# Introduction

According to the Department of Economic and Social Affairs of the United Nations Secretariat, 53% of the world’s population resided in urban areas in 2014 and the world continues to urbanize rapidly (United Nations 2014). The process of urbanization is accompanied with challenges regarding economic, social and ecologic aspects. For example, even today, 60-80 per cent of energy is consumed in cities, and cities account for 75 per cent of carbon emissions. Consequently, “to make cities inclusive, safe, resilient and sustainable” is one of the sustainable development goals which were developed as an outcome of the United Nations Conference on Sustainable Development (Rio+20) and came into force in 2016 (United Nations 2016).

According to the definition by Yin et al, 2015, “a smart city is a system integration of technological infrastructure that relies on advanced data processing with the goals of making city governance more efficient, citizens happier, businesses more prosperous and the environment more sustainable”.

There are many activities in the context of the smart cities projects in different domains for instance in energy, mobility, water, last mile logistic, business, etc. Looking at all of them from above, it can easily be seen that these hot topics all have some overlaps with each other. Offered solutions in the framework of Smart City projects are mainly focused on new technologies such as “Humble lamppost”, “parking sensors”, etc. for various domains such as energy, mobility, crowd management, etc. Each of these technologies is well adapted to the present needs of the cities and performs precisely in such a way that all the requirements for the specific challenges of the cities are met. Nonetheless, these are top down solutions. In fact, the lack of adequate bottom-up approaches to a dominance of top-down and supply-focused solutions resulted in indirectly ignoring the sustainable integrated solutions. Looking at the definition given above, it emphasises the role of smart data infrastructure in approaching toward sustainability.

Globally, many cities have committed to ambitious goals to make their cities smart and sustainable especially with focus on climate adaptation and mitigation. But most are struggling to bridge the gap between their aspiration and the practical steps that lead to measurable impact. This is where districts come in. Districts have the autonomy, and are an effective unit of scale at which to test integrated systems and bottom-up solutions that can help accelerate sustainability and meet climate goals.

According to the Oxford dictionary, district means, “An area of a country or city, especially one characterized by a particular feature or activity” or “A region defined for an administrative purpose”.

According to these definitions it is very hard to define the border of a district. Indeed, the district has different definitions varying from country to country. From the governing and administrative point of view even in central Europe the way a district is defined varies considerably. For example the Metropolis of Greater Paris has quite a specific structure: Looking at the map of Paris shows that the core area belonging to the city of Paris, is divided into 20 administrative districts while the surrounding suburbs as parts of Greater Paris have a different structure. Each of the suburbs itself can have more than one subsections. Each of these subsections, called “arrondissements” in French, has its own commune or so called cities. These cities may consist of several districts. This example shows that the definition of a district can vary even in a country. Therefore, dealing with districts means working with a vast variety of features, challenges and opportunities of a part of a city.

One of the reasons that the focus from cities has been shifted to one lower scale, i.e. district, is the fact that in the district scale, it is more likely that overlaps of different sections and fields can be discovered. It is also more realistic to bring different stakeholders to the table on this scale and to discuss with them and find out what and where the barriers are. If smart and sustainable actions in one district are successfully applied, other neighbouring districts will no doubt be willing to look at this district and try to adapt the solutions in their areas.

The goal of being twice as productive with half the resources (materials and energy), leading to a factor 4 improvement in efficiency.

The concept was introduced in the 1998 book, Factor 4, written by Ernst von Weizsäcker, founder of the Wuppertal Institute for Climate, Environment & Energy, and L. Hunter Lovins and Amory Lovins of the Rocky Mountain Institute. The book explains how relatively easy it is for businesses to achieve these results with existing technologies. It has many examples of real-world projects that save money and reduce pollution simultaneously. Another way of phrasing the Factor 4 efficiency gain is that it reduces energy and materials usage by 75%.

While Factor Four is a common term representing a minimum four-fold increase, Factor 10, “ten times as much productivity from the same inputs”, represents an even greater challenge. Factor 10 equates to a 90% decrease in resource usage.
ICT, or Information and Communications Technology (or technologies), is the infrastructure and components that enable modern computing. In fact, there is no single, universal definition for ICT. However, it is generally accepted to be a combination of all devices, networking components, applications and systems which allow people and organisation to communicate and interact with each other in a digital manner.

Although there is no single, universal definition of ICT, the term is generally accepted to mean all devices, networking components, applications and systems that combined allow people and organizations (i.e., businesses, nonprofit agencies, governments and criminal enterprises) to interact in the digital world.

But what is the role of ICT in the management of smart and sustainable urban infrastructure?

Over the past few years, advances in the ICT have significantly challenged the traditionally stable management of urban infrastructure service provision. This has resulted in increasing interest from both private vendors (technology vendors) and public authorities in the transition of their urban areas towards being smart and sustainable. There is no doubt that information and communication technologies have the potential to assist citizens and government in facing the challenges, but it also becomes obvious that monolithic IT system or sectoral smart city solutions might not be suited well for taking into account all the diverse challenges.

The systems and technologies as they are offered by the big players from the IT domain are quite often top down proprietary solutions whereas distributed bottom up solutions might be more suitable taking into account the variety of stakeholders involved in smart city projects: these are owners (e.g. municipality, housing companies, citizens), administrations (e.g. municipality), service owners and providers (e.g. energy providers, transportation and mobility companies) and citizens, all having different interests, goals and tasks and last but not least already existing IT systems helping them to fulfill their specific tasks. The solutions proposed by the big players are mostly related to IoT and Big (unstructured) Data, often not taking into account the variety of structured data sources – such as cadastral data, utility networks and so on - which are already available in diverse IT systems used by city administrations. Moreover, although nearly 100% of the data analyzed in the context of smart cities is related to artificial and natural physical objects in the city, geospatial information often does not play a major role in smart city projects.

According to our experiences in the last three years, during interactions with some of the European districts, it was observed that most of the time the problem is not a lack of data but how to access it and how to know which data are useful for different use cases in the district. Finding the right persons or organizations who have the required information, is on its own a challenging task but convincing them to offer their information in such a project is a big barrier in the transition process. Due to the open data culture in Scandinavian districts this is way easier but still in some domains the problem exists. The system and data providers (who are mostly private bodies) cannot be forced to share their own data and services with others but should rather be encouraged to give access to others to work with their data. To do so, they should know that they can link their systems to the platform without a huge effort and that they can define the level of access to others in a controlled manner. In this way, the data security and privacy concerns can be well handled and the stakeholders can be encouraged to integrate their system and data into such a platform. Such a data platform cannot be a monolithic system that can be installed on one machine but consists of multiple individual components some used by everybody and some specific to individual stakeholders.

On the other hand, the way this distributed systems should be managed is not yet clearly stated in any of the given solutions in the “Smart Cities” initiatives. How these distributed systems are related to each other is often overlooked. This is very essential especially when it comes to evaluate the effects of one solution on other solutions and aspects and elements of the system. Therefore, the lack of a common relator may result in misinterpretation of the consequences of the decisions.
The abovementioned facts have inspired us to think about a smart data infrastructure that can be used by any district or city for managing their data infrastructure in a standard manner. The result of this, led to the development of "Smart District Data Infrastructure" (SDDI).

The Smart District Data Infrastructure (SDDI) (the concept shown in the above image) is designed based on an open, distributed, spatially-enabled system architecture capable of integrating structured as well as unstructured data as well as a bottom up process for addressing the specific information needs of specific city challenges. The SDDI is currently being implemented in four big European cities, and is going to be implemented in the new districts coming from different parts of Europe.