tool works, see its advantages and disadvantages towards other tools, see what other tools are there, that could be competitive, and analyze those. I will look into the various indicators and evaluate whether it is possible to apply a recurring set of indicators on different cities and if not how to approach the way or how to evaluate a city adapting the city's needs.

Development studies and policies have, since their inception, been relying heavily on statistics - yet there is a risk of perfectly valid data, if not correctly contextualized and integrated, giving rise to entirely deceptive insights. The in this context very often used word "indicator" will be analysed throughout this research.

With the acceleration of the global urbanization trend, large cities in developing countries are arguably the world's most central arena for sustainability and development initiatives by local and global institutions. Leveraging on science and tech, a whole landscape of new solutions and policies is at the disposal of such players, and their decision-making process should become ever more transparent and well informed, in order to apply their limited yet appreciable resources most effectively, with the widely accepted goal of sustainability in mind. Ever since then, the so-called Smart Cities are brought into context with sustainability. What is sustainability? What are sustainable cities, and which are their benefits? What impact will they have on their citizens' lives, and if considering the smart city concept, how far do we want our

urban context to be handed over into technological hand? What are the dangers and uprising more critical: how can we prevent climate-damaging behaviour?
Taken at face value, a currently available set of statistical indicators can be fragmented and may not necessarily convey each city's reality and needs accurately. The goals of this research initially were to come up with an analysis of the in the current process of IKI developed set of statistical indicators, that, when specially applied to cities in South America undergoing a rapid transformation process can inform fruitful decision making. The work being developed at Fraunhofer Institute under the framework of the Morgenstadt initiative (integrated since May 2018 by the Author) is addressing this problem, and the current research was supposed to evaluate its validity and utility, vis-a-vis other available methodologies. Throughout the process of writing the thesis, the methodology could not be developed and subsequently analysed, as initially intended. Due to political disagreements, the process got postponed and was not closed as the thesis was concluded.

Chapter I - City Systems

1.1 Description of current Urban Systems

In the 21st century, cities are at the centre of multiple dynamic developments of global proportion: Shortage on Resources (Rockström et al., 2009: 18), population growth and climate change, but also rising prosperity in emerging economies and demographic shifts are increasingly acting as global drivers. To counteract those CO2-intensive and resource-based systems, we are forced to radically change our production and consumption patterns as well as our Lifestyles.

Cities will be taking over an essential role in this Development. By 2030, nearly 5 billion humans will be living in cities, a vast majority of them in today's emerging and developing countries. (Angel et al. 2005). It is expected that cities worldwide will expand their current area by a factor of 2.5 by 2030 and seal up to 7% of the globally available fertile land (Angel et al. 2005). According to the Organization for Economic Cooperation and Development (OECD, 2010: 179-195), cities already consume 60%-80% of global energy production and are responsible for a similar share of greenhouse gas emissions (Angel et al. 2005).

Meanwhile, they are also responsible for the vast majority of the global value added: between 2010 and 2025 alone the GDP of the 600 largest cities worldwide will rise by over 30 trillion US $ and account for over 60% of global economic growth (Dobbs et al. 2012). It is expected that an additional amount of floor space will have to be built in the same period, corresponding to 85% of the total current global building stock (Dobbs et al. 2012). This increase of importance of urban space is accompanied by rapid technological and societal change, which is mostly determined by Digitalization. To not being dependent of technological developments and to be able to manage the transformation to new intelligent systems, we need to use an approach, that allows clean, intelligent and energy-efficient technologies combined with innovative business models and stringent administrative and policy approaches. A holistic approach to a so-called green economy (Dickel et al., 2013: 14–16) is needed to transform our current industrial society into a 'green society' based on sustainable resource use (OECD, 2015: 46-48). Looking into cities in Development, the preconditions for a green economy, not to speak of a smart city, differ.

Heat waves, health problems, floods, terror-attacks, migration, congestion, lack of water, overexploitation of soils, affordable housing for a growing population, etc. are just a few of the phenomena that cities around the world are struggling with. They point out an urgent need for a flexible urban development, which is able to respond rapidly to technological and societal change while creating a long-term foundation for a sustainable local economy and society. The challenge thus lies in the Development and implementation of sustainable and innovative processes and technologies in cities. On the one hand the need to satisfy the everyday needs of people, but at the same time consume radically fewer resources and energy than today's solutions and produce almost no waste and no emissions.

To date, approaches that combine an integrated analysis of complex urban structures with strategies and technologies for sustainable urban development are lacking. There are two possible main reasons to be found for this:

Urban infrastructures consist out of a complex number of systems, that need to interact together and interconnect with each other (energy generation, energy networks, transportation, production, Logistics & Goods flow, Construction processes, Supply and structures, Water infrastructures, etc.). These structures, in turn, are depending on technologies, processes, organization, social behaviour, business models and legal regulations. Interdependent interactions of urban subsystems lead to an exponential growth of Complexity. Risk and uncertainty have thus become system-inherent elements of the planning and operation of urban systems – which mainly occur when unpredictable elements (e.g. storms, rains, earthquakes, or also migration) take place.

Initially, entities like public or private institutions and companies are focusing on finding ways regarding specific solutions for particular problems. Often, there is no defined concept for communication between such institutions to be found. This miscommunication leads to organizations dealing with complex problems, responding to the necessities on single levels.

As a result, Organizations are being differentiated into separate actors. If the issue is too complicated to be solved by one institution, it is being divided into several smaller tasks and then distributed. However, the high Complexity of urban systems cannot be combined with the conventional approach of organizational differentiation of companies and institutions in sectors and individual technologies, since synergy effects and interdependencies must be considered on another level.

The importance of this field has sparked a good number of initiatives and studies worldwide, intending to gather and organize data related to Development and sustainability. The wide range of uses for this data forces it to be general and usage-agnostic. In a smart-cities framework, small and organic measures can yield excellent results hence the need of a bigger resolution lens, for example, national literacy data will often not offer meaningful insight into literacy in a city, let alone the vast discrepancies between different city areas.

From the scientific point of view, proven methods and models for measuring the efficiency of cities in terms of sustainability are lacking. Some of the approaches that were designed tenting to measure a city through different aspects will be presented in the following of this thesis. Later on, the case of Piura in Peru will be regarded.

When applying the different Methods, awareness needs to be created towards the circumstance that every city works and reacts differently. The Origin and development of cities are determined by numerous, closely interwoven factors on many levels (economy, culture, politics, society, infrastructure, geography, etc.). In this way, each city has got its fundamental constructs, which define the daily life of the population as well as the interplay between space, citizen and technology. It is pre-defined and permanently continued. This individual characteristic of cities presents each urban development model with the challenge of being flexible and standardized at the same time. Flexibility and the ability to respond are required to be able to meet the needs of the individual characteristics of a city. Meanwhile, a level on which they can be standardized is necessary to ensure objectivity and the comparability of results.

1.2 Definition of Complex Adaptive Cities

In this thesis, cities are perceived as complex adaptive systems (CAS) (Miller et al., 2009: 55-90), open evolutionary systems consisting of a multitude of interacting subsystems. In the general definition, CAS consist of a multitude of adaptive participants whose interactions result in complex, non-linear dynamic developments (Brownlee, 2007:1). The parallelism of events (including positive and negative feedback loops), conditionality, modularity as well as adaptation and evolution are elementary characteristics of complex adaptive systems (Ibid.: 4). The development of a city that takes place in parallel on many levels (technological, political, economic, social, etc.) is, therefore, more seen here as a progressing system than as a planned and controlled process.

The consequence of this definition of cities as CAS is reflected in the approach and the process. It is shared by several authors (Holland, 2006: 1-6; Vester, 2012) that a System understanding cannot be produced with conventional research methods that are traditionally based on the division of complex questions into their individual parts, which are then examined separately in depth. CAS lose most of their characteristics if individual parts are considered in isolation (Holland, 2002: 24-33). Therefore, a central aspect of a project is thus to identify fields of technology and action as well as impact factors that are relevant for sustainable urban development and to locate them in a systemic context.

> „As coevolving human-environment systems, cities are spatially heterogeneous, complex adaptive systems. As such, the dynamic trajectory of cities can never be fully predicted or controlled, but can and should be influenced or guided in more desirable directions through planning and design activities that are based on urban ecological knowledge and sustainability principles.“ (Wu, 2014: 2010)

The analysis of cities as CAS will be further exemplified in the context of this thesis in connection with the development of the "Morgenstadt Index" and Vesters Sensitivity Model.

Chapter II - Approaches to measuring cities today

When approaching the topic of city development and the usage of public space under the aspect of the development studies, two ‘thinkers of space’ (Charnock, 2014: 313-325) are to be mentioned, that have regarded the usage and influence of public space under the currently attention regaining topic of ‘the right to the city’ (Lefebvre, 1996; Harvey, 2003: 939-941). Harvey claims in ‘The right to the city’ (2003), that it is a human right, to remake and create an urban sociality. He questions, if the ‘chaotic forms of urbanization', we live in today, have been created by the citizens themselves. As an approach towards answering this question, the topic of justice within a city, as well as the definition of justice, is raised. There is a need for ideals within the question of an urban justice, as well as for utopian plans. Looking at the liberal financial markets, the profitable ownership within the private property market widens the gap between rich and poor, he states, that equality within the urban space, is not worth every price. As a solution, he proposes, the accumulation of capital, as well as the conception of right, which are embedded within it. Further, he suggests a new definition of the right to the city. This right should not give access to property speculations, but rather allow shaping the city with the citizens ‘heart's desire'. This would imply an active democratic participation in a more inclusive society.

2.1 What is Sustainability?

Notably, the term sustainability is rarely translated into other languages. It seems that an equivalent term is missing in other languages. This applies not only to sustainability but also to many other terms found in the Anglo-dominated development discourse. After Andrea Cornwall, many of those words are used or associated with agencies, that make use of those in their strategies, policies and reports compulsory. (Cornwall, 2010:4).
A look at relevant non-English documents shows that although the term 'sustainability', 'sustainable development' is translated, that these terms are defined as vaguely as their English counterparts. Our understanding of sustainability, as Cornwall has already stated, results from the use of the term in a manner similar to that used at the United Nations. If we contextualize the term sustainability, we can see that it is closely interwoven with the global environmental debates that arose, above all, around the Rio Conference in 1992. At the UN Conference on Environment and Development in Rio in 1992, the concept of sustainability was praised as an "important monumentum for innovation". The 'Rio Declaration on Environment and

Development' states that economic progress is only possible in the long term in conjunction with an intact environment (United Nations, 1992). In order to guarantee this, the 27 principles adopted at the time established the global right to 'sustainable development' for the first time. This means that the rights of those people who currently inhabit the earth should be taken into account just as those of those people who will live on our planet in the future (WCED, 1987: 43). The individual states are granted the sovereign right over the resources in their country while at the same time committing themselves to environmentally friendly behaviour. In the Rio Declaration, the international community called for close cooperation to preserve a healthy environment for the first time. If one considers the 27 principles to which the states have committed themselves, it becomes clear that parts of them are very similar to the requirements of the in 2012 adopted Sustainable Development Goals (SDGs), which will be discussed later on.

Within the Development Studies, sustainability functions as a how Thomas Gieryn (1999) calls it a boundary term, i.e. a term that can combine science and politics. In this context, Ian Scoones (2007: 589) writes: "sustainability as a buzzword is an influential and powerful meeting point of politics and ideas". Sustainability is, therefore, a buzzword in international development discourse, which was examined in more detail by Andrea Cornwall and Deborah Eade in 2010. Cornwall refers to W.B.Gallies interpretation of buzzwords (1956). She states that the general agreement of what those terms might mean in practice is based on the principle of the disagreement at the same time. (Cornwall 2010: 2). Also, regarding the term 'buzzword' it is again difficult to find a non-English equivalent for the English term. A 'trend word' could be a possible translation, but, similar to the term 'sustainability', it is too short to cover it in its entirety. The above-given definition of a developmental 'buzzword' is a critical one, but it seems correct in view of how these terms are used by different actors in the international political field. Among these so-called 'buzzwords' are many terms that are found mainly in the documents and strategy papers of the United Nations. Besides sustainability, the terms citizenship, participation and poverty reduction represent only a small part of the terms used at the international level to talk about development. The vagueness of these terms and the difficulty of defining the term that is accepted and uniform by all is at the same time, their strength and weakness. Discussing the buzzword sustainability, Scoones states:

> “It is at this complex intersection between science and politics (…) where words, with often ambivalent and contested meanings, have an important political role in processes of policymaking and development."(Scoones, 2010: 153)

It seems to be a characteristic of buzzwords, which also applies to sustainability, to recurrently appear with different meanings. Thus, the idea of 'sustainability' was already defined in 1987 in the 'Our Common Future Report' of the United Nations: "Sustainable Development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987:43). In the following years, intellectual debates on the aspect of 'sustainability' took place in various scientific disciplines before the term temporarily lost popularity again. This was mainly because the term could not achieve long-term success in its first appearance in connection with an environmental policy agenda within the United Nations. This was not so much due to the idea of sustainability itself as to a general disillusionment of the international community concerning environmental policy issues as a result of the failure of the globally developed environmental policy within the framework of the Kyoto Protocol and various other environmental conferences (Scoones, 2010: 157). Looking at what remains of the idea of sustainability today, Scoones states why it is again playing such an important role for global development:

> “With climate change and wider risks associated with environmental change in particular – whether biodiversity change or epidemic disease – now being seen as central to economic strategy and planning, there are clear opportunities for the insertion of sustainability agendas in new ways into policy discourse and practice.” (Scoones, 2010: 160)

The repositioning of the term in development policy discourse also opens up new opportunities for the actors involved. The term can unite various aspects of development policy debates. In its current meaning, the term is often brought into line with the terms robustness, diversity, resilience and protective measures. In view of the SDGs, which aim to combine a variety of different development policy measures under one catchword, it is not surprising that sustainability has been chosen as a strong boundary term for this task. Nevertheless, the term is not necessarily becoming more popular due to its revival within development policy. Supporters of post-modernity theories and post-development movements are particularly critical of the concept of sustainable development. As the founder of the degrowth movement, Serge Latouche sees a multitude of contradictions in the concept of 'sustainable development' alone. According to Latouche, the development policy of the United Nations is still geared to economic progress. This, however, can never be sustainable and can never be achieved through forms of so-called 'sustainable management':

> “Sustainable development is an oxymoron. It is a contradiction of terms and appears as a miserable or terrifying word. With leastly "unsustainable" development, we could maintain the hope that this lethal process would have an end. We could hope that one day it would be stopped, a victim of its own contradictions, of its failures, due to its unsustainable character, or from the exhaustion of the natural resources. We could reflect on “after-development” and work for a less desperate and damaged conclusion by putting together an acceptable postmodernity. The oxymoron of sustainable development takes any perspective of hope. It promises development for, and even as, an eternity!” (Latouche 2003:10)

Following Amaro (2003:16), the sustainable concept falls under the conceptual family of the ambient. He claims the ‚Ecodevelopment‘ developed by the Brundtland-Commission needs to fulfil three demands: an intergenerational solidarity, the integration of the management of natural resources into development strategies and the sustainability in production and consumption processes. Considering the developmental aspect, under which the term ‘sustainability’ was established, he sees a main critique within the industrial and economic concept that impacts the general concept of sustainability. Amaro (2017:83) cites Sachs (1992:1), who states, that ‘development stood as the idea which oriented emerging nations in their journey through post-war history.' The concept of development would also after the countries of the south were freed from colonies proclaim development as their primary aspiration, ‘having their eyes fixed on this light (of a towering lighthouse) flashing just as far away as ever: every effort and every sacrifice is justified in reaching the goal, but the light keeps on receding into the dark.’ (ibid.)

Amaro names another criticism that comes in synthesis with the developmental concept, which claims the concept of development was a result of a logic of inequality, of the domination of gender.

The concept of sustainability, therefore, comes associated with further definitions, which might lead to confusions whether it supports (Lefebvre, 1996) or opposes (Latouche, 2003) the citizens right to claim and shape their city.

2.2 How is Sustainability measured?

There is a variety of instruments and approaches from the governance sector that can help cities develop and implement a sustainability strategy.

Many representatives (Sachs, 2015; Rist, 2014) of this approach are turning their attention to emerging and developing countries. The focus is mostly set on poverty reduction, social participation, securing essential services and the environmental aspects of metropolitan areas.

2.2.1 Sustainability as a framework for city development

As stated at the beginning, a large number of global indicators show that only a rapid transformation of cities worldwide into CO2-neutral, resource-efficient, intelligent systems can minimize adverse developments in global ecosystems and at least reduce the associated severe impacts on the lives of many people.

Sustainability is as previously described a principle of urban development, which will also in the following be considered based on the definition in the Brundtland Report and the United Nations Conference on Sustainable Development (UNCSD) of 1992. Steps to be taken in order to reach a sustainable development are oriented towards the Sustainable Development Goals (SDGs).

The Fraunhofer Initiative, whose methodology will be regarded in the following of this thesis, has developed some principles for sustainable city development. It defines the following SDG Indicators as a basis (Radecki, 2013: 9):

- Reduction of per capita resource and energy consumption (SDG 7, 12, 13)
- Reduction of emissions (CO2, other greenhouse gases, or toxic substances) (SDG 13)
- Reduction of social inequality (SDG 10)
- Security of supply (SDG 2, 9)
- Creation of economic structures aiming at long-term stability (SDG 11)
- Increasing social well-being and life expectancy (SDG 3)
- Preservation of the natural basis of cities (SDG 15)
- Improving the health of urban ecosystems (SDG 11)
- Increasing resilience of physical infrastructures and social networks (SDG 11)
- Reduction of social and physical vulnerability of urban societies (SDG 11)

2.2.2 What is an Indicator? Meaning of Indicators

In order to assess sustainable development and to be able to implement and control the implemented measures, the status quo must be evaluated. In order to do so, the objectives pursued, and the criteria derived from those objectives form the basis. Due to its abstractness, however, the model of sustainable development is characterised by a lack of direct measurability. Many general frameworks for a standardised structure of indicators have been developed at regional, national and international level (Hák et al., 2016: 565-573). The amount of those has been named obsessive, and some authors even step as far as to call it an explosion of indicators (e.g. Morse, 2013; Riley, 2001). The UNSD (2015), therefore sees an explicit need for a framework to structure these indicators and to avoid arbitrariness throughout the selection process. For this reason, tools that not only define what to measure but also how to measure it (Singh et al., 2009) are required. The current status of and indicator-based assessment proposes the assignment of one or more indicators to a criterion, depending on the information content and significance of the available indicators. Measurement is particularly necessary here as a basis for describing the current situation, as well as for justifying the necessity of further activities with the aim of sustainable development and their planning, decisions and control in order to achieve the desired target level. Also, a retrospective performance review, i.e. for the definition as a research objective, can be better recorded through indicators.

Thus, measurement is a necessary prerequisite for processing a particular development as well as for the implementation of such a development within a framework as, e.g. the later topicised cybernetic controlling cycle (Vester, 2012). Measurement is understood as the mapping of an empirical structure into a numerical system, i.e. the assignment of values to benchmarking systems.

Kromrey (2000, 88) defines indicators as "observable evidence, i.e. facts that can be directly experienced, of a phenomenon that cannot be directly observed in its generality or abstractness". Born (1997a, 25), on the other hand, understands an indicator as a "measurand that provides information about a certain phenomenon, whereby it can summarise information in a targeted manner in order to facilitate a certain assessment". The difference among both definitions is that Born understands the term indicator as a quantifiable parameter, whereas Kromrey speaks only of obvious indications, which can also be of a qualitative nature. In the "Guide to Indicators in the Framework of a Local Agenda 21" (FEST 2000, 2000), indicators are therefore understood as "measures or indicators for evaluation and trend description". This reflects the fact that indicators can be both descriptive and normative.

Indicators are thus understood as simplifying, but important characteristic or measured variables as representative variables or " informational instances" (Ludwig, 1999: 102).

They enable the quantitative recording of the actual or target states of a system concerning objectives that cannot be directly measured, thus concerning the current state and the prognosis of trends.
This enables an execution control as well as an aggregation and reduction of complex real information and correlations. The communication of correlations, which is essential for CAS, can thus be facilitated. (Hammond, 1995: 1)

The use of indicators as a tool does not yet lead to sustainable development. It only makes it possible to measure sustainable development. Sustainability indicators should be based on the concept of sustainable development, characterised by interdisciplinarity and a cross-sectional character. The formulation of the indicators initially requires an understanding of sustainable development. It is, therefore only possible after determining the individual definition of sustainable development and its purpose. The indicators obtained can be used to evaluate various alternative courses of action. As indicator variables, preferably those variables should be chosen that depend on many other variables of the system. This improves the meaningfulness. These indicators can also serve as a basis for reporting on activities.
The development and application of indicators must take into account the quantity and actuality of information.
Any aggregation of information is associated with an implicit or explicit evaluation. The higher the degree of aggregation, the more blurred the problem description becomes. The lower it is, the more the results lose clarity (Radermacher, 1998: 411)
The starting point for aggregations is primary data. These are particularly useful for scientists who can analyse and evaluate the data using statistical methods. (Szerenyi, 1999: 35). Consequently, with each aggregation, the target group of the information should also be taken into account. Starting from these, various key figures and indicators can be formed. They can be identified for any point in time. In this context, KPIs (Key Performance Indicators) are supporting the

> 'understanding and use of quantitative data as a part of engaging to achieve sustainability in a complex and 'globalizing' world. All manner of information – presented in the form of quantitative 'facts', such as population demographics, climate change or resource-use data, and 'rankings' of one sort or another – provides important and useable evidence about the world.' (Scerri, A. et al., 2009: 222).

KPIs can also serve as indicators. Indicators are numbers which are intended to cover slightly more than the measured size.

Due to the more comprehensive importance for sustainable development, where many aspects cannot be directly quantified, when addressing sustainable development, the focus should as a first step be set on formulation and research on indicators. Hák et al. (2016) claim in this context, that 'without thorough expert and scientific follow-up Indicators may be ambiguous'.

Through aggregation, condensed or sum indicators can be formed. They combine several, but not all potential individual key figures or indicators to form a significant reference value, especially for decision-makers. In this way, they provide an overview of the essentials in the event of a loss of information. (Ludwig, 1999: 103) The indices can be calculated for any point in time, but already require a selection and weighting of individual criteria. As a further level of highly condensed indicators, especially for communication with the public, i.e. with non-experts, it is possible to form a label of value valid for a more extended period. This could take the form of a certificate, for example. This would represent the complex situation at a certain point in time as "fulfilled" or "not fulfilled" concerning specific objectives on two levels and can be valid for a more extended period.

An aggregation across different levels is not always possible or useful. Indicators are necessarily also part of sustainable development concepts. While the concepts of sustainable development are rather implementation-oriented, indicators initially focus on the measurement, presentation and collection of information. Situations and various alternatives for action can thus be described and evaluated with regard to the goal of sustainable development. Existing information deficits on the way to sustainable development should be bridged by the development of indicators and their subsequent filling with data. As an informational framework, they can then serve as a starting point for the identification of crucial problem and action areas, influencing and driving variables for sustainable development, and for starting points for controlling sustainable development. Aspects that can be assigned as components of sustainable development (e.g. gross national product, unemployment figures, data on pollutants in the environmental sector) represent indicators for certain aspects and objectives of sustainable development and thus enable individual aspects to be measured. However, a single indicator cannot usually fully describe a situation. Therefore, the development of target-oriented indicators is especially necessary for sustainable development as well as for the general coverage of an indicator system framework with a sufficient degree of aggregation.

2.3 Approaches to evaluate and enhance Sustainability

The following chapter gives an overview of different approaches that have been developed and used in order to measure city development regarding the aspects of sustainability. The development itself can be described and measured through indicators. As previously discussed, the measuring can be a simplification process, which implies the risk of putting together heterogeneous attributes.

The aim of using an indicator is to support decision-makers with an adequate overview of the necessary information, that might serve as a basis for further decisions, affecting changes in future issues regarding urban development. When developing an indicator, the city needs to be considered as a CAS. Each city has got its own needs, weaknesses and strengths, whereas the indicator itself for the moment of being applied is static and complicated to be defined adaptively. It is essential to consider the previously named attributes when approaching the measurement of a city through an already defined system.

Pursuing the development of an appropriate set of indicators, studies, previous analyses and other indices should be taken into consideration. Following, several approaches that previously have been used to measure cities will be used and compared. Those were mainly developed by the public, but also by the private sector.

2.3.1 SDGs

In 2000, the United Nations (UN) General Assembly adopted the Millennium Declaration, which resulted in the Millennium Development Goals (MDG's). These goals were to be achieved by 2015. This laid the foundation for a revival of international development policy. (United Nations, 2000) At the end of this time, a follow-up agenda had to be adopted in order to set new impulses for global development policy. To this end, the UN General Assembly initiated a further resolution. It adopted the Sustainable Development Goals (SDG's). Under this title, the United Nations set a new frame of reference for global development policy in September 2015.

Similar to its predecessor, the Millennium Development Goals, the United Nations is attempting to advance development cooperation worldwide by setting a clear timeframe and defining goals. To achieve "commitment to a global partnership for development" is the main goal of the United Nations. (UN System Task Team on the POST-2015 UN Development Agenda 2013: V). This legally non-binding commitment was signed by 193 states worldwide. During the presentation of the SDGs, it was pointed out that the goals of the MDGs not yet achieved should be incorporated into the current development agenda. The SDGs, therefore, do not only build on the MDGs, but they are also rather a continuation and should bring the already started projects and efforts of the MDGs to a successful conclusion. Under the slogan POST-2015 Agenda, a wide range of actors from all areas of development policy have been working on the global future before the MDGs expired. After this, it was agreed to draw up a new frame of reference based on the MDGs.

While this decision seems to have been taken without many critiques, the particular aspects of the content of such project in comparison to it are the subject of numerous discussions, critical debates and compromises.

With the "2030 Agenda for Sustainable Development", the member states of the United Nations have developed a roadmap to 2030. This is intended to promote sustainable social, economic and ecological development throughout the world. The goals are meant to implement fundamental improvements in the living conditions of all people today and future generations as well as the protection of the environment. The final document adopted by the heads of state and government at the "UN Summit Post-2015 Agenda" is entitled "Transforming our World: The 2030 Agenda for Sustainable Development".

The post-2015 process began at the "Rio+20 Conference" in 2012, where common goals in the fight against hunger, poverty and soil erosion as well as climate change and its consequences were developed and formulated. In the past, there have always been programmes that tried to tackle these problems individually. The post-2015 agenda is different: it links poverty, development and environmental agendas. For the first time, the international community also committed itself to the concept of sustainability, i.e. to making economic growth ecologically and socially compatible.

Concrete measurable and timed targets were not initially set in 2012. However, it was decided to draw up proposals for globally applicable sustainable development goals. These are the 17

Figure 1: United Nations. (2015). United Nations Sustainable Development Goals.

sustainability goals that were adopted three years later in September 2015 under the preposition "Transforming our World".

The Sustainable Development Goals comprise 17 objectives with a total of 169 sub-objectives. The eradication of extreme poverty (Goal 1) is a key element, but also the development of safe, resilient and sustainable cities are considered (Goal 11). Unlike its predecessor, the UN Millennium Development Goals, the SDGs should not be seen as a programme to improve living conditions in developing countries. Within the framework of the SDGs, all social, economic and ecological goals have equal status. The crucial aspect is sustainability, which should enable future generations worldwide to enjoy good living conditions in a healthy ecosystem. The SDGs intend to be a balanced system of interwoven and interdependent goals that shall be pursued simultaneously. The responsibility for implementation lies with the individual states. They are responsible for ensuring sustainable social, economic and ecological development in their country according to their means.

Despite financial support from the international community, in particular from developing countries, individual countries are encouraged to prioritise their most important goals. For example, it can be assumed that in the developing countries, there is a focus on combating poverty, while in industrialised countries, there is more emphasis on implementing climate targets. However, the networked structure of goals and sub-goals means that the achievement of individual goals can also have a positive impact on others. Thus, approaches are possible in the implementation of the SDGs that generate a dynamic process for the system as a whole through the selective achievement of objectives.

2.3.2 ISO 37120:2014

A seal that can be reached through a Set of Indicators is through the International Organization for Standardization. The international standard 'Sustainable development of communities - Indicators for city services and quality of life' defines methodologies for several indicators and establishes them in order to measure the performance of urban service providers and the quality of life. It follows the principles that are defined and can be used in accordance with ISO 37101, Sustainable development in communities - Management systems - General principles and requirements, and other strategic frameworks. This international standard is supposed to apply to any city, municipality or city administration that carries out the measurement of its performance in a comparable and verifiable manner, regardless of its size and location. As stated earlier, cities can make use of indicators in order to measure their performance. The ISO Standard 'Sustainable development of communities - Indicators for city services and quality of life ' claims that the existing indicators are often non-standardized, inconsistent or not comparable over time or with other cities.
As a part of a new set of international standards that have been developed for a comprehensive and integrated approach to sustainable development and resilience, this set of Standardized Indicators aims to provide a unified approach to what is being measured and how it is to be measured.

As a list, the ISO 37120 does not provide a justification of the values or thresholds or a numerical target value for the indicators. When complying with this standard, no legal status is conferrable in this field. Cities that comply with this standard to measure urban services and quality of life through the ISO indicators can only claim compliance with this standard. The fundamental purpose of these indicators is to be used to track and monitor progress concerning their performance in the development of sustainable principles. This tool must take into account the whole urban system in order to achieve sustainable development. It is essential that urban planning is taking the current use and conservation of resources into account in order to be able to plan better for the future. The indicators and associated test procedures according to this international standard have been developed to help cities, in particular, to measure the performance of urban service management and quality of life over time, through cross-system comparisons across a wide range of performance measures. The ISO standard is a frequently used tool for exchange within the public sector and is also accepted as a widespread standard at the non-research level.

Cities may not have direct influence or control over factors that determine some of these indicators, even when applying the ISO standard. For a meaningful comparison, however, reporting is essential and provides a general overview of a city's service delivery capacities and quality of life. According to the ISO 'Sustainable development of communities, Indicators for city services and quality of life', the indicators were selected in this international standard in order to make reporting as simple and cost-effective as possible. They can, therefore, reflect an initial platform for reporting. The indicators are structured by topic. In recognition of the global differences in resources and capabilities between cities, the whole set of indicators of city performance in terms of resources and capabilities has been divided into "core indicators" (the implementation of which must comply with this international standard) and "supporting indicators" (the implementation of which should comply with this international standard). Core indicators and supporting indicators are attached in the annexe.

Also, regarding the SDG's, the international standard ISO 37120:2014 is becoming increasingly useful for the assessment of status and progress on the basis of indicators and KPIs. The ISO indicators are supposed to help to clarify progress in implementation.

The basis for the indicators presented with the ISO standard was laid above all by the so-called 'Global Cities Indicators Facility' (GCIF) (Fox, 2013), an association of various institutional, private sector and municipal partners led and supported by the University of Toronto. Based on their preliminary work and test runs with cities, the proposed set of indicators for city reporting was further developed using the ISO standardisation procedure. At the same time, untreated task areas were identified for implementation in ISO 37120:2014, in particular, the addition of specific indicators for 'smart cities' and resilience, but also a clear reference to the already mentioned SDGs.

2.3.3 DPSIR

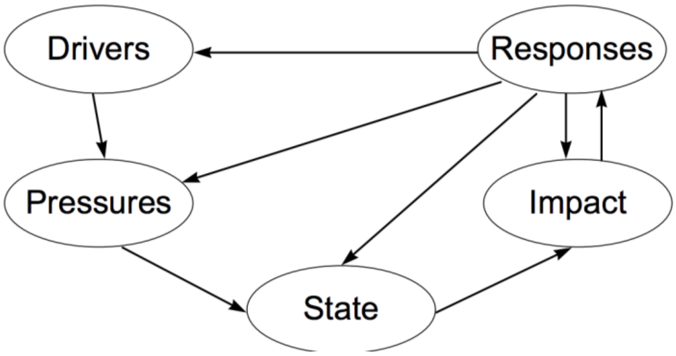

Figure 2:The DPSIR framework for reporting on environmental issues. (Smeets et al., 1999: 6)

The European Environment Agency (EEA) developed in the 1990s based on former environmental frameworks, as the Pressure-State-Response (PSR) (OECD, 1993) and the Driver-State Response (DSR) which is widely used for societal–environmental interrelations (Burkhard, 2008), a categorisation of environmental indicators that is particularly useful when they are embedded in indicator systems and functional relationships are to be demonstrated. The classification has since then frequently been used.

Accordingly, the letters D, P, S, I and R are standing for:

Driving forces: driving indicators show which human activities (e.g. land use) and lifestyles (e.g. waste generation) are responsible for the relevant environmental impacts of the world.

Pressure: Pressure indicators express which concrete environmental impacts are caused by (e.g. carbon dioxide emissions, pollutant inputs) through the various activities (sectors) are caused.

State: Condition indicators describe the quality of environmental media (e.g. air pollutants, water quality) and the availability of natural resources.

Impact: Impact indicators show the impact of changes in the case of environmental media, with regard to the overriding objects of protection (e.g. climate development) out.

Response: Action indicators measure by which means (e.g. nature conservation areas, Renewable energies) and, if applicable, with what objectives policy and society in the fields of action to respond to environmental changes.

The DPSIR model brings several main advantages. Firstly, it identifies the concepts of disaster risk, vulnerability and disaster impacts in the DPSIR model and places them within the ranking. Furthermore, it provides suggestions regarding how to implement the DPSIR model, which is a problem when using a tool by non-professionals. Also, it suggests starting from “Impacts” while analysing former cases and starting from “Drivers, Pressures and States” when examining potentially impacted zones without formerly gathered Information or experiences. The DPSIR model can help researchers explore causes and inspect risk management strategies from different angles.

2.3.4 Morgenstadt Approach

2.3.4.1 Why was it developed?

The Federal ministry of education and research approved the High-Tech Strategy in August 2006, as the first nationwide strategy on innovation in Germany. Concerning future technical and social challenges, this High-Tech Strategy aims primarily for improvement within the country. Therefore, cooperation in-between innovative and technological processes were supposed to be increased. Combining the resources of all federal government ministries this plan aims to invest around € 4 billion annually into the development of innovative nationwide tech-strategies.

As set in 2010, the objectives that, through the new High-Tech Strategy were supposed to be reached by 2020, were the development of a market for future sustainable urban systems, enhanced collaboration of research and industry and the further development of the general framework for innovation.

Core objective here is to establish Germany as 'a leading provider of science and technology-based solutions in the fields of climate & energy, security, mobility, communication, and health & nutrition' (Federal Ministry of Education and Research, 2010).

The Federal Government adopted the action plan to support the further development of the High-Tech Strategy 2020 in early 2012 and made available € 8.4 billion for the time from 2012 - 2015 in order to implement the actions defined in the plan.

These 11 determinants were defined within the High-Tech Action Plan as essential to innovative technological improvement and are stated:

1. „CO2 -neutral, energy-efficient and climate-adapted cities ("Morgenstadt“);
2. Intelligent restructuring of the energy supply system;
3. Renewable resources as an alternative to oil ;
4. Treating illnesses more effectively with the help of individualized medicine ;
5. Better health through an optimized diet;

6. Living an independent life well into old age;
7. A million electric vehicles in Germany by 2020;
8. More effective protection of communication networks ;
9. Increasing Internet use while decreasing energy consumption
10. Making global knowledge digitally available and accessible
11. Tomorrow's working world and its structure."

(Federal Ministry of Education and Research, 2010: 6–8)

The first topic „CO2 -neutral, energy-efficient and climate-adapted cities" is to be found on top of the defined determinants: Numerous cities find themselves challenged by the necessity for a sustainable, future proof city. Therefore, the German government assigned the leading role to this position within the 2020 Hightech Strategy Action Plan.

2.3.4.1 What is it?

The Fraunhofer society, which is the most prominent Institution of applied research in Europe, was then commissioned for the coordination of the Morgenstadt Initiative ('City of tomorrow / the Future'), aiming to develop sustainable, future proof cities, that are resilient to the challenges, that cities will have to face.

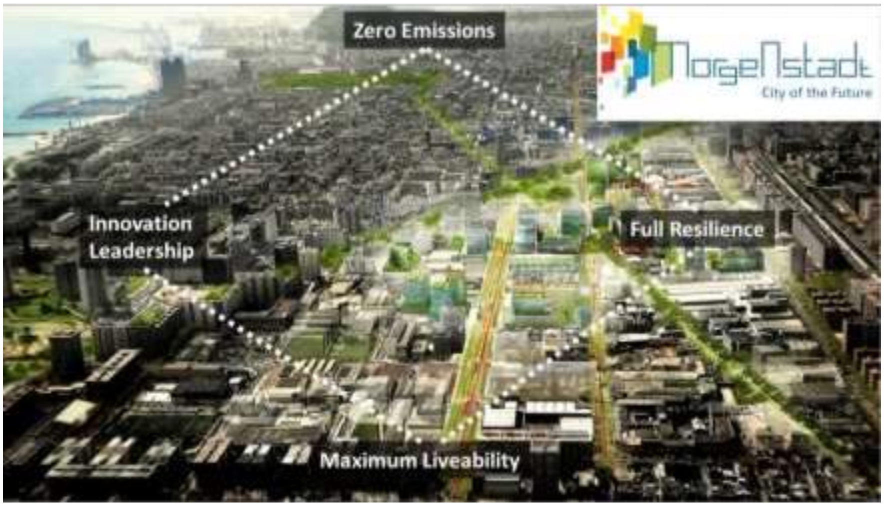

Figure 3: Morgenstadt Vision (Fraunhofer IAO, 2013, p. 24)

Following the Morgenstadt vision, those cities would produce zero waste and emissions, provide a high quality of life, general high living standards and a healthy, green and secure environment. Furthermore, it would leave space for innovation and would be resilient and sustainable. (See Figure 3: Morgenstadt Vision). Moreover, it supports a high level of democratic structures. Through innovative concepts as IoT (Internet of things), E-Mobility, and shared Economy etc. „future cities and city quarters will have to produce almost zero emissions or waste, enable a maximum quality of life for all its inhabitants, provide a maximum of resilience towards expected- and unexpected changes and deliver prosperity and progress through sustainable innovations“ (MCI Final Report, 2013).

"Morgenstadt: City Insights" is an innovation network of the Fraunhofer-Gesellschaft in which currently 11 Fraunhofer Institutes are working together with 15 industrial partners and 12 city partners on issues of sustainable urban development. The Morgenstadt Initiative surrounds three phases, on which all explanatory information will be given throughout the following section.

The Morgenstadt Model, a complex analytical framework developed in the course of the 18-month-long Phase I by around 50 Fraunhofer experts from 12 different Fraunhofer Institutes lies at the core of the City Lab.

2.3.4.1.1 Vester Model

The theoretical basis of this framework is based on the by Frederic Vester[1] In the 1970s developed biocybernetic[2] Sensitivity Model.

The fundamental concept of the Model is that the global structure we live in shall be regarded as a complex system which cannot be defined, understood or managed through linear planning and thinking. The linear, „unsystemic“ strategies of thinking and analysis needs to be dropped as not adequate, and simulations and comparable models need to update simple projections (Vester, 1976)[3].

In his works (Vester, 1976, 2012; Vester & Hesler, 1988), Vester highlights the idea of structures thinking, also as he calls it „interconnected thinking“, that he saw as essential in dealing with complex systems including contemporary towns and regions (Vester, 2012). The

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[1] Frederic Vester (1925-2003) was a biochemist and expert in the field of ecology. Besides the academic activities at Munich and St. Gallen University, he acted as a governmental and business consultant in biocybernetic strategies in public and private sector.

[2] „Cybernetics is the perception, control (steering), and self-regulation of interconnected processes with minimal expenditure of energy. Apt as the term is for new intellectual models, it has often been equated with control technology and computer guidance [...], with the result that it is frequently misunderstood. For this reason, we should do better to speak of “biocybernetics” (Vester, 2012: 150).

[3] Vester’s biocybernetic approach to deal with complexity is in detail described in his latest book “The Art of Interconnected Thinking” (2012)

resistance of decision-makers and policy advisers to adopt systems, which are demanding an answer has already ended in a wide variety of failed initiatives and projects. Natural catastrophes, like the ozone layer depletion, the desiccation of the Aral Sea, the desertification of previous fertile regions because of unsustainable agricultural behaviour, repeatedly occurring oil spills killing sea wildlife, the use of antibiotics in extensive animal breeding and therefor micro-organisms becoming resistant and animals extra inclined as well as global warming are only the beginning of a further expandable list.

The Sensitivity Model was developed in the 1970s, firstly applied in the UNESCO Project "Ecology in Urban Systems". This project was aiming to provide an insight into the infrastructural dynamics of a highly-populated area in order to be able to evaluate ecologically relevant measurements and proposals. (Vester, 1976)

The Aim of the Model is not, to predict future scenarios, which in complex systems is out of touch regardlessly. Instead, the Model is aiming to support the understanding of the driving powers. Like this, predictions about the system's behaviour can be made to enable a better way of dealing with the complexity of the system (Malik Management Zentrum St. Gallen, 2014). Looking at a future perspective, the Model is providing decision-making aids for complex systems, like cities.

2.3.4.2 Phases of Development

Phase I „Understanding Sustainable Urban Systems“

The aim of the first project phase (May 2012 - October 2013) was to determine a global status quo with regard to best practices of cities for sustainable development in the technology sectors of energy, buildings, mobility, ICT (information and communications technology), production & logistics, urban water infrastructure as well as in the cross-sectional areas of governance and security. The innovation network was led by the Fraunhofer Institute for Industrial Engineering (IAO) (Fraunhofer IAO, 2013).

Through the analysis of a total of 94 best practices from the six pioneering cities of Singapore, Freiburg, New York, Copenhagen, Berlin and Tokyo, the empirical research basis of "m:ci" represents the starting point for the consolidation of the results in a comprehensive analysis model for sustainable urban development.

These six cities hosted Fraunhofer teams in order to resume on their capability of innovation under the framework of an on-site workshop of 2-3 weeks: "identify the cutting-edge global status quo of sustainable city systems and to create a starting point for the research and development of innovations in future urban systems "(Ibid.)

NGO's, scientists, officials on a local and municipal level, as well as research institutions and other significant Stakeholders, were consulted through around 30 - 80 interviews in order to give a substantial evaluation on the state of development. As a next step, a workshop took place, and over 300 best practice examples were collected covering the sectors of energy, buildings, mobility, ICT, production & logistics, water infrastructure, governance and security, defining the 100 best practices for urban sustainability. The Morgenstadt City Index (m:ci) consisted of the following Indicators:

	Berlin	Singapore	NYC	Copenh.	Tokyo	Freiburg
Inhabitants in City (Total)	3,501,900	5,399,200	8,244,910	559,440	13,159,388	229,808
Size city (km²)	892	712	785	91	2.188	153
Increase of population (% p.a.)	0.39%	1.99%	0.90%	1.86%	0.46%	1.03%
Population density (inhab./km²)	3,927	7,163	10,506	6,127	6,029	1,501
Share of green areas/parks	11.93%	13.60%	3.44%	25%	-	3.70%
NO2 (µg/m³)	55.0	25	29.52	19.2	39.5	22
PM10 (µg/m³)	25	27	20	23.4	33.1	18
Amount of waste (kg /cap / a.)	652.86	1,198.82	1,602.56	1,478.44	341.96	168.15
CO_2 emissions per year (t. per cap)	5.4	6.67	7.1	5.38	4.8	7.97
Ecological footprint (gha/ cap)	4.4	5.34	7.2	-	4.9	3.9
GDP per capita (€ / year)	29,455 €	44,576 €	55,605 €	58,252 €	52,134 €	39,321 €
Rate of unemployment in %	12.80%	2.10%	9.60%	6.00%	5.00%	5.60%
Share of employment tertiary sector	87.60%	68.70%	95.00%	93.00%	80.80%	81.70%
Persons per Household	1.74	3.5	2.61	2.1	2.05	1.9
Average Age of population	42.9	33.5	35.9	-	41.8	40.3

Public spending on Education (%GDP)	4.60%	3.30%	2.23%	8.70%	-	10.92%
Total energy demand per capita (MWh/a/person)	19.8	19.2	25.8	13.6	15.3	22.6
Local renewable energy (%)	1.60%	2.30%	0.01%	37.30%	-	11.30%
Cars per 1000 residents	323.7	117.24	230	228	308	392
Exposure to natural disasters	low	medium	medium	medium	high	low
Water use per cap (liters per day)	112.8	155	476.2	104	249	93
Tariff for water supply (€/m³)	2.169	1.17	0.88	2.07	-	1.83
Size of Public Sector (city employees per 1.000 people)	19.8	38.7	54.5	35.8	12.5	18.3
Public confidence in government	low	high	high	high	medium	Medium
Voter participation in last elections	77.40%	93.18%	90.00%	87.50%	54.35%	67.00%
Police Officers per 1.000 inhabitants	4.61	1.60	4.14	1.37	3.52	5.24

Figure 4: City Performance- Selected Morgenstadt Indicators (The Morgenstadt Framework, 2013)

In the following, the development of the applied model is being explained, that was used in Phase II of the Morgenstadt Project.

Phase II „Creating Sustainable Urban Demonstrators“

Phase II of „m:ci City Labs“ (2014 – 2016) was built on the framework research and outcomes of Phase I. Its aim was the initiation of a long-term transition of non-sustainable cities of today into sustainable cities of the future and to thereby creating future reference projects of national and international importance (Fraunhofer IAO, 2014b). Five cities participated, amongst them were Prague, Chemnitz, Lisbon, Tbilisi, and Berlin. Multidisciplinary teams composed of Fraunhofer experts carried out on-site research in each city to identify their strengths and weaknesses and their potential for sustainable development. The cities then received thorough analytical reports of their sustainability profiles as well as action-oriented strategic roadmaps towards sustainable development (Fraunhofer IAO, 2014). The roadmaps included suggestions for innovative pilot projects that „clean integrated technologies with business models and innovative urban development approaches" (Radecki, 2014). Those were adjusted to the specific needs of each city. Especially crucial during Phase II was to tackle the issue of a lacking cooperation between the businesses, the science and the city identified in Phase I, regarding that addressing an urban living improvement, this would be the most efficient method of a transfer of innovation into real projects.

Phase III „Developing the Market for Sustainable Cities “

The current Phase III (2017 – 2020) is continuing the two previous phases. Its work is focused on the following four key aspects, the so-called „growth poles“ (Radecki: 2015,7), which are closely interconnected and mutually reinforcing, namely:

1. “Living Labs for urban systems solutions for the testing of new ideas and technologies in a real-world setting;
2. Innovation partnerships and strategies;
3. Business models for smart cities and smart districts, e.g. „Morgenstadt Marketplace“ where innovative businesses can offer cities customized sustainable solutions to best address their development challenges;

4. „Flexible City" concept including Cradle2Cradle[4] Solutions and adaptive urban housing concepts". (Radecki, 2015: 7).

These tasks imply partnership of applied research and strategic business development; therefore, this phase is undergoing a closer co-operation within the m:ci Innovation Network.

The Morgenstadt model initially represents a multi-level analytical framework that takes into account both quantitative and qualitative aspects of urban sustainability through indicators and so-called action field levels, that show up areas and interventions that need to be done. This is a significant advantage when compared with the other assessment instruments described earlier. Also, the third level - the impact factors - enables the collection of city-specific data that are not included in the lists of indicators and fields of action.

Another significant advantage of the model is its "living model character" - it can be adapted to the needs of each city analysed by adding new relevant indicators and fields of action and removing irrelevant ones.

Finally, the sensitivity analysis of the impact factors helps to identify the drivers, levers and indicators for change. This knowledge has a high practical relevance, as it is essential for the presentation of the strategic roadmap for the creation of sustainable foundations.

Being based on the empirical studies of the six leading cities in the field of urban sustainability approaches, the Morgenstadt Model is burdened with certain biases inherited from those cities, as its creators admit in the Final Report for the Phase I (Fraunhofer IAO, 2013). Four out of six cities (Copenhagen, Singapore, New York City, and Tokyo) are located in the coastal areas and are threatened by the danger of storm surge and flooding for reasons such as cloudburst, hurricane and tsunami events. This is why the resilience sector of the Morgenstadt Model also includes an action field „flood protection strategies". In this way, a flood is the only natural disaster that is analysed as an action field. However, keeping in mind that this model is meant to be applied in different cities, other natural disasters are just as important as floods but usually overlooked such as earthquakes, cold spells, heat waves or ice storms. Yet assessing vulnerability to disasters on the action-fields level is not possible as action fields describe the

[4] "Cradle-to-Cradle design (also known as Cradle2Cradle, C2C, regenerative design) is a biomimetic approach to the design of products and systems. It models human industry on nature's processes viewing materials as nutrients circulating in healthy, safe metabolisms. It suggests that industry must protect and enrich ecosystems and nature's biological metabolism while also maintaining a safe, productive technical metabolism for the high-quality use and circulation of organic and technical nutrients" McDonough and Braungart (2002).

resilience-building actions of the city, whereas natural vulnerability due to geographic location or climate is not an aspect a city can influence.

Moreover, assigning points for vulnerability (a negative phenomenon) would be illogical as the points in other action fields are assigned for resilience (a positive phenomenon): e.g. a question that relates to vulnerability: „Has an increased risk of floods in the future been identified?“. When replied to with a „yes“, this would mean gaining points for resilience, which is fundamentally wrong. As already mentioned before, several other important aspects are also left beyond the scope of the Model. These include, for example, environmental protection measures for vulnerability reduction and boosting of resilience, volunteer management, early warning system, evacuation plans, education programs and training on behaviour in emergency situations, provision of supply of potable water, food, medications and fuel. In addition, for thorough planning during phases in which the resilient city takes hold it is essential to know how much population is affected as well as for evacuation purposes it is vital to have the information about the number of people cannot move to safety independently and will, therefore, require assistance. Furthermore, the model needs to include other measures to be undertaken during the recovery phase, such as psychological assistance to the victims and the revision of plans and strategies based upon the post-disaster assessment.

Moreover, such an essential aspect as the involvement of households and businesses in all phases of resilience-building has not been given attention. Finally, all these additional aspects also need to be quantitatively assessed on the level of the indicators.

Chapter III - Application of M:CI in IKI

3.1 What is IKI

The IKI of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is financing since 2008 climate and biodiversity projects in developing and newly industrializing countries.

> 'The IKI is a key element of Germany's climate financing and the funding commitments in the framework of the Convention on Biological Diversity. The Initiative places a clear emphasis on climate change mitigation, adaption to the impacts of climate change and the protection of biological diversity. These efforts provide various co-benefits,

particularly the improvement of living conditions in partner countries.' (Federal Ministry for the Environment, 2018)

3.1.1 How was the Methodology Developed?

In order to conduct an assessment of the by the IKI targeted cities, a City Lab will be conducted. The City Lab is based on the Morgenstadt Framework, i.e. on over 100 (certified) indicators and 90 action fields. First, a comprehensive data analysis is performed. This includes an analysis of strategic documents such as, urban master plans. The aim is to use this information (analysis of fields of action and influencing factors) to individually identify the essential parameters for sustainable urban development and to demonstrate the interlinking of technologies, business models, usage processes, actor structures, as well as regulations and governance approaches. This is providing the basis for the on-site assessment. It includes interviews with relevant urban stakeholders and visits to relevant or planned projects. The results are presented in a city profile. The steps taken are the basis for the development of the roadmap with an investment plan.

The expected outcome of City Labs is a data-driven implementation strategy that promotes sustainable urban development, minimizes urban environmental pollution, reduces resource consumption and (indirectly) reduces greenhouse gas emissions. The roadmap aims to improve the efficiency of public spending, to develop secure sources of funding for sustainable projects, and ultimately to improve the quality of life of citizens.

Through capacity and expertise building, the project aims to build and strengthen national institutional capacities in adaptation planning and ecosystem management practice. The roadmap for the cities will take into account the corresponding on-site adaptation measures and link them with new measures. These strategies and processes will allow partner cities to anticipate and better respond to the impacts of climate change.

The concept of the Morgenstadt is based on the four pillars of sustainable urban development:

- Zero emissions/waste
- Full resilience to climate catastrophes
- Maximum quality of life of the inhabitants
- Innovation leadership

The Morgenstadt model is as previously defined directly linked to SDG No. 11, "Designing Cities and Residential Areas Inclusive, Safe, Resilient and Sustainable".

A key impact here is the ability of the local city administration employees to consider sustainable innovation in their planning and to prioritize it for implementation. Agile planning, stronger networking of city administration, research and local economy, as well as a higher adaptability of the city system, are the consequences.

In order to contribute directly to the Sustainable Development Goals (especially SDG 11 " Designing Cities and Residential Areas Inclusive, Safe, Resilient and Sustainable") in the implementation countries of i.a. Peru, the selected cities (including Piura) are supposed to be analysed in detail through a City Lab, which identifies the fields of action, strengths and weaknesses, challenges and opportunities in the relevant urban sectors.

After the analysis, the traceability of solutions is supposed to be demonstrated through three implementation projects. The aim is to facilitate urban innovation and transfer of expertise within and between partner countries. At the same time, the replicability and scaling of solutions to other cities are promoted.

3.1.2 Methodology IKI Development

Throughout the process, the Morgenstadt Team of which the Author of the thesis was part of, went through different phases. As a first step, the interdisciplinary team analysed the Framework of the Morgenstadt City Labs. The Indicators that were developed for the Morgenstadt City Indices were gone through thoroughly, in their detail and explanation. Some Indicators, like e.g. those, relating to the length of bike trails, being developed within the mainly European context needed to be updated or adapted.

Each Indicator was discussed on its relevance for the IKI, as well as on the Teams Capability to analyse it on site. Important aspects were if within the interdisciplinary team the scientific knowledge was given, to analyse different sectors of different focus groups. Potential external areas of expertise that should be included were discussed. A prospective Implementation was analysed, and a future best-case scenario was designed. The indicators themselves were detailed and explained, the explanation and understanding of an indicator were discussed and noted down, in order to be supportive in retrospective doubts or for later throughout the process participating scientists.

Indicators were then grouped into sectors of interest and afterwards merged with the Action Fields.

In order to orientate towards the most prominent example, the SDG's, each goal was discussed individually. Goals that were adaptable by the Morgenstadt Framework and within the capabilities of the research department were selected and assessed.

It was then concluded to conduct a desk-research on the M:ci index for each city. Throughout this process, chosen Indices were found out not to be applicable, as the benchmarking system would not suit countries outside Germany. In order to develop a country-specific Benchmarking, at least ten comparable Cities within a country would have needed to be assessed.

At that, the sectors were divided into new challenges, that could be identified within the city. An approximate goal was to select 20 challenges for the evaluation catalogue. The following sectors were elaborated:

- Governance
- Waste/ Mobility
- Environment and green infrastructure
- Economy
- Social
- ICT
- Energy and Buildings
- Water

All identified challenges of M:ci, as well as the challenges resulting from the Analysis of the SDGs, were merged. Those challenges were clustered, and a compilation of a list of suggestions for the challenges that cities might face in each of the sectors was included. The targets were distributed to the sectors within the SDGs challenges; missing challenges were added.

This process could have been facilitated, had the team already been prepared on how to execute a city lab in an emerging country with a focus on the specified goals of the SDG's. Furthermore, a more participative approach could have simplified the process. The stakeholders within the analysed city could have been involved, at least in an informing position, as the cities for the IKI were already chosen, and the indicators did not need a broad generalisation.

A list of challenges was developed, previously used Indicator Systems were taken into consideration and overlaps were edited. All challenges got linked back to the SDGs.

Afterwards, the Fraunhofer Institutes that would be involved as external consultants, as well as further external partners and experts were consulted.
Taking into consideration external knowledge on the theoretical framework, set a scope for indicators that should be left out. Those that were selected as non-suitable due to an overrepresentation or an elusive challenge were left in the list, in order to reflect the deselection of specific indicators.

3.1.3 M:CI Choice of SDG Indicators

Can Indicators be the right approach to measure & evaluate a city in the development context? When applying an indicator, the precondition needs to be on a comparable basis. Can the concept be transferred, and should it be transferred? It is questionable if the existing concepts, that analyse the current situations of cities and then reproduce a smart city to their needs can be transferred.
When speaking of transference, it must be clear that not a diagnosis is being transferred, but the idea. Challenges within a city are not always transferable, even though smart, preformulated approaches might seem most comfortable and bring a positive impact; the right solution might have been a different one. It is to be doubted if an indicator, that smartens up a city's internal structure can be applied, if the basic needs are not met and if the city still needs to build up basic infrastructure. An intelligent planning approach might be right in order to focus on different weaknesses, but is it hypocrite to ignore the reality of unfulfilled needs of a community, that lives within a city? As Lefebvre claims the right of the city's inhabitants to the city (Lefebvre, 1996), its inhabitants should be the ones, reaching for a smart city structure.
Technological development will from now on be part of a city's development, in particular under the framework of a smart city approach. The adaptability here seems critical. If these approaches fail to adapt to the local context, they might not add value, neither regarding the technological, nor the social aspect. As Schelings et al. claim, the Smart Cities

> ‘stability over time and thus its sustainability is consequently heavily dependent on the citizens' perceptions. Their acceptability is crucial: citizens have a decisive influence on the potential success/failure of the Smart City global model, as they have the power to decide which concepts or technologies they accept/reject, this way either enhancing or endangering the sustainability of the model‘ (Schelings et al., 2017: 1)

A precondition for the application and added value of technological developments and implementations, therefore, needs to be the acceptance within the citizens and the belief that technological implementations can be for their benefit and the community's well-being. Therefore, acceptance studies are a further basis, on which the successful analysis and implementation of technological transference or replication.

3.2 General Situation of Smart Cities in Latin America

After Berrone et al., the top 50 ranking of smart cities is dominated by European and North American Cities (Berrone et al., 2017: 39-40). The first Latin American city to be ranked is Buenos Aires in Argentina, represented on the 83rd position. (Calderón et al., 2017: 15-26)
As the idea of creating a 'Smart City' is not as broadly spread in the Latin American Countries, as it is in Europe and North America, the smart city development has no timely determination yet, neither has it been heavily analysed in terms of its technical, economical or environmental readiness.

3.3 Overview Piura

Figure 5: Piura, Peru

Peru is the third most affected by climate change country, as was underlined by devastating floods in early 2017. 66% of the Peruvian population lives in areas with a chronic water shortage. Besides, rural depopulation increases the pressure on urban centres.

Peru has a high degree of urbanization/urban growth and has identified urbanization as a source as well as a solution to many sustainability challenges in regional development strategies. However, Peru does not have a coherent approach that underpins urban climate change and sustainable urban development with innovation policy and efforts to develop clean and interconnected technologies and infrastructures. Although the 'Plan de Desarollo', the developmental Agenda, published by the local government of the Piura Region, exists (Gobierno Region Piura, 2017). It is set up for 2016-2021 and mainly directs itself to solutions

in the areas of territorial management and human inclusion, as well as to the patrimonial heritage.
The department Piura in northern Peru is an area which in regional studies is first associated with the Peruvian coast. The oil fields, the ports and the desert of Sullana are typical images of Piura, but they refer to its coastal region only. Piura has many natural resources. In addition to numerous mineral deposits, two economically important rivers, the Piura and the Chira, which run from the mountains right across the coast, permit high-yield irrigation farming. The flat land on both sides of these rivers is providing ideal preconditions for agro-industrial cultivation. It is home to some of Peru's most extensive and most prosperous agro-industrial plants in the sugar and cotton industries. Since the beginning of the 20th century, investors interested in modern agriculture have been pushing ahead with the construction of watering systems to regulate the irregular water supply of both rivers optimally. This is how the colonization area of San Lorenzo and recently the Chira-Piura project (Megapuerto San Lorenzo Megaport Project, 2004), one of the largest construction projects of the Peruvian state, came into being. However, the strong presence of specific industrial sectors and the preference of the state for investment in Piura should not cover the fact that the majority of the population lives in poverty. The former haciendas and the industrial plants do only employ a small part of the population. The rest of the population lives off micro-farming, supplemented by seasonal work during harvest time. Growing urbanization and the corresponding emergence of urban marginal settlements can be seen above all around the capital Piura.

Looking into the national statistics (INEI PERU, Instituto Nacional de Estadística e Informática) the main employment area in Peru is Agriculture, Fishing & Mining with a total of 4.266.000 people working in that area, whereas the trend is going towards a lower number since 2009, where the number was at around 4.152.000. Looking at the second most common area of occupation, the area of trade is the most significant sector. Here, the number of employed people has grown from 2.678.000 to 3.110.000 within the last nine years. Other relevant fields are the manufacturing industry, as well as transport and communications. It stands out, that when comparing rural and urban fields of employment, the number of people working in the public sector is 16 times higher in urban areas, leading to the conclusion, that these areas are only weakly covered. Data of the city Piura itself can be found online only based on the status of 1993 and will therefore not be further included in the current employment overview. (INEI – Perfil Sociodemográfico – Departamento de Piura)

Peru is divided administratively into 24 departments and a separate province, the port of Callao. This division is primarily caused by history, and political mechanisms drew the borders. The 1979 constitution laid down the formation of administrative regions to accommodate centralism from the capital. The regions were to provide a high degree of financial and administrative autonomy. The formation of the regions was carried out between 1985 and 1991. In contrast to the debate about other regions, the decision about the region of Piura and Tumbes, which are forming a common Zone, this one was free of conflict.

One main challenge that Piura is currently comparting is the repetitive frequently extreme natural event, the 'Fenomeno del Niño', which is causing floodings and landslides along the river. A further upstreaming problem is deforestation and the degradation (Guevara et al., 1999: 49-51) of the ecosystem. Conservation projects for maintenance and recovery of the current ecosystem services are not developed, neither implemented on a municipal or governmental level yet.

In order be capable to understand the weaknesses of the area and to take action to develop resilience, there is a need to understand and analyse the complexity and the need for integrating the three existing systems: environmental management, water resources management and risk management, coming together at the principle of urban environmental planning and management. After Bartone et al., Urban environmental planning and management aim to 'identify urban environmental issues (ideally before they turn into costly emergencies), to agree on strategies and actions to resolve these issues among all those whose cooperation is required, and to implement these strategies through coordinated public and private actions.' Furthermore, it should improve health and productivity in cities as well as reducing environmental hazards, and the protection of natural resources to sustain economic and social development.' (Bartone et al., 1994). Piura currently is facing the situation, that the previously listed three systems are disarticulated and are lacking a Common level of systematic coordination.

Therefore, it is necessary to clarify the functions of each institution and design a mechanism of collaboration.

In that regard and considering that one of the main upstreaming problems is deforestation and the degradation (Guevara et al., 1999: 49-51) of the ecosystem, it is necessary to implement conservation projects for the maintenance and a recovering of the current ecosystem services, in order to support resilience towards deforestation and the reoccurring floodings.

As a first step, Peru has, for the first time, introduced a national solid waste plan with a social perspective. The plan does not only provide sustainable waste management but also creates opportunities for sustainable local development and "green jobs" by integrating social, economic and environmental dimensions and recognizing the work of recyclers. After the UNDP (United Nations Development Programme), another current challenge is to raise awareness within the citizens. (UNDP Peru, 2019)

3.3.1 Interviews to the current situation in Piura, what is the actual current challenge

Looking into the current situation in Piura from a researcher's point of view was challenging while doing a 'desk-research'. The project research originally was supposed to be conducted under the framework of the Fraunhofer Morgenstadt City Lab, which would have been financed by governmental funds. As the German government still needed to set up its composition, the budgets were not released, and the initial project start got postponed from November 2017 to April 2019.

Field research could not take place on-site as initially intended. Except for some interviews, the research method was a desk research approach.

For further in-depth analysis, it is recommended to conduct research on-site. Reaching out to experts or involved citizens for an Interview turned out to be difficult from a distance. It turned out to be very difficult to obtain information about biophysical conditions, about municipal structures and land use since after I approached potential interlocutors, they would not get in touch with me or if so, not be able to provide any collected data, as there was none.

Nevertheless, Piura already has devised an existing plan for the further urban development of the City (Propuesta de Rehabilitación y mejoramiento del casco central de la ciudad de Piura, 2014). This Plan mainly considers land use. Resilience and other projects concerning the returning Storm El Niño are not included so far.

During my research, I became aware of a workshop, organized by the Newton Fund, a funding organization to support international projects run by the British Council. I was able to interview a participant, a Greek researcher from Cambridge University who had previously lived in Peru. The workshop took place on August 2018 and brought together 20 British scientists and 20 Peruvian participants, including members of the Peruvian government.

The group worked together for five days. After on-site visits and exchange of generating ideas for the future, the flooded areas in and around Piura were analysed. The interlocutor claimed that until 2018 the government had planned to take action. After the floodings, the Peruvian government reviewed the option to put up catchments in order to make the most damaged and impacted areas of Piura more resilient.

There is no information on biophysical measurements given or collected, but researchers would have used elevational plans and models to develop possible catchment systems, that could be applied in order to prevent a land move, a result of the massive natural impacts. Looking at the flood damage reduction compared to the cost-benefit model, the consideration was refused, a relocation would have been financially more viable.
As an output of the workshop, a report will be published. While writing the thesis, the report was not published yet. Amongst others, the sector of governance will be analysed.

Following the researcher I had talked to, the value of communities land or properties is low. Currently, the infrastructure is quite expensive, and the financial support from the Government in Lima is missing. Alternatively, it supposedly is challenging to acquire fundings to deal with a phenomenon that occurs every 20-30 years. As the business case cannot be considered, following my interlocutor, citizens are beginning to be more creative, trying to find temporary solutions. A more common problem then floodings are draughts. People instead want to deal with solutions for this frequently recurring event, than investing in a less repetitive problem like floodings.
It seems to be difficult for citizens to access running water or toilets. Also, roads are poorly developed, as the municipality does not want to invest in temporary solutions since they might be destroyed through the next natural incident. The interviewee proposed to bring more actors together, in order to elaborate on how a low-cost integrated solution could look like. He proposed building reservoirs to store floodwater, to provide while draughts. An article published by the Guardian proposes a similar method. As found on The Guardian, Jorge Nieto, Peru's defence minister (2016-2018), proposes the installation of reservoirs in the mountains, so that rainwater can be stored in the water-stressed country. That way would guarantee a constant water supply so that the rain can be profited off, being turned into a support of the dried-out zones. (Collyns, 2017)
Currently, the city of Piura has not elaborated a collaboration within the sector of governance yet. As stated in the interview, there are no attempts to establish partnerships, even though as it was stated, the governance structures would not be counterproductive. It is a 'working culture'.
Piuras population is mixed in terms of wealth. The Interviewee sees, no extremes as he did in Lima, but considering the urban situation, the city is equipped with wealthy, secure, as well as with weak and poorly invested areas without access to all the basic needs like water, infrastructure and housing.

Mentioning technologies, it seems to be an abstract topic to relate to Piura. Inhabitants of the city would not want to leave their houses in cases of thunderstorms, fearing theft rather than death, which again highlights the extreme poverty within the population.
Following an Interviewee of the Globally represented German Development Agency GIZ, the local university maintains prominent position, including competent engineers, which are active in their position and trying to get involved in current municipal political matters. Generally, the responsiveness is low when trying to initiate projects.
A researcher from the University of Piura claims that the main challenges Piura is currently facing still are the frequently extreme events as the 'Fenomeno del Niño', causing flooding and landslides along the river. She states it is crucial to understand the complexity and the need for integrating the three existing systems: environmental management, water resource management and risk management. Currently, the three systems are very disarticulated, and they don't coordinate. Therefore, she argues, the first approach would be to set up an organizational structure, that clearly defines the tasks of every institution and the way of communication.
Besides, deforestation and ecosystem degradation are building another massive and still growing impact on the population of Piura. She claims the necessity to implement conservation projects, in order to be able to maintain and recover ecosystem services, which face and include water regulation, water quality, control of erosion and avoid landslides. Beginning at a local level, the roadmap should be developed in an up-scaling direction, in order to include national-level institutions. Multisectoral participation on different levels is essential for a sustainable approach. Local knowledge shall be included and taken into consideration while comparing with scientific results. As a conclusion, a roadmap shall be developed and implemented.

As a conclusive result of the three interviews, the sentiment within the interlocutors proposes participative planning through building collaboration and enabling integration. As a first step, the problem analysis and prioritization shall be conducted. For this purpose, a Stakeholder Analysis needs to be mapped. In the case of already existing plans, those need to be identified. Existing regulations need to be taken into consideration.
Problems need to be discussed within the criteria of their effectiveness, feasibility, accessibility and efficiency. Subsequently, an analysis and a problem prioritization can be conducted. Priority areas for short, medium- and long-term projects can be identified here.
In order to proceed with new policies, governance needs to be involved. Roles and responsibilities need to be identified and clarified, which requires an evaluation process to be conducted. Existing committee and stakeholders need to strengthen their integration,

which could happen throughout a multilateral agreement and an accountability transfer. In order to ensure a knowledge transfer within policies and science, the integration of academia, i.e. the University of Piura, must be included. To integrate the broader population, communication mechanisms at different levels should be included, including social networks and newsletter. At the same time, sources of financing and investment shall be approached and secured.

As the last step, all existing plans and attempts need to be matched, and overlaps between those should be identified. A roadmap for the implementation should be planned, with a simultaneous definition of a collaboration mechanism, also including data sharing and monitoring and evaluation systems.

Conclusion

This chapter shall resume the previously illustrated topics, whether a set of indicators is applicable throughout various urban contexts, and if it can be replicated in different cities.

My answer to this question is yes, as long as the necessary preconditions are given. Therefore, my ideal circumstances would include a well-informed, interdisciplinary team, that might stand in a certain relation to the analysed country, with a basic understanding of the official language. Furthermore, a participative approach is required in order to involve and identify all necessary stakeholders, who will also be conducting the implementation of a jointly developed roadmap. If those preconditions are not fulfilled, I would doubt a proper implementation of the analysis, since an imposed analysis takes place here, which possibly does not fall back on more far-reaching problems. This could also derive from the fact that not all stakeholders might be involved in important decisions due to corrupt municipal governments. However, this raises the question of whether they can at all have the opportunity to participate in a previous stakeholder survey. The question of whether a politically unstable or politically infrastructure-weak system can independently involve the necessary stakeholders will have to be addressed in further research. A solution could be the imposition of policies that entail decentralisation of power as a prerequisite for the implementation of smart technologies. In further research approaches, it can be explored to what extent communities and countries would be interested in and would use the implementation of new technologies and thus agree to such a policy.

As the Iki project has not taken place yet, further research will be needed. In order to analyse and rate the results, the city lab needs to be conducted, e.g. interviews need to be held, analysis as well as data collection on-site. I consider the Morgenstadt approach as a well thought out methodology to measure the future-proofness of a city. It is flexible in terms of the individual challenges that cities are facing and adaptable for various cities with various difficulties, and it seems to be an excellent approach to execute an intense On-Site workshop, in order to collect all necessary data locally. Nevertheless, I am supporting the participative approach from the very beginning. Inclusion of local city representatives from different areas seems reasonable, regarding the fact that they are involved in local daily challenges. In case of a stakeholder exclusion, subtle tensions could be caused, that might be counterproductive in particular in a collaborative process, as well as evincing an arrogant attitude. Urban approaches, like the previously mentioned approach of Harvey and Lefebvre, claim the citizens right, to shape their city. Both approach the concept of urban development from a Marxist perspective, but Amaro's definition of the people-centred approach (2003:17), involving the citizens through participative development can be synthesized. Hence, it is crucial to reach the citizens through different platforms.

Finalizing I think, it needs to be kept in mind, that adding new, smart features or services to a city is a wholesome process, in which the citizens' needs should be understood, built and finally tested prior to implementation. The efficiency of a smart city or a city with smart tools is here depending on the local management and infrastructure, e.g. the city hall, industrial participants and academia. Therefore, the governance approach is not to be dismissed but rather needs an additional focus throughout the whole analyzation, as well as during the implementation process. Initiatives need to be brought together and to be supported throughout the implementation and growth process.

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Annex

Annex A ISO Core- and Supporting Indicators

ISO 37120: LIST OF INDICATORS

- 5 Economy
  - 5.1 City's unemployment rate (core indicator)
  - 5.2 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties (core indicator)
  - 5.3 Percentage of city population living in poverty (core indicator)
  - 5.4 Percentage of persons in full-time employment (supporting indicator)
  - 5.5 Youth unemployment rate (supporting indicator)
  - 5.6 Number of businesses per 100 000 population (supporting indicator)
  - 5.7 Number of new patents per 100 000 population per year (supporting indicator)
- 6 Education
  - 6.1 Percentage of female school-aged population enrolled in schools (core indicator)
  - 6.2 Percentage of students completing primary education: survival rate (core indicator)
  - 6.3 Percentage of students completing secondary education: survival rate (core indicator)
  - 6.4 Primary education student/teacher ratio (core indicator)
  - 6.5 Percentage of male school-aged population enrolled in schools (supporting indicator)
  - 6.6 Percentage of school-aged population enrolled in schools (supporting indicator)
  - 6.7 Number of higher education degrees per 100 000 population (supporting indicator)
- 7 Energy
  - 7.1 Total residential electrical energy use per capita (kWh/year) (core indicator)
  - 7.2 Percentage of city population with authorized electrical service (core indicator)
  - 7.3 Energy consumption of public buildings per year (kWh/m²) (core indicator)
  - 7.4 The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption (core indicator)
  - 7.5 Total electrical energy use per capita (kWh/year) (supporting indicator)
  - 7.6 Average number of electrical interruptions per customer per year (supporting indicator)
  - 7.7 Average length of electrical interruptions (in hours) (supporting indicator)
- 8 Environment
  - 8.1 Fine particulate matter (PM2.5) concentration (core indicator)
  - 8.2 Particulate matter (PM10) concentration (core indicator)
  - 8.3 Greenhouse gas emissions measured in tonnes per capita (core indicator)
  - 8.4 NO2 (nitrogen dioxide) concentration (supporting indicator)
  - 8.5 SO2 (sulphur dioxide) concentration (supporting indicator)
  - 8.6 O3 (Ozone) concentration (supporting indicator)
  - 8.7 Noise pollution (supporting indicator)
  - 8.8 Percentage change in number of native species (supporting indicator)
- 9 Finance
  - 9.1 Debt service ratio (debt service expenditure as a percentage of a municipality's own-source revenue) (core indicator)
  - 9.2 Capital spending as a percentage of total expenditures (supporting indicator)
  - 9.3 Own-source revenue as a percentage of total revenues (supporting indicator)
  - 9.4 Tax collected as a percentage of tax billed (supporting indicator)
- 10 Fire and emergency response
  - 10.1 Number of firefighters per 100 000 population (core indicator)
  - 10.2 Number of fire related deaths per 100 000 population (core indicator)
  - 10.3 Number of natural disaster related deaths per 100 000 population (core indicator)
  - 10.4 Number of volunteer and part-time firefighters per 100 000 population (supporting indicator)
  - 10.5 Response time for emergency response services from initial call (supporting indicator)
  - 10.6 Response time for fire department from initial call (supporting indicator)
- 11 Governance
  - 11.1 Voter participation in last municipal election (as a percentage of eligible voters) (core indicator)
  - 11.2 Women as a percentage of total elected to city-level office (core indicator)
  - 11.3 Percentage of women employed in the city government workforce (supporting indicator)
  - 11.4 Number of convictions for corruption and/or bribery by city officials per 100 000 population (supporting indicator)
  - 11.5 Citizens' representation: number of local officials elected to office per 100 000 population (supporting indicator)
  - 11.6 Number of registered voters as a percentage of the voting age population (supporting indicator)

- 12 Health
  - 12.1 Average life expectancy (core indicator)
  - 12.2 Number of in-patient hospital beds per 100 000 population (core indicator)
  - 12.3 Number of physicians per 100 000 population (core indicator)
  - 12.4 Under age five mortality per 1 000 live births (core indicator)
  - 12.5 Number of nursing and midwifery personnel per 100 000 population (supporting indicator)
  - 12.6 Number of mental health practitioners per 100 000 population (supporting indicator)
  - 12.7 Suicide rate per 100 000 population (supporting indicator)
- 13 Recreation
  - 13.1 Square meters of public indoor recreation space per capita (supporting indicator)
  - 13.2 Square meters of public outdoor recreation space per capita (supporting indicator)
- 14 Safety
  - 14.1 Number of police officers per 100 000 population (core indicator)
  - 14.2 Number of homicides per 100 000 population (core indicator)
  - 14.3 Crimes against property per 100 000 (supporting indicator)
  - 14.4 Response time for police department from initial call (supporting indicator)
  - 14.5 Violent crime rate per 100 000 population (supporting indicator)
- 15 Shelter
  - 15.1 Percentage of city population living in slums (core indicator)
  - 15.2 Number of homeless per 100 000 population (supporting indicator)
  - 15.3 Percentage of households that exist without registered legal titles (supporting indicator)
- 16 Solid waste
  - 16.1 Percentage of city population with regular solid waste collection (residential) (core indicator)
  - 16.2 Total collected municipal solid waste per capita (core indicator)
  - 16.3 Percentage of the city's solid waste that is recycled (core indicator)
  - 16.4 Percentage of the city's solid waste that is disposed of in a sanitary landfill (supporting indicator)
  - 16.5 Percentage of the city's solid waste that is disposed of in an incinerator (supporting indicator)
  - 16.6 Percentage of the city's solid waste that is burned openly (supporting indicator)
  - 16.7 Percentage of the city's solid waste that is disposed of in an open dump (supporting indicator)
  - 16.8 Percentage of the city's solid waste that is disposed of by other means (supporting indicator)
  - 16.9 Hazardous Waste Generation per capita (tonnes) (supporting indicator)
  - 16.10 Percentage of the city's hazardous waste that is recycled (supporting indicator)
- 17 Telecommunication and innovation
  - 17.1 Number of internet connections per 100 000 population (core indicator)
  - 17.2 Number of cell phone connections per 100 000 population (core indicator)
  - 17.3 Number of landline phone connections per 100 000 population (supporting indicator)
- 18 Transportation
  - 18.1 Kilometres of high capacity public transport system per 100 000 population (core indicator)
  - 18.2 Kilometres of light passenger public transport system per 100 000 population (core indicator)
  - 18.3 Annual number of public transport trips per capita (core indicator)
  - 18.4 Number of personal automobiles per capita (core indicator)
  - 18.5 Percentage of commuters using a travel mode to work other than a personal vehicle (supporting indicator)
  - 18.6 Number of two-wheel motorized vehicles per capita (supporting indicator)
  - 18.7 Kilometres of bicycle paths and lanes per 100 000 population (supporting indicator)
  - 18.8 Transportation fatalities per 100 000 population (supporting indicator)
  - 18.9 Commercial air connectivity (number of non-stop commercial air destinations) (supporting indicator)

- 19 Urban planning
  - 19.1 Green area (hectares) per 100 000 population (core indicator)
  - 19.2 Annual number of trees planted per 100 000 population (supporting indicator)
  - 19.3 Areal size of informal settlements as a percentage of city area (supporting indicator)
  - 19.4 Jobs/housing ratio (supporting indicator)
- 20 Wastewater
  - 20.1 Percentage of city population served by wastewater collection (core indicator)
  - 20.2 Percentage of the city's wastewater that has received no treatment (core indicator)
  - 20.3 Percentage of the city's wastewater receiving primary treatment (core indicator)
  - 20.4 Percentage of the city's wastewater receiving secondary treatment (core indicator)
  - 20.5 Percentage of the city's wastewater receiving tertiary treatment (core indicator)
- 21 Water and sanitation
  - 21.1 Percentage of city population with potable water supply service (core indicator)
  - 21.2 Percentage of city population with sustainable access to an improved water source (core indicator)
  - 21.3 Percentage of population with access to improved sanitation (core indicator)
  - 21.4 Total domestic water consumption per capita (litres/day) (core indicator)
  - 21.5 Total water consumption per capita (litres/day) (supporting indicator)
  - 21.6 Average annual hours of water service interruption per household (supporting indicator)
  - 21.7 Percentage of water loss (unaccounted for water) (supporting indicator)