

Smart Cities and the Low-Carbon Economy as Drivers of Productivity

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Abstract

The World Confederation of Productivity Science (WCPS) takes a broad, inclusive and holistic view of productivity recognizing that to be sustainable, businesses, governments and other organizations have to address the social, environmental and economic dimensions of productivity. The development of smart cities and low-carbon economies align well with these three dimensions.

Smart city development has progressed from sustainable, to smart, to smart sustainable cities. Throughout, this development, the three pillars of sustainability; social, and economic have remained at the forefront.

In a parallel development, there has been movement towards a low-carbon economy. The triple bottom line of the low-carbon economy, "people-planet-economy", aligns with the three pillars of sustainable cities. Importantly, this triple bottom line and the smart cities' three pillars of sustainability align with the three dimensions of productivity recognized by the WCPS.

This position paper posits that, when viewed through the lens of the WCPS productivity framework, smart cities and low-carbon economies are not just about mitigating climate change, but are in themselves drivers of sustainable productivity.

1. Introduction

We live in a world in which 55 per cent of the world's population lives in cities, and where it is predicted that by the year 2050, 68 per cent of our population will live in cities [1]. Many cities have huge populations, for instance, Tokyo, with a population of 38 million is the largest city by population in the world, the same population as the state of California and the same as all of Canada [2]. Global climate change is putting the world at risk [3] and as cities take up just two per cent of global land area but account for 70 per cent of global emissions, they have a major role to play in mitigating climate change [4].

Since the early 1980s there have been agendas for the development of "sustainable cities" [5, 6], where sustainability is defined by the three pillars of social sustainability, environmental sustainability, and economic sustainability. In the early 1990s the emphasis shifted to "smart" cities, then to "smart sustainable" cities [7]. Recognizing that cities themselves are a significant cause of climate change [4], there has been a considerable effort to address sustainability and, more broadly, climate change through the application of technologies and processes to create climate smart or carbon smart cities [8].

While the names and foci for smart and sustainable cities have evolved over the last 40 years [9], the three central pillars have remained constant over this period [9]. These three pillars are recognized as essential to having liveable and sustainable cities [10].

Over the last few years the low-carbon economy has grown in an effort to combat climate change. A low-carbon economy is based on low-carbon power sources, minimizes the output of greenhouse gas (GHG) emissions into the biosphere, and specifically refers to the greenhouse gas carbon dioxide [11]. Central to the low-carbon economy is the "triple bottom line", articulated as "people-planet-economy", which aligns with the three pillars of social,

environmental and economic sustainability.

This position paper makes two important contributions. The first is to show the alignment of the pillars of smart city development and the triple bottom line of the low-carbon economy movement with the WCPS view of sustainable productivity. The second contribution shows that when viewed through this WCPS lens, smart cities and the low-carbon economy become important drivers of productivity.

The remainder of this paper is organized as follows: section 2 shows the alignment among the WCPS, smart cities, and low-carbon economy models; sections 3 and 4 discuss the evolution of smart cities and the low-carbon economy, respectively; section 5 makes the case for smart cities and the low-carbon movement as drivers of sustainable productivity.

2. Model alignment

2.1. WCPS dimensions of productivity

At the 2008 World Productivity Congress in Sun City, South Africa, the WCPS launched their concept of SEE (Social, Economic, Environmental) productivity, recognizing that to be sustainable in the longer-term, organisations, nations and regions need to improve all of social, environmental and economic productivities so that their operations are socially equitable, environmentally bearable and economically viable [12].

Social productivity is the efficient conduct of social interactions and transactions. Environmental productivity measures an economy's relative efficiency in its use of and impact on natural resources, and economic productivity measures how efficiently goods and services can be produced. Figure 1 illustrates the interaction among these three dimensions of productivity. Sustainable organizations fall in the area at the overlap of the three dimensions.

This is the lens through which we view smart cities and the low-carbon economy. It should be noted that Figures 1, 2 and 3 are essentially the same, illustrating the alignment of the pillars of smart cities, the triple bottom line of a low-carbon economy, and the three dimensions of productivity.

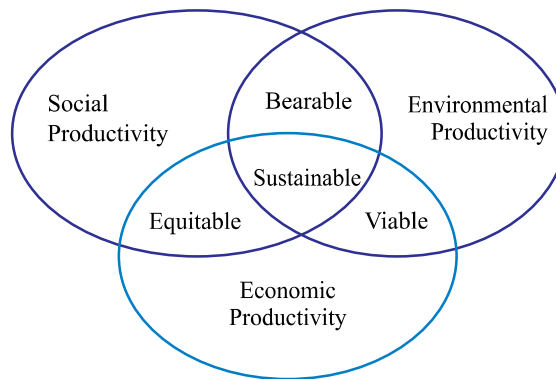


Figure 1. WCPS three dimensions of productivity.

2.2. Sustainability pillars

The concept of sustainability of cities predates the 1960s environmental movements, evolving into the concept of "sustainable development" by the 1980s [9]. The three pillars of sustainable development; social, environmental and economic sustainability are defined as follows [13]:

- Social sustainability is the ability of a social system, such as a city, to function at a defined level of social well-being indefinitely.
- Environmental sustainability is the ability to maintain rates of renewable resource harvest, pollution creation, and non-renewable resource depletion that can be continued indefinitely.
- Economic sustainability is the ability to support a defined level of economic production indefinitely.

Purvis, Mao and Robinson [9] discuss in some detail the origins of the three pillars of sustainability and the three rings as shown in Figure 2.

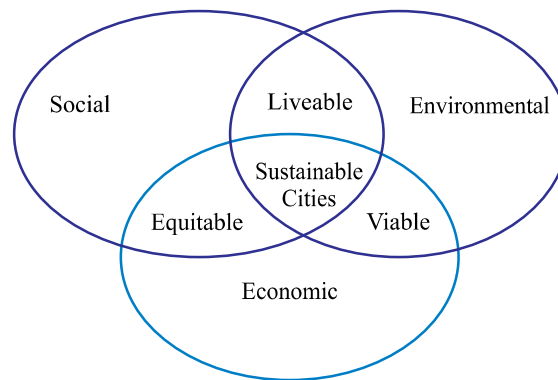


Figure 2. Three pillars for sustainable cities.

2.3. The triple bottom line

Similar to the three pillars of sustainability, the triple bottom line concept is central to the low-carbon economy. Although the "triple bottom line" was first articulated [14] as financial performance, with responsibility for social and environmental concerns, the triple bottom line is now more generally articulated as "people-planet-economy".

These triple bottom line can be defined as follows:

- "People" should be able to live and function in a healthy and safe environment.
- "Planet" should produce less carbon emissions, use less energy, produce less waste and use renewable sources of energy.
- "Economy" will be more sustainable with lower energy costs, carbon taxes avoided, and the monetization of the low-carbon infrastructure.

This triple bottom line aligns closely with the three pillars of sustainability. As an example, a developed country will have building codes that define the minimum legally permissible level of performance for attributes that support key building code objectives which often include health & safety and energy efficiency. Building codes may embody elements that address all three sustainability pillars - people (through health and safety); economic (through energy efficiency); and environmental (carbon emission implicit to energy efficiency).

Figure 3, the Triple Bottom Line for sustainable buildings, is very similar to Figures 1 and 2 and illustrates the realised co-benefits of improved health of people; reduced operating costs; and increased organisational productivity.

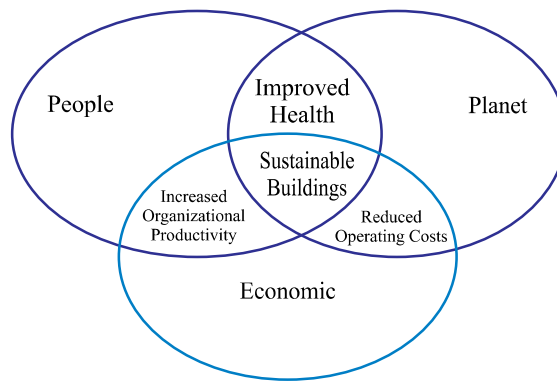


Figure 3. The triple bottom line in sustainable buildings.

3. Smart cities

Over the last 40 years, the thinking on city development has progressed from sustainable, to smart, to smart sustainable, to climate smart cities. What has remained constant throughout this progression has been the three pillars of sustainability.

The term "sustainable cities" was first used in the early 1980s [5] and then in the UN Brundtland Report [6]. The idea of sustainable cities is based on the three pillars of sustainability as described above. Although there are often more pillars included in the discussion, these three sustainability pillars are consistent throughout and virtually all of these additional pillars can be reduced to these essential three pillars.

The concept "smart city" was introduced in 1994 by Dameri and Cocchia [15]. However, a sustainable city does not have to be smart, and a smart city does not have to be sustainable. Similarly, a smart city that has advanced technology embedded in its organization is not necessarily a sustainable city if it does not align strategically with the three pillars of social, environmental and economic sustainability. Ahvenniemi, et al. [7] argue that, "A general goal of smart cities is to improve sustainability with [the] help of technologies." In other words, apply smart technologies to make a city more sustainable. Thus, they suggest that the term "smart sustainable cities" may be more accurate than simply, "smart cities".

Recognizing that cities account for 70 per cent of global emissions, there is now pressure towards the development of climate-smart or carbon-smart cities. The Climate Smart Cities (CSC) program [8] recognises that climate action in many cities depends in part on the presence of a clear, compelling economic case for action. Led by the University of Leeds, and supported by the Centre for Low-carbon Futures, research in the CSC program has pioneered the development of new approaches that examine the economic case for cities to act on climate change. In doing so, the program looks at the case for investing in various sectors, such as transportation, water and waste management.

4. The low-carbon economy

A low-carbon economy is one that minimises the emission of GHG by the end-uses (typically buildings, transportation, agriculture, and manufacturing) and the input energy (typically electricity, and combustible fuels such as oil, and gas) upon which they rely. The 197 countries that pledged to achieve significant carbon reduction under the 2015 "Paris Agreement" [15] and the Glasgow Climate Pact of 2021 [16], have agreed implicitly to develop a low-carbon economy to combat climate change. The degree to which they are successful in developing and maintaining a low-carbon economy will determine the success in achieving the carbon reduction targets in the short and long term, respectively.

Core to a low-carbon economy is policy that steers public and private sector investment and action toward decarbonisation. Policy, while necessary is not sufficient. In addition to policy there must be technical solutions that are both effective and affordable. While there is little disagreement that deep carbon reduction can be achieved (80% by 2050 relative to 2005 levels) what is not clear is what the economically optimal pathway would be [17]. This economic concern is expressed in both the Climate Smart Cities program and the C40 program referenced above.

Low-carbon economies require low-carbon energy and low-carbon materials. Low-carbon energy can be generated through new clean energy generation techniques, clean electricity generation and smart grids, and through decarbonized gas generation. Low-carbon energy is then used to power low-carbon buildings, low-carbon manufacturing and low-carbon transportation, contributing to a low-carbon economy.

Countries such as Canada have realised significant carbon reduction [18] through greening of the electricity grid by phasing out coal-fired plants and massive integration of renewable energy. While expensive, an accelerated Canadian phase out of coal fired electricity plants has been estimated to result in a reduced future health burden valued at \$5 billion [19].

5. Productivity impacts

The alignment of smart cities and low-carbon economies with the three productivity dimensions presented by the WCPS can be leveraged to increase productivity as illustrated by the following few examples.

5.1. Productivity impact of smart cities

While there is still a gulf between the promise of a smart city and the full realization of a smart city, there are obvious areas in which smart cities enhance productivity.

The Global Fund for Cities Development in collaboration with UN Habitat, developed a platform on smart cities with more than 300 cities across the world to evaluate the social impact of smart city investments. Its work suggested that the return on investment in smart public lighting systems is usually seven years and such investment can help lower the cost of the service by up to 75%. Another example can be found in Tokyo (Japan), where the installation of sensors on water pipelines allowed for saving more than a hundred million of litres per year by reducing leaks. Such examples show that smart city investment can have a measurable impact, and also to deliver services and infrastructure for all. [20]

Traffic congestion in major cities is responsible for lost productivity, a decline in social sustainability, and increased GHG. The Hindu [21] reported that lost productivity in Bengaluru due to traffic congestion cost \$4 billion USD a year, while the Times of India [22], in a study of four major Indian cities calculated the cost of lost productivity to be \$14 billion USD. Even in sparsely populated Canada, the loss is calculated to be about \$4 billion CAD per year. [23] Such lost time is lost productivity, a social loss in terms of time not available for individuals to use for other purposes. Such traffic congestion wastes fuel, which has an impact as both an economic cost and an environmental cost. The release of these carbon emissions into the atmosphere, has consequences for the economy now and for the environment in the years ahead.

Smart city projects such as being undertaken in London can have a major positive impact on traffic congestion. The Smart Mobility Lab is deploying the world's most advanced urban testbed to provide 5G connectivity for connected and autonomous vehicles. O2, the mobile operator enabling the testbed reported that the value of 5G for road management systems could reduce time for motorists stuck in traffic by 10 percent, save the economy £880 million a year, and reduce CO2 emissions by 370,000 metric tons per year. [24]

5.2. Productivity impact of low-carbon economy

Cities account for 70 per cent of global emissions [4] and as every city has buildings, and buildings and construction accounted for 39 per cent of the global emissions [25] in 2017, low-carbon buildings are a cornerstone of a low-carbon economy.

There are assessment and certification frameworks for sustainable (low-carbon) buildings. Industry and NGOs have developed voluntary sustainability programs, such as LEED (USA, Canada), BREEM (UK), HQE (France), etc., to which a building can be certified. To accelerate the uptake of certified sustainable buildings, organisations such as the World Green Building Council and Canada Green Building Council (CaGBC) have demonstrated that buildings certified to their rating system out-perform non-certified buildings in three areas [26]: energy efficiency (and more recently carbon footprint); wellness; and economic value - the triple bottom line.

Voluntary sustainability programs such as LEED [27] have used a balanced score card approach where the designer selects a series of measures from a basket of sustainability options. The number of options incorporated into the design determines the overall sustainability rating. As early versions of the program did not have mandatory energy efficiency requirements, a certified building did not necessarily outperform a non-certified building [28], but on aggregate certified buildings were shown to perform better.

Recently, human resource data have been available to objectively assess organisational productivity [29]. On aggregate, persons working in a certified office building tended to report being happier, and healthier than their counterparts in non-certified buildings. As well, workers in green certified buildings had higher manager assessed performance, were more engaged and more committed to the employer. These studies objectively demonstrated the potential for organisational productivity gains and a triple bottom line improvement through investment in sustainable certified green buildings.

Studies have shown that certified green buildings command a greater leased-rent than a non-green building [30]. However, more work is needed to understand the building attributes that are responsible for the financial benefits; develop key performance indicators and monetise these in a framework for valuation of buildings. Like cities, smart or intelligent buildings make use of data-driven technologies and analytics and/or AI to drive greater operational and energy efficiency, which translates into significant carbon reduction when the input energies are carbon intensive. An example of a smart building attribute could be a retro-commissioning system with automated fault detection and diagnostics to identify inefficiencies in building HVAC operations which when remedied can significantly reduce energy consumption and building operating costs, while having potential to increase occupant comfort.

Going beyond operational carbon reduction, voluntary programs such as the Zero-Carbon Standard of the CaGBC sets a threshold of zero carbon emissions for new and existing buildings [31], while requiring reporting of the estimated total carbon footprint associated with the building over a sixty-year service life to promote low-carbon design and selection of lower carbon materials. The life-cycle assessment can be expanded to include the total cost of ownership (capital for construction and operations and maintenance) over the same period of time. A recent study [29] demonstrated that while a zero-carbon building in Canada will have higher capital cost over its lifespan it will have a positive net-present value compared to a building built to code minimum.

6. Discussion

Throughout the evolution of smart cities the three pillars of sustainability have remained at the forefront. In parallel to sustainable and smart city development, there has been movement towards a low-carbon economy. The triple bottom line of the low-carbon economy aligns with the three pillars of sustainable cities. This potential convergence of the low-carbon economy and sustainable cities can help to dramatically mitigate climate change and will further enhance sustainable productivity.

There are currently many assessment frameworks for smart and sustainable cities, but few if any for an entire low-carbon economy. There are, however, strong assessment frameworks for low-carbon buildings and ultimately there is the potential to expand these to include low-carbon neighbourhoods and low-carbon cities. This would be consistent with the "groundswell" of sub-national initiatives discussed by Bernstein and Hoffmann [33].

An alignment between smart cities and the low-carbon economy assessment frameworks is needed to inform policy and guide investment. Given that the goals of both the smart cities programs and the low-carbon programs are well aligned, an alignment of assessment frameworks would inform sustainable productivity assessment frameworks.

Climate smart cities that adhere to the pillars of social, environmental and economic sustainability and the triple bottom line of "people-planet-economy", will not just have a mitigating effect on climate change, but will be drivers of sustainable productivity.

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