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FROM LOW CARBON BUILDINGS TO SUSTAINABLE CITIES

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FROM LOW CARBON BUILDINGS TO SUSTAINABLE CITIES

Sustainability transitions in the built environment towards the UN Agenda

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ABSTRACT

This thesis addresses sustainability transitions in the built environment, from buildings to the metropolitan scale, while ranging from low carbon development to the multidimensional challenges currently faced by cities. Emphasis is made on the urban global south, with special focus on Latin America.

The work is structured in four stages. First stage focuses on finding a low carbon path for the building sector, based on scenario projections from existing policies. Under a life-cycle approach, results reveal a path consisting on reducing emissions from: 1) building materials and constructive systems; 2) energy use at operation stage for both new and existing buildings; and 3) residential waste management. Results show potential synergies between mitigation and adaptation goals, while showing that low carbon measures do not perform equal between industrialized economies in temperate regions and emerging economies in tropical climates, thereby highlighting the importance of science based and context specific policy making.

Second stage addresses current science, policy and practice relative to the sustainable BE, regarding thematic areas, goals and issues set by the New Urban Agenda (UN, 2017a). Findings show that mainstream scientific research, international certification systems and public policy instruments are mainly focused on resource efficiency and environmental quality. Hence, other environmental aspects, such as low carbon development, natural disaster risks reduction and biodiversity protection are conferred less importance. Likewise, social issues, such as inequality, informal settlements, housing, security, culture and heritage as well as economic aspects; such as local economic development and job provision, are all receiving marginal attention in the framework of the sustainable BE. However, findings also show that some policy instruments issued in Latin America address topics of the global agenda in a more comprehensive way as compared to some green building certification schemes that have been widely disseminated over the last decades, suggesting that the Region is building self-sufficiency to align global issues with national priorities.

Third stage analyses the potential role of the built environment in fulfilling goals, targets and issues of the UN Agenda. Links between subjects, goals, targets, thematic areas and issues of these four major multilateral agreements were analysed. Findings show that NUA underlines the critical role of spatial planning and design for realising inclusive cities; protecting cultural heritage; boosting local economy and creating jobs; while optimizing the use of natural resources; protecting ecosystems; decreasing carbon emissions, adapting to climate change and reducing natural risks. Hence, when bringing the SDGs to the urban sphere, extensive and strong interactions concerning infrastructure, housing, public space and informal settlements, become evident. Likewise, since urban resilience,

climate action and disaster risk management are included in both NUA and SDGs, the implementation of the Paris Agreement and the Sendai Framework may also be linked to the sustainable built environment. These results allow producing an integrative framework of the global agenda, useful for guiding directions towards urban sustainability transitions.

Fourth stage addresses urban transformative change by assembling perspectives on sustainability transitions on low carbon buildings and the sustainable built environment. Concerning low carbon buildings, findings show that regulatory rules of the socio-technical regime tend to favour the implementation of low carbon measures, whereas normative and cognitive aspects play a strong role as implementation barriers. In this sense, emerging national policies are advised to make use of a Multi-Level Perspective on transitions, aligning with international private agendas, in order to widen opportunity windows within the socio-technical regime, while adopting a bottom-up approach that uses existing innovation niches to actively promote low carbon innovations that are already available in the market. Although conventional instruments may still be useful, policies have to evolve on the use of novel instruments based on stakeholder networks, sequential experimentation and gradual up-scaling, in order to facilitate the progressive learning required by socio-technical systems to undergo long-term transitions.

Concerning sustainability transitions in the built environment, an exploratory method was used here to 1) link analytic perspectives on sustainability transitions, thereby allowing to produce an integrative conceptual model of the built environment as a socio-technical-institutional-economic-ecologic system; 2) linking transition management perspectives in the Urban Transformative Capacity framework (Wolfram, 2016) and 3) connecting both the conceptual model and the managing framework with the UN agenda, in order to provide elements for issuing and navigating transformative urban policies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AFOLU: Carbon emission sector comprising Agriculture-Forestry and Other-Land-Use

AM: Adaptive Management

BAU: Business-As-Usual Scenario. Specially used here in reference to GHG emissions

BE: Built environment

CAMACOL: National Trade Union of the Building Sector in Colombia

CCCS: Colombian Green Building Council

CDW: Construction and demolition waste

$CO_{2\text{-eq}}$: GHG emissions expressed in CO2 units of Global Warming Potential

CONPES: Policy document issued by the National Department Planning in Colombia

COP: Conference of the Parties. Governing body of the UNCCC

GHG: Greenhouse gases

GMS: Great Mind Shift Perspective on Socio-economic transitions

IPCC: Intergovernmental Panel on Climate Change

MLP: Multi-Level Perspective on socio-technical transitions

MPA: Multi-Pattern Perspective on socio-institutional transitions

NDC: Nationally Determined Contributions on Climate Change

NGO: Non-Government Organization

NUA: New Urban Agenda

SDGs: Sustainable Development Goals

SNM: Strategic Niche Management

STAM: integrative analytical model for understanding sustainability transitions of the built environment

TM: Transition Management

UN Agenda: Compendium of the four major multilateral agreements issued in the UN framework (SDGs; the Paris Agreement, the Sendai Framework and the NUA

UN: United Nations

UNEP: United Nations Environmental Programme

UNDP: United Nations Development Programme

UN-Habitat: United Nations Programme for Human Settlements

UNFCCC: United Nations Framework Convention on Climate Change

URT: Urban Resilience Transition

UTC: Urban Transformative Capacity

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PREFACE

The study of natural sciences provided me with the most fabulous narrative to interpret the world: the living things existing on our planet all arose from a single-celled being that swam in a warm pool 4,000 million years ago. All life that we know is connected to that story and yet our life, that of human beings, seems to be part of another narrative, one where planet, time and life, exist because we are there to observe them and transform them.

Nowhere on earth do these two narratives seem more distant from each other than in cities, and yet nowhere are they so close that they collide with each other. In the city, everything seems to tell us about ourselves, about our technology, about our success as a species to escape natural laws. But at the same time, cities do not produce food, water, energy, materials. Cities cannot absorb our emissions, clean our sewage, process our waste, and as we are now witnessing, urban life does not keep us from diseases, it can actually make them spread faster. Without the constant flows and interactions connecting them to the natural world, cities simply would not be. Nowhere else are we frailer.

Cities are the largest physical evidence of our transformative capacity, yet are precisely for this reason the largest physical evidence of exceedance over planetary boundaries. Cities are also a physical display of social inequality, yet are also the places that more densely gather our knowledge, our creativity, our affections, our places, our cultures.

In no other place like in cities and at no other time like now was it so urgent to reconcile these two narratives of the world. I would like to think that here is a tiny contribution to help us fulfil this task.

1. INTRODUCING THE RESEARCH

Sustainability of the built environment is a basic support for urban sustainability and thereby for fulfilling aspirations raised by the global Agenda for Sustainable Development. From social perspective, the built environment consists on the collection of buildings and public spaces where people live, work, learn and interact, plus the infrastructure required to satisfy human basic needs. From the economic perspective, construction's value chain involves multiple economic sectors such as mining, industry, transport, energy, water, sanitation, real estate and finance. Accordingly, construction-related expenditures are estimated to contribute 13% to global GDP, while employing 7% of the global workforce (Barbosa et al, 2017). From the environmental viewpoint, the built environment faces important challenges though. Operational stage of buildings consumes 30% of the world's final energy, while manufacturing building materials consumes an additional 10%. Therefore buildings are estimated to be responsible for 30-40% of all energy-related carbon emissions. 12% of water consumed by humans is used by buildings (UNEP & IEA, 2017). Roughly 40-50% of the global material flow is used by the construction sector and construction and demolition waste - CDWs account for 40% of solid waste streams in developed countries (UNEP, 2010).

All of these challenges and opportunities will continue to rise, as urbanization increases. Currently, 4.3 billion people live in cities, representing 55% of the world´s population. By 2050 numbers will rise to 7 billion and will be equivalent to 75% of the population (UN Habitat, 2020). Consequently, it is expected that 60% of the buildings that will exist in 2050 have not yet been built (UNEP & IEA, 2017). This multiple relationship between social, economic and environmental aspects; confers the built environment a fundamental and cross-cutting role regarding the fulfilment of the Global Agenda set by the Sustainable Development Goals, the Paris Agreement, the Sendai Framework and the New Urban Agenda (UN, 2016). Hence, a transition to a sustainable built environment is urgently required, particularly in the developing world, where not only, most of current urban growth taking place, but also where cities have been strongly defined by low institutional capacity and commodification of urban land, thus given place to complex urban challenges, such as housing deficit, incomplete infrastructure, ecosystem lost, environmental pollution, social exclusion, informal economy and increased exposure to natural disasters (UN, 2017a).

This thesis aims to develop a comprehensive conceptual and management framework that allows understanding and encompassing the multiple processes, scales, dimensions and challenges relative to the sustainable built environment, in order to contribute to the design of urban transformative policies. Specific aims are: 1) Demonstrating the importance of guiding national and local actions on urban sustainability based on context-specific scientific information; 2) Evaluating the incorporation of goals, targets and issues of the UN Agenda into the current science, policy and practice of the sustainable built environment, in order to help filling knowledge gaps, adjusting existing instruments and strengthening available tools; 3) To build a comprehensive on the UN Agenda to the built environment based on interactions relating goals, targets and issues across the four current major global agreements and 4) To propose a conceptual model of the built environment, by simultaneously incorporating social, technological, economic and ecological aspects at different scales in order to offer both an integrative tool for understanding sustainability transitions and an a comprehensive framework for transition management under the Transformative Urban Capacity concept, in line with the goals and targets of the UN Agenda.

1.1. JUSTIFICATION AND STATE OF THE ART

1.1.1. Low carbon buildings

On a global scale, the building sector is responsible for 36% of energy-related GHG emissions, showing at the same time the greatest cost-effective mitigation opportunities, thus being a key sector to fulfil the aspirations raised by the Paris agreement by 2030 and achieving the goal of decarbonizing the global economy by 2050 (Parikh et al., 2014; UNEP & IEA, 2017). In developed economies, located in temperate regions with marked annual climatic seasonality, it has been determined that operational stage is responsible for up to 80% of the total emissions of the life-cycle of a building (Gong & Song, 2015; Chau et al., 2015). Therefore science, policy and practice regarding sustainable building make particular emphasis on energy efficiency during this stage as the top priority climate action (Guldager & Birgisdottir 2018; UNEP & IEA, 2017).

However, these facts may regionally differ, depending on multiple factors, such as climate; urbanization dynamics; dominant construction systems and materials; technological development and electric power sources, among others. A roadmap for effective climate policies in the building sector must come from understanding context specific conditions determining emission sources and adaptation priorities.

This section aims to assess existing local and national policies concerning climate action in the building sector in Colombia, with the aim of identifying their potential to allow complying the National Determined Contribution by 2030, and furthermore, to achieve decarbonisation by 2050. Results are expected to provide useful information for national policy adjustment and updating, while providing useful methodological criteria for policy making at other emerging economies, with increasing urbanization dynamics, particularly in Latin America and the Caribbean.

1.1.2. Science, policy and practice of the built environment and the UN Agenda

Sustainability of the BE is a key aspect for transitions to sustainable cities. It is related to all the issues of the New Urban Agenda (UN Habitat, 2017; UN 2017; Tollin, 2017), it may contribute to the fulfilment of the 17 SDGs (Opoku, 2016) as well as to the implementation of the four priorities of the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) and it may play an important role on climate change adaptation and mitigation, also contributing to the fulfilment of the Paris Agreement (UNFCCC. 2015; IEA & UNEP, 2018; Tollin et al., 2016).

The science, policy and practice of the sustainable built environment, at the scale of buildings, districts and infrastructure are analysed here, with emphasis on Latin American countries. Trends and thematic areas addressed by scientific publications, policy instruments and certification systems are evaluated in order to identify trending topics as well as knowledge and policy gaps. The purpose is to provide insights for a comprehensive approach to urban sustainability with respect to the post-2015 agenda on sustainable development.

1.1.3. The UN Agenda and the built environment

The central role of the BE in the transition towards sustainable cities has extensively been studied and discussed (CIB, 1999; Langston & Ding, 2001; Plessis et al., 2002; Brandon & Lombardi, 2005; Rydin et al., 2007; Hassan et al., 2008; Haghighat & Kim, 2009; UN Habitat, 2009; van Bueren et al., 2012; Lucon et al., 2014; Revi et al., 2014; Sertyesilisik & Al-Shamma'a, 2015; Habert & Schlueter, 2016; UN Habitat 2016; Seta et.al; 2017; IEA & UN Environment, 2018 ; UN Environment; 2019). The role of the BE in fulfilling the aspirations raised by the current global agenda for sustainable development is studied here by considering the four major multilateral instruments: the Sustainable Development Goals - SDGs, agreed in the framework of Agenda 2030, issued in 2015; the New Urban Agenda - NUA issued in 2016 at the Habitat III conference; the Sendai Framework for Disaster Risk Reduction, issued in 2015 and the Paris Agreement, signed in 2015 under the COP 21 (Tollin, 2017).

At first glance, the role of the BE in the current global agenda would not require further analysis. Concerns about elements and processes related to the BE are expressed in the NUA, specifically by issues 8, 11, 18, 20 and 22, referred to spatial planning and design, public space, infrastructure, housing and informal settlements (UN, 2017a). In turn, the relationship between NUA and Agenda 2030 is determined by SDG 11, referred to sustainable cities and communities; while NUA issue 17, addressing climate change and natural disasters, would define the relationship between the BE, the Paris Agreement and the Sendai Framework. Yet, both the role of the BE in the current global agenda, as well as the synergies between the four instruments, are actually more complex, being part of an ongoing discussion. Initiatives focusing on systemic approaches to SDG targets in order to identify transformative innovation pathways are being set (Le Blanc, 2015; Schot et.al, 2018; Lundin et.al, 2018). Synergies between Agenda 2030 and the Paris Agreement are currently being discussed in the framework of multilateral conferences (Bouyé et al., 2018). Studies concerning the role of sustainable urbanization in global climate action, as well as overviews concerning both the general role of cities and the specific role of the built environment in achieving the SDGs have been published (Tollin et al., 2016; Tollin, 2017; Opoku, 2016). Even NUA papers provide a draft lists of SDG targets, related to sustainable urban development (UN, 2017a). All these efforts agree on the need to continue analysing synergies within and between instruments in order to strengthen comprehensive cross-sector approaches in the implementation of the global agenda (UN, 2017a; Bouyé et al., 2018; Lundin et al., 2018). Such approaches are urgently required for guiding the planning, development and management of the BE (Campbell, 2016).

Literature review shows no previous studies analysing the role of the built environment across the four major instruments of the current global agenda. The aim this work is not redefining the subject, or setting a set of specific technical criteria, but highlighting directions for sustainability transitions based on synergies, rather than focusing on thematic areas. This work is expected to provide a map allowing policy makers, researchers and practitioners to navigate the UN Agenda as an interconnected system, instead of reading it as a list of unrelated goals, targets and issues.

1.1.4. Future scenarios and societal change

The notion of scenario planning dates back to the 1940s and is originally related to military strategy. However, it began to evolve from the 1960s in other fields, such as corporate planning, thus showing significant results in terms of competitive advantage, based on the anticipation of possible future situations (Chermack et.al. 2020). Scenario planning approaches may be classified according to several criteria, one has to do with the action that is expected to guide, ranging from descriptive scenarios. Descriptive scenarios are based on trend extrapolation and present a range of possible future alternative events. Prescriptive scenarios respond to policy planning concerns to achieve desired objectives. Scenario planning approaches are also classified according to geographic scope, ranging from local or national to global scenarios. They can also be classified according to thematic scope, from single-sector to multi-sector scenarios. Another classification has to do with integration levels, ranging from scenarios based on a single variable, guided by a single knowledge discipline; to scenarios integrating both multiple variables and several knowledge disciplines (Amer et.al, 2013).

Regarding methods, there is also a wide diversity of approaches, ranging from predictive to intuitive scenarios. Predictive approaches use computational tools to analyse trends and extrapolate them to the future. These methods are often associated to prescriptive scenarios, seeking quantitative results on a single variable and a low level of integration. In contrast, intuitive scenarios are based on qualitative approaches aimed to develop narrative and descriptive futures, rather than numeric scenarios, thus involving multiple variables, different sectors, various knowledge disciplines and diverse social actors or stake-holders (Amer et al. 2013). Table 1-1 shows a general comparison of scenario planning approaches, based on methods.

Table 1-1. Comparison of the principal scenario development techniques

Characteristics	**Predictive scenarios**	**Intuitive scenarios**
Purpose	A onetime activity to make extrapolative prediction and policy evaluation	Multiple, from a one-time activity to make sense of situations and developing strategy, to an ongoing learning activity
Scenario type/perspective	Descriptive	Prescriptive
Scope	Scope is narrowly focused on the probability and impact of specific events	Can be either broad or narrow, ranging from global, regional, country, industry to a specific issue
Time frame	Varies: 3–20 years	Varies: 3–20 years
Methodology type	Outcome oriented approach, very directed, objective, quantitative and analytical using computer based extrapolative simulation models	Process oriented approach, essentially subjective and qualitative
Nature of scenario team	External teams, scenario developed by experts (external consultants)	Usually an internal team from the organization for developing scenarios
Role of external experts	Leading role of external expert using proprietary tools and expert judgments to identify high impact unprecedented events	Experienced scenario practitioner to design and facilitate the process. External experts are used to obtain their views for new ideas
Tools	Proprietary tools like trends impact and cross impact analysis etc.	Generic tools like brainstorming, STEEP analysis, and stakeholder analysis
Starting point	Decisions/issues for which detailed and reliable time series data exists	A particular management decision, issue or general concern
Identifying key driving forces	Curve fitting to past time series data to identify trends and use expert judgment to create database of unprecedented events	Intuition, STEEP analysis, research, brainstorming techniques, and expert opinion
Output of scenario exercise	Quantitative baseline case plus upper and lower quartiles of adjusted time series forecasts	Qualitative set of equally plausible scenarios in narrative form with strategic options, implications, and early warning signals
Use of probabilities	Yes, conditional probability of occurrence of unprecedented and disruptive events	No, all scenarios are equally probable
Evaluation criteria	Plausible and verifiable in retrospect	Coherence, comprehensiveness, internal consistency, novelty, supported by rigorous structural analysis and logics

Source: Based on Bradfield et.al. 2005

Considering classification criteria in table 1-1, attempts to understanding societal changes, with regards to environmental challenges and economic restrictions, also known as "sustainability transitions", may be considered as scenario planning approaches. Hence, Integrated-Assessment-Models (IAMs) described in section 1.1.5 and used for projecting carbon emission scenarios in chapter 2 are related to prescriptive, quantitative approaches to future planning. On the other hand the Multi-Level Perspective, The Transition Management and other transition approaches, also described in section 1.1.5 and used for guiding transformative urban policies in chapter 5, may be considered as emerging approaches to intuitive, qualitative, participatory, multi-actor future planning.

1.1.5. Sustainability transitions

The UN Agenda proposes a series of goals and targets, which help defining 1) directions for sustainable development aspirations (transversal directions), 2) ambits for applying strategies and actions to fulfil these goals (implementation areas), as well as 3) the institutional conditions required to promote such strategies and actions (framework conditions). However, this agenda does not define the mechanisms, nor does it describe the routes by which the goals can be prompted.

Current approaches to global challenges addressed by multilateral agreements and national policies are based on Integrated-Assessment-Models (IAMs), which understand transformations as specific, non-interdependent processes that obey linear cause-effect logics, giving rise to predictable results. Such kind of approach is in fact used in section 2 to project the potential reduction of GHG emissions in the building sector, based on the existing policy framework. IAMs are useful for long-term projections and support high-level decision-making, however are insufficient to understand and manage the intricate dynamics posed by transformative change in the real world (EEA, 2017).

Academic perspectives on understanding and managing transformations towards sustainable development have evolved over the past decades towards more systemic perspectives, where neither social nor natural processes behave under linear, deterministic paths, but rather undergo complex dynamics through conflicts, lock-ins, negotiations and agreements, thus requiring different approaches to be understood and managed (see table 1-1). Despite the fact that these perspectives were born in late 1990s, they are still considered emergent, because are continuously evolving, are not joint together in a single theoretical model and have not entered the mainstream of sustainability policies yet. These complexity based approaches are known as sustainability transitions.

Table 1-2.Evolving understanding of Environmental challenge, policy responses and assessment approaches

Characterization of key challenges	Key features	In the spotlight in	Policy approaches	Assessment approaches
Specific	Linear cause-effect	1970s/1980s	Targeted policies and single-use instruments	Data sets
Diffuse	Cumulative causes	1980s/1990s	Policy integration and raising public awareness	DPSIR, data sets, environmental accounts, outlooks
Systemic	Systemic causes	1990s/2000s	Policy coherence and systemic approaches	DPRIS, STEEP, systems analysis, foresight, stakeholders

Source EEA (2017)

1.1.5.1. Perspectives on sustainability transitions

Given the diverse flux of disciplines around sustainability transitions, existing perspectives greatly differ in their epistemology and ontology. One way to classify them is by considering their scope. From this point of view, Loobarch et al (2017) recognize three ambits, corresponding to socio-technical, socio-institutional (De Haan &Rogers, 2017) and socio-ecological systems. On the other hand, the European Environmental Agency (2017) recognizes these same three and identifies one more ambit corresponding to socio-economic systems. All these perspectives share common aspects, typical of complex systems, such as non-linearity, multilevel dynamics, coevolution of actors and structures on Darwinian-like section mechanisms, and emergence of systemic properties that cannot be explained from single components (Loorbach et al., 2017). In this work, the built environment is understood as a meta-system, whose sustainability transition depends on social, technological, economic and ecological aspects. Perspectives applicable to all these areas are incorporated and linked.

Another way to classify transitions may be based on focus and overall goals. A first stream have focused mainly on developing theoretical foundations aiming to understanding transitions, while other have focused on designing prescriptive methods with the aim of promoting transitions and providing tools to intervene and navigate them. In this work these two currents are approached for the purpose of integration. Perspectives from the first stream are used to conceptualize the meta-systemic transition to the sustainable built environment, while perspectives from the second stream are used to link a reference framework for urban transition policies aimed at realizing the UN Agenda.

1.1.5.2. The Multi-Level approach as a transversal perspective

One prominent theoretical body regarding sustainability transitions is provided by the Multi-Level Perspective, initially developed to address change in socio-technical systems, it is progressively being adopted in other ambits (Köhler et al, 2019).

Within the framework of socio-technical systems, the MLP raises three levels, referred as landscape, regime and niche. The regime level is the core of the system and consists of a set of "institutions", aligning science, technology, finance, culture and market, thus forming a lock-in, reinforced over time as long as it remains successful on satisfying a specific social need, tending to preserve itself from change. Within this context, institutions are not understood as public organizations, but as the set of regulatory, normative and cognitive rules, that have been widely accepted within a social system determining its functioning, thus being "institutionalized" (Geels, 2002; Geels and Schot, 2010).

The landscape is constituted from physical, environmental and social external forces, which can act permanently, periodically or sporadically and, depending on their magnitude, amplitude and frequency, can destabilize socio-technical regimes. This includes, for example, the global macroeconomic and financial system, social megatrends, political conflicts or pandemics. Global climate change, growing concern of public opinion about it, multilateral agreements aimed at guiding action on it, and national policies emerging to adopt such agreements, are also examples of landscape forces (Geels et al., 2016).

Niches are protected spaces where technological innovations are produced, away from the regime rules. Niches may be constituted from both regime and non-regime actors, such as Universities, research and innovation centres, new entrants to existing markets, trade-unions, existing companies, NGOs or public organizations, among others. Innovations produced in niches are mobilized by intermediaries and champions towards the socio-technical regimes through struggles and negotiations. But the regime will only incorporate incremental innovations, unless an external forces it otherwise (Geels and Schot, 2010).

As long as the landscape remains stable, it tends to reinforce the regime, which will reject innovations that are not compatible with existing rules. However, if the landscape forces are strong enough to misalign regime rules, this will create windows of opportunity for transformational innovations to enter, thereby triggering a socio-technical transition. Further transition paths are determined by 1) the frequency, depth and range of the landscape forces; 2) by the stability of regime rules; and 3) by the readiness degree of technological innovations at the niche level (Geels and Schot, 2010; Geels et al., 2016).

Multilevel dynamics of socio-technical change results in non-deterministic transitions that can be fostered, regulated or managed only to certain extent. Therefore, scholars often describe the function of public policies in terms of "navigating", rather than "governing" transitions (Rotmans & Loorbach, 2010).

Despite of some criticisms of epistemological, ontological and practical nature (Geels, 2011), the MLP continues to develop its theoretical body, while accumulates empirical evidence, providing an increasingly comprehensive framework for understanding transitions, which has been extended and adjusted to also encompass socio-institutional and socio-economic systems. In the present work, the Multi-Level perspective is used with several different scopes:

- First place, the MLP is used to analyse the capacity of existing policies on buildings to boost actors, processes and structures in this sector to undergo low carbon paths. Here, building sector is taken as a **socio-technical system**
- Subsequently, the MLP is used to describe how socio-technical systems of the built environment, corresponding to buildings, infrastructure, public space and urban planning may be subjected to similar landscape forces and influenced by related niches on **a socio-technical meta-system** that may undergo **deep transitions**
- Third, the MLP on **socio-institutional systems** is used in the conceptual framework of transitions to describe how informal urban development, could undergo sustainability transitions from their own regimes and niches.
- Fourth, the MLP on **socio-economic systems** is used to describe formal and informal urban development as part of the same meta-system, being are jointly subordinated to an economic paradigm aimed at infinite capital growth, resulting in a collective narrative of an ever growing, social excluding city. Sustainability transition here depends on shifting both the economic paradigm and the resulting collective narrative.

1.1.5.3. Sustainability transitions in the built environment

Sustainability transition studies have mainly focused on single sectors, such as water, transport, energy, industry. However, cities do not operate and evolve in response to the actions of a single economic sector. As already mentioned, developing and operating the built environment involves the mining, industrial, transportation, real estate and finance sectors. On the other hand, the built environment unfolds in a spatial dimension where people live, learn, work and interact, while shape, density and distribution of buildings, streets, parks and infrastructure is conditioned by landscapes, climates and ecologies specific to each region, thus producing unique features to each city. Hence, sectorial studies only make fragmentary contributions to urban transitions and are far from providing a comprehensive view on the multiplicity and complexity of the city, besides just providing the space for transitions to take place (Torrens, 2019; Nielsen & Farrely, 2019).

This complexity of cities generates ontological and epistemological difficulties for the study of transitions since neither the definition of the object of study, nor the approaches for its study are univocal.

City limits can be physically defined from the extent of the built environment, but they can also be defined metabolically, thus extending to ecosystems and regions providing water, energy, food and materials, as well as ecosystems and regions receiving and processing waste, discharges and emissions. However, empirical studies on urban transitions are usually focus on analysing specific construction projects or initiatives, restricted within the scale of parcels or districts. Often these case studies are referred to as "urban experiments" (Torrens, 2019). However, it is still under discussion whether urban changes produced by such experiments remain contained within the physical limits of each initiative or may be considered actual “seeds” for wide long-term transformational changes at larger scales, as equivalent to innovation niches in socio-technical transitions (Nielsen & Farrely, 2019).

On the other hand, widely used approaches on transitions studies, such as the Milti-Level Perspective, are limited here due to their sectorial approach. However, some elements of the MLP can be useful to understand urban transition challenges, for example, the notion of a regime that tends to remain refractory to change is useful to understand the difficulty of modifying function, location, form or distribution of buildings, streets, urban plots or infrastructures. In fact, this obduracy of the built environment is acknowledged as the main single barrier for urban transitions (Nielsen & Farrely, 2019). This notion of societal regimes is also useful to understand the struggles of shifting technologies, practices and cultures embedded in regulations, standards, business models, perceptions and expectations related to the building and infrastructure sectors. However, there is no methodological framework for the study of urban transitions. Some academics have developed proposals managing urban transitions (Tollin, 2015) or have defined a broad framework of criteria defining Transformative Capacity of Cities (Wolfram, 2016). Every empirical study concerning urban transitions built on its own methods though. This makes comparative analysis difficult, and it also makes clear the need of integrative approaches understanding and studying urban transitions, which is precisely the ultimate goal of this thesis.

1.1.5.4. Sustainability transitions for transformative policies

At the final stage, this thesis identifies synergies and similarities that allow extending a common thread between the multiple and diverse challenges related to the sustainability of the built environment, involving technological, societal, economic and ecologic aspects. This aim is fulfilled by selecting perspectives and approaches that are compatible with each other in order to build an integrative approach to urban sustainability.

Although some authors have approached urban transitions through adaptations of the previously described perspectives. Cities have really been a neglected topic, receiving little attention from the mainstream literature on sustainability transitions (Frantzeskaki et al, 2017; Torrens, 2019). Consequently, the theory and practice of urban transitions has been developing in a relatively parallel way, giving rise to its own perspectives. Among these, the referential framework of the Urban Transformative Capacity stands out (Wolfram, 2016), as well as a Process Methodology for Urban Resilience Transition (Tollin, 2015). Both are addressed in this work as connecting elements for building an integrative framework on managing urban transitions.

1.2. SCOPE AND LIMITS

1.2.1. Study object

The object of study of this thesis is the built environment, whose standard definition is a "Collection of man-made or induced physical objects located in a particular area or region. When taken as a whole, the built environment typically is taken to include buildings, external works (landscaped areas), infrastructure and other construction works within the area under consideration" (ISO, 2008).

Within the framework of this definition are processes, sectors, actors, scales and flows. A complete definition of the built environment requires incorporating the following aspects:

- The integral life-cycle of the development of construction projects, includes urban norms, governance and finance, spatial planning and design, feasibility studies, extraction and manufacturing of materials, architectural and engineering design, as well as construction, operation, maintenance and demolition stages (Plessis et al., 2002; Emina et al., 2007; Haghighat & Kim, 2009; Crawford R. 2011; Habert & Schlueter 2016; Sarshar et al., 2015; Seta et al., 2017; UN, 2017a; Dixon et al., 2018; SRBE Alliance, 2019; Alalouch et al., 2019)
- Considering the life-cycle perspective, the built environment is a macro sector, involving several sectors of the economy, such as mining (extraction of raw materials), industry (manufacturing of materials, engineering systems, devices and supplies), energy (throughout the entire life-cycle), water and sanitation (throughout the entire life-cycle), transport (of materials and construction and demolition waste), the creative sector and engineering services (at planning and design stages), the real estate sector (property management) and the

financial sector (development investments) (Plessis et al., 2002; Yang et al., 2008; Bueren van E. 2009; Haghighat & Kim, 2009; Roaf, 2010; Cotgrave & Riley, 2013; Sertyesilisik et al., 2015; Seta et al., 2017)

- At a larger scale, the built environment refers to the development of human settlements, playing a fundamental role in the provision of basic services such as water supply and sanitation, energy supply, transport and mobility. Likewise, productive, health and education facilities are part of the built environment, as it is the public space, which is the basis of urban social interaction and ultimately the element defining the character of a city (UN, 2017a)
- By referring to human settlements, the built environment impacts the physical health of people in terms of habitability, environmental quality, hygiene, ergonomics, accessibility and walkability. It also involves all modalities of reality as perceived by human beings. Hence, it is related to experiences, memories and expectations, being responsible for making a "sense of place", which plays a role on emotional wellbeing, and influencing relevant social aspects such as cohesion, solidarity and even security (Brandon & Lombardi, 2005; Boussabaine H., 2008; Dushenko et al., 2012; Crocker & Lehmann, 2013; Loftness et al., 2013; Dastbaz et al., 2015; Kumaraswamy et al., 2015; UN, 2017a)
- By consuming water, energy, materials and land, while generating wastewater, emissions and waste, the built environment is a determinant factor for urban environmental impacts. Considering that a growing majority of the human population currently lives in cities, the built environment plays an important role on the use of natural resources and the health of ecosystems on a global scale (Smith, 1998; Kibert C. 1999; Langston & Ding, 2001; Graham, 2003; Newton et al., 2009; Young R. 2012; Hassan et al., 2008; Radovic D. 2013)

1.2.2. Geographical and methodological scope

In principle, the geographical context of this thesis is in Latin America, however, the work moves between different scales from local to global. Regarding time scope, analysis focuses on the period following agreements leading to: the Sustainable Development Goals, the Paris Agreement, the Sendai Framework and the New Urban Agenda. However, influence of previous agreements on policies and practices at the national level goes back to Agenda 21, signed in 1992.

In methodological terms, the thesis also moves in a wide range, which includes reading, analysing, relating and contrasting supporting documents of: multilateral agreements, national and local policies, certification schemes, scientific papers, reviews and textbooks. National reports and statistical databases on economic activity, construction systems and emission inventories were also reviewed.

Methodology also includes gathering of primary information through interviews and surveys carried out at the local levels.

A detailed description of scopes per section is provided below:

- The potential for reducing GHG emissions in the building sector is made from emissions inventories and relative policies formulated in Colombia. The results are contrasted with best practices promoted on a global scale, to demonstrate the importance of designing strategies based on context-specific scientific information.
- Analysis of trends and thematic scope of science, policy and practice of the sustainable built environment uses global databases of scientific papers and conferences, as well as standards, codes and policy documents produced by countries and cities in Latin America. Supporting documents for certification schemes on sustainable buildings, districts and infrastructures were also analysed here.
- Identification of interactions among urban sustainability challenges was made from reading, relating and contrasting documents that support the four main agreements of the global agenda. This analysis is also supported on previous publications providing outcomes on similar efforts.
- The application of the Multi-Level perspective to building socio-technical system starts from the identification of multilateral agreements, international private sector initiatives and national-scale policies and regulations produced in Colombia. But normative and cognitive rules constituting the socio-technical regime are identified from interviews and surveys at local level.
- The integrated framework for conceptualizing the built environment was made from reading, relating and contrasting original papers and reviews on sustainability transitions in socio-ecological, socio-institutional, socio-economic and socio-technical fields. Finally, the integrated framework for managing urban transitions was built from the concept of Urban Transformative Capacity – UTC, linked with approaches on managing transitions, based on the reading of related original papers, theses, reviews, and textbooks.

1.3. RESEARCH FRAME

This work is organized in four stages, as described next:

1) The role of buildings in the global reduction of GHG emissions has been widely highlighted (IEA & UNEP, 2018). However, since mainstream information in this regard has been produced in

developed countries or large emerging economies located in temperate regions; suitable strategies in countries with other environmental, technological, economic and social characteristics may be different. This thesis reviews GHG emissions from the life-cycle of buildings, as well as related policies in the context of minor emerging economies, located in a tropical zones, in order to highlight the importance of guiding national and local actions from context-specific scientific information.

2) Despite the undeniable importance of mitigating global climate change, urban areas face a long series of equally urgent environmental, social and economic challenges, which are included in the current multilateral agenda on sustainability. In a second stage, this thesis reviews whether thematic scopes of science, policy and practice of the sustainable built environment are addressing such multidimensional challenges, in order to identify knowledge gaps and provide insights to adjust existing instruments and strengthen available tools.

3) Sustainability challenges addressed by the UN Agenda are interrelated in various ways, which are not evident at first sight. A comprehensive approach to the global sustainability agenda should be based on identifying such interactions, instead on just focusing on individual goals and targets. In a third stage, this work analyses supporting documents of current multilateral agreements in order to identify and highlight the synergies connecting all these elements together in order to provide a comprehensive version of the global agenda, using the Built Environment as a context.

4) The built environment is not a set of buildings, but a complex meta-system, whose development and function is determined by interdependent social, technological, economic and ecological processes operating at different scales. Morphologically these scales range from buildings to cities, but metabolically, the scales extend to bioregions, nations and even the whole planet. These processes cannot be explained from deterministic linear approaches. In a fourth stage, this thesis proposes a conceptual framework of the built environment by connecting analytical and management approaches on sustainability transitions, ranging from socio-technical to socio-ecological systems. The resulting framework could serve as the basis for the comprehensive analysis of the built environment, while also serves as a referential and methodological framework for designing policies aimed at strengthening the Urban Transformative Capacity, aligned with the goals and targets of the global agenda.

Figure 1-1 lustrates the four stages of the research frame.

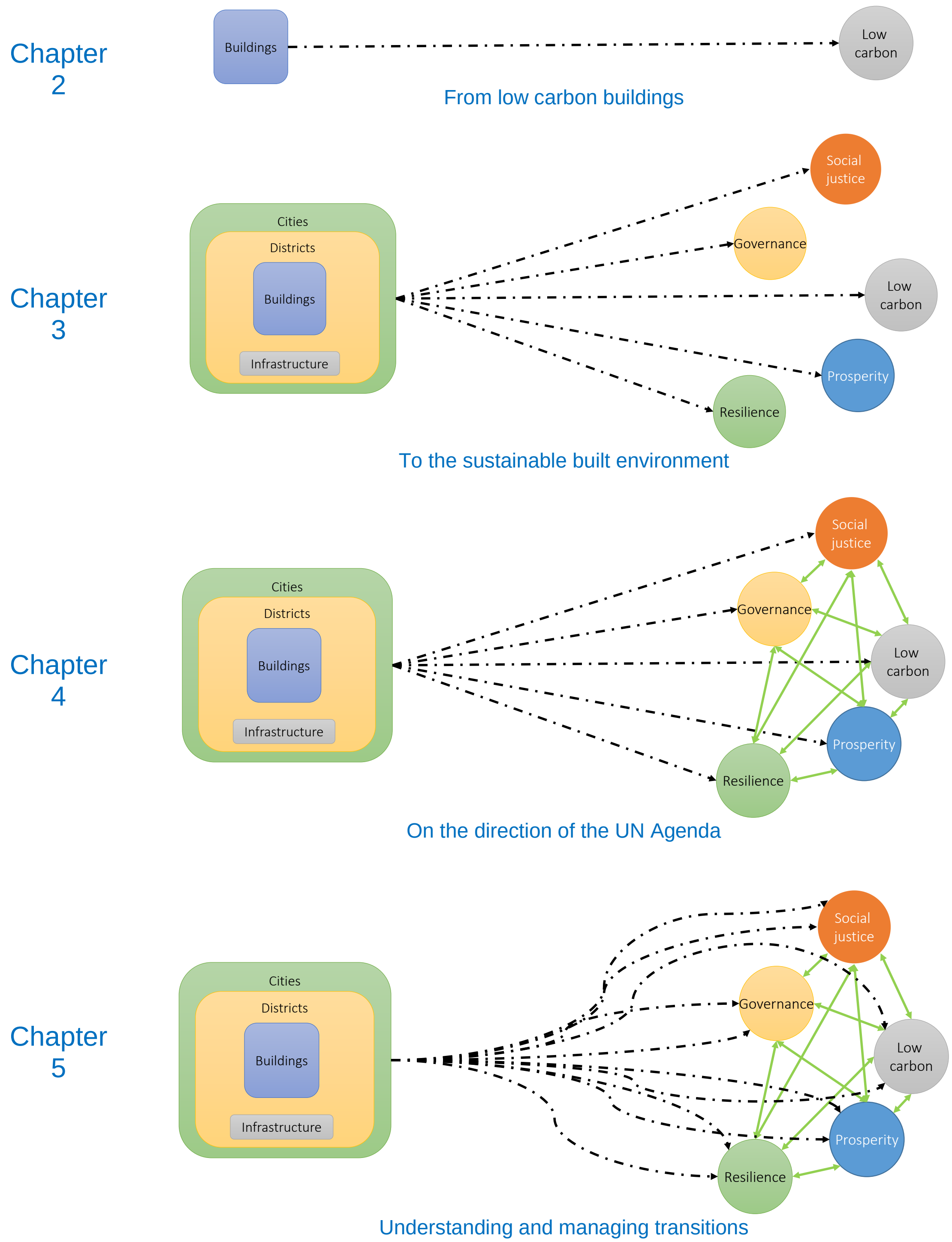


Figure 1-1. The research frame
Source: the author

1.3.1. Research questions and goals

Planning, design, construction, operation and maintenance of the built environment depends on the successive, constant and simultaneous interaction of multiple elements at different time and space scales. Such interactions contribute to satisfy basic human needs, shaping the relationship between cultural and natural realms, while taking a relevant part in material, energy, capital and information flows of cities, thus playing a fundamental role in urban sustainability. Upon these considerations: **¿How may the built environment, be integrated in a systemic approach useful to guide the design of transformative urban policies that consider the dynamic nature of sustainability transitions in Latin America?** This guiding question may be further decomposed in the following specific questions:

1) Concerning the relevance of buildings for on reducing GHG emissions, do globally prioritized strategies apply in the same way in all environmental, technological, economic and social conditions?

2) Are the science, policy and practice of the sustainable built environment heading in the directions that are globally agreed at the UN Agenda? If not, what adjustments are required to fill knowledge gaps, adjust existing instruments, and strengthen available tools?

3) May the built environment serve as a base for identifying and highlighting interactions connecting goals, targets and issues included in the UN Agenda on sustainability?

4) May a conceptual model of the built environment simultaneously incorporate social, technological, economic and ecological aspects that operate at different scales to offer an integrative tool of urban sustainability transitions? And subsequently, is it possible to link methodological approaches on transition management in an integrative framework useful for designing transformative urban policies?

1.3.2. Research goals

The general goal of this thesis is **to develop a comprehensive conceptual and management framework that allows understanding and encompassing the multiple processes, scales, dimensions and challenges relative to the sustainable built environment, in order to contribute to the design of urban transformative policies**.

The specific goals are:

1) To demonstrate the importance of guiding national and local actions on urban sustainability based on context-specific scientific information, from the analysis of GHG emissions in the building sector

2) To evaluate the incorporation of goals, targets and issues of the UN Agenda into the current science, policy and practice of the sustainable built environment, in order to help filling knowledge gaps, adjusting existing instruments and strengthening available tools.

3) To build a comprehensive approach to the UN Agenda based on interactions relating goals, targets and issues across the four current major agreements.

4) To propose a conceptual model of the built environment, by simultaneously incorporating social, technological, economic and ecological aspects at different scales in order to offer both an integrative tool for understanding sustainability transitions and an a comprehensive framework for transition management under the Transformative Urban Capacity concept, in line with the goals and targets of the UN Agenda.

1.3.3. Research hypothesis

Urban sustainability transitions require comprehensive approaches with the ability to move along various scales, thematic axes and methodological approaches, in order to produce tools and instruments that meet the following conditions:

1) Be based on scientific information, specific context,

2) addressing environmental, social and economic challenges simultaneously, because priority-based approaches are no longer acceptable,

3) understanding interactions and synergies linking all urban sustainability challenges,

4) addressing cities as complex meta-systems, determined by interdependent social, technological, economic and ecological processes operating at different scales, while strengthening the Urban Transformative Capacity by promoting participatory governance, collective visions, experimentation, networking and systemic learning.

1.4. METHODOLOGY

The methodological approach of this thesis consists of a combination of deductive and inductive approaches, as well as empirical and theoretical bases that bring it closer to the methodological framework known as "systematic combining " (Dubois and Gadde, 2002). In this framework, there is no linear direction that leads from theoretical propositions to their testing in the real world, nor is there a theoretical construction based on obtaining data. Instead, there is a dynamic interaction between the theoretical bases, the framework of analysis, empirical data and a case study. In this dynamic interaction, all the elements are restructured as research progresses. Therefore, there is no single direction of analysis. In this case, chapters 2 to 4 are made mainly from empirical information and use a predominantly inductive approach, while chapter 5 is built mainly from the critical and systematic analysis of various theoretical bodies, which brings it closer to a deductive approach.

Empirical data used for the analysis comes from the collection and analysis of documents, which include multilateral agreements, policies, certification schemes, technical reports, official statistics and research papers. On the other hand, surveys and interviews provide information for the first part of chapter 5. Furthermore, quantitative data is used in chapter 2, while all other chapters relay on qualitative information.

Concerning the case study, it also varies in different chapters, while quantitative data used in Chapter 2, as well as the qualitative information used at the beginning of Chapter 5 is related to Colombia, certification schemes and existing policies analysed in Chapter 3 cover different countries in Latin America and the Caribbean.

The analysis framework of this work focuses on buildings, infrastructure and districts, but also on an integral vision of the built environment as a system, as a place and as a process. Similarly, this framework of analysis goes from the specific issue of GHG emissions to a broader approach to sustainable development, which includes concerns such as equity and social inclusion, economic prosperity, urban resilience and ecosystem services.

The theoretical body of this thesis is related to the conceptual definition of the built environment, including its approach as a socio-technical, socio-institutional, socio-economic and socio-ecological system. On the other hand, the theoretical framework is related to different approaches related to the study of futures, from the analysis of scenarios based on quantitative data, to the perspectives for understanding and managing sustainability transitions.

A detailed methodology description for each chapter is provided next.

1.4.1. Assessing carbon emissions form the building sector

The framework of policies related to sustainability, eco-efficiency or climate action, concerning the building sector in Colombia were reviewed in order to extract baseline information, quantitative goals, scenario projections and costs analysis. When such information was not available within policy documents, relevant technical reports and databases from national and local government agencies were consulted.

Concerning GHG emissions, every stage of the life-cycle of buildings takes part in a different economic sector, either within the IPCC or the National Inventory frameworks. While emissions from the extraction of raw materials are accounted for in the mining sector, emissions from end materials are attributed to industry, whereas emissions from the use of electrical energy during operational stage, are accounted for in the energy sector and the emissions derived from residential waste take part of the sanitation sector. The only emissions explicitly attributed to buildings are those corresponding to burning fossil fuels for cooking and water heating (IDEAM et al., 2016). From current national inventory, it is not possible to disaggregate emissions specifically attributable to the life-cycle of buildings within each of these sectors. Consequently, there is no baseline of emissions from buildings in Colombia. In the present work, a first baseline of building emissions in Colombia is produced, based on the combination of information related to building activity, construction systems, energy consumption, waste disposal and emission factors, published by the national government through reports and data bases, complemented with policy baselines, when available.

Upon the baseline information, scenarios for the building sector in Colombia were projected for the 2019 – 2050 period. For this purpose, population and economic growth projections published by the National Planning and National Statistics Departments were used. The zero point for scenarios was defined from government reports on building activity, construction systems, energy use and waste disposal, corresponding to the average value of the 2014 – 2018 period. Emission factors from fossil fuels and waste disposal were obtained from the National Inventory of GHG emissions (IDEAM et al., 2016), whereas emission factors from building materials were obtained from PNUD, UPME and Ecoingeniería (2012) and Pardo et al., (2017).

Policy scenarios were set based on data provided by policy supporting documents, when available, completed with relevant technical reports by national and local government agencies and scientific papers. In addition to assumptions on population and economic growth considered for BAU scenario, an assumption of gradual implementation with full adoption by 2050, was used for every policy scenario.

Implementation costs for each measure at each policy were analysed based on their respective supporting documents, complemented with sectorial reports and scientific papers. For measures concerning waste management and energy efficiency, which produce savings during operational stage of buildings, values were calculated on averaged current official charges on public services. All values are calculated as net-present-values, no interests and inflation rates were considered. Units were calculated in relation to GHG emission reduction potential of each single measure.

1.4.2. Assessing science, policy and practice of the sustainable built environment

1.4.2.1. Science

In order to determine the trend of research related the sustainability of the built environment, Scopus database was reviewed in search of indexed journals and conferences whose scope is oriented to processes and elements of the BE. The review period runs from 1976 to 2018 (Scopus, 2019). Contents addressed by the scientific research post-2015 were defined based on titles, keywords and abstracts of papers published from 2016 to 2018.

1.4.2.2. Policy

In order to assess the trend of policies related to the built environment, databases and publications summarizing global and regional trends on this type of instruments were reviewed. Concerning the content of policy instruments, policy documents, strategies, plans, standards, guidelines and voluntary schemes issued at both national and local level were reviewed in order to both identify both, topics covered by each scheme as well as the relative importance conferred to each topic at rating system or policy thematic matrix.

In order to determine the degree to which policy and practice of the built environment are aligned with the aspirations for sustainable development defined by the post-2015 Global Agenda, findings are tabulated according to the 22 issues covered by the New Urban Agenda (UN, 2017a), which not only defines the roadmap for the sustainable cities, but also relates to each of the SDGs, the four priorities of the Sendai Framework for Disaster Risk Reduction and sets the potential contribution of cities to the Paris agreement, thus covering the four main instruments of the Global Agenda (Tollin et al., 2016; Opoku, 2016, UN , 2017).

We set an index for thematic comprehensiveness based on the Shannon information index (Shannon-Weaver, 1964), according to which the amount of information contained in a message is given by the relative importance of is constitutive elements. In this case, each evaluated scheme is taken as a message and the degree of importance of its elements is given by the relative value conferred to each topic. If a scheme is uniformly covering all topics, its comprehensiveness index shall be higher. Shannon's index is calculated according to the following equation:

$$H = \frac{Ho}{Hmax}$$

$$Ho = -\sum pi * \ln pi$$

$$Hmax = -\ln 1/t$$

Where:
H = Relative comprehensiveness index (expressed as proportion)
Ho = Comprehensiveness index at each policy instrument and rating scheme
Hmax = maximum comprehensiveness index that a scheme could achieve if it uniformly covered all the topics of the global agenda
pi = degree of relative importance of each topic in each scheme
t = number of topics addressed by the Global Agenda

1.4.2.3. Practice

In order to assess the trend on practice concerning sustainability in the built environment, evaluation and certification schemes of buildings, districts and infrastructure were reviewed. Here, both international shames widely used in the regions, as well as national schemes were considered. Websites of these schemes were searched for reports concerning the number projects being certified each year.

1.4.3. Bringing the UN Agenda to the sustainable built environment

The multilateral agreement setting the roadmap for cities, being the most closely related to the BE and the starting point of this analysis, is the New Urban Agenda – NUA. The supporting documents reviewed here are the Issue papers. This is a compendium of summary documents providing the background and knowledge, concerning key challenges, and recommendations on the most significant urban topics. From these 22 issue papers, the NUA commission of experts identified priorities and challenges, which would serve as inputs to the New Urban Agenda (UN, 2017a). Key drivers for action listed at each issue paper was reviewed in order to find references to elements and processes of the built environment. Each issue paper containing this type of references would be used later to analyse BE related interactions with the other three instruments of the global agenda.

Interactions between the NUA issues and the Sustainable Development Goals were identified afterwards. While SDG 11 and 9 explicitly refer to it, the BE might potentially contribute to almost all SDGs (Opoku, 2016). Those, less evident interactions were identified here by first looking for direct references to SDGs made within the NUA issue papers. Then, the official list of 169 SDG targets was reviewed in order to select those that could be related to BE elements and processes, according to literature review.

Potential contributions of the sustainable BE to the Sendai Framework document for Disaster Risk Reduction were identified by reviewing the list of 59 specific actions at national/subnational level, which are divided into four priorities in the supporting document of the agreement. References to BE elements and processes were identified and classified these according to the categories derived from the NUA issues.

Finally, same procedure was followed with the Paris Agreement. In this case, both the Agreement and the Decision of the UNFCCC were revised. It should be noted that, NUA, Agenda 2030 and the Sendai Framework raise goals, targets, issues and actions explicitly related to climate action. Therefore, previously identified interactions between the built environment and those instruments already allowed the identification of potential contributions of the BE to the Paris Agreement.

In addition to identifying interactions between elements of the agendas, frameworks and agreements, these interactions were qualified according to the number of specific criteria relating one element to another. Concerning Agenda 2030, the strength of the interaction increases with the number of SDG targets, related to a specific aspect of the BE, at each SDG. This approach has been previously used by other authors to analyse synergies inside Agenda 2030 (Le Blanc, 2015). Concerning Sendai Framework, the strength of the interactions is given by the number of actions related to the BE, within each of the four priorities. However, it was not possible to set an indicator to measure the strength of the BE interactions with the Paris Agreement or the NUA. Concerning the Paris Agreement, it is not structured by thematic areas that could be used as specific categories to be counted. As for the NUA, each issue paper allows defining whether there is an interaction to the BE or not, but by being written in a narrative way, with no specific goals or targets, it is not possible to set a count for the number of interactions of the BE at each issue paper.

Both the extent and strength of interactions across instruments highlight potential BE related landmarks towards sustainable cities. A network graph is used to illustrate the resulting conceptual map.

With the aim to provide a framework and direction to the conceptual map, the transformative policy approach was used (Schot et al, 2018). Here elements of the global agenda are classified into three types:

- Goals, targets, issues or criteria covering a specific or a wider range of sociotechnical systems or **"implementation areas"**.
- Goals, targets, issues or criteria highlighting **"transversal directions"** or directionality

- Goals, targets, issues or criteria focusing on structural transformation or **“framework conditions”** necessary for realizing transformation. This includes changing governance arrangements among the state, the market, civil society and science (Schot et.al, 2018).

1.4.4. Producing a conceptual framework for understanding and managing transitions

1.4.4.1. Analysing low carbon transitions for buildings

Projecting the potential impact of existing policies on reducing carbon emissions from the building sector is based on a IAMs approach. As a first attempt to introduce the perspectives of sustainability transitions, the Multi-Level perspective of socio-technical transitions was used to analyse the actual capacity of such policies to boost the sector towards a low carbon path, considering: 1) the influence that multilateral agreements, private initiatives and national policies are actually exerting on sectorial practices, structures and cultures, 2) the barriers and enablers derived from the regulatory, normative and cognitive institutions of the socio-technical regime and 3) the readiness of innovations required for undertaking the low carbon path, and the power of existing niches to introduce those innovations into the regime.

To analyse landscape forces, multilateral agreements on sustainable development, environmental management and climate issued during the last three decades were studied, along with national responsive policies, either sectorial (green building) or related (energy efficiency, waste management).

Regulatory institutions of the socio-technical regime were identified from the national regulatory framework. While normative and cognitive institutions, were identified from semi-structured interviews, surveys and focus groups, on public officials, private company professionals and regular citizens, participating in training courses, construction fairs and real estate fairs, within the framework of the implementation stage of the Sustainable Construction Policy of the Aburrá Valley, in the period 2016 – 2018 (AMVA & Camacol, 2018).

Review of national statistical databases on construction activity and sectorial publications were used to define the readiness degree of technological innovations and identify the existence of niches with the capacity to promote such innovations into the regime. Interviews conducted to characterize the socio-technical regime also provided information in this regard.

Table 1-2 presents a technical sheet that lists the approximate number of people, the type of approach and the scenario in which the approach was made in each case.

Table 1-3. Sectors and actors approached for this research

Sector	Type of actor	Individuals	Organizations
Private	Sectorial guilds	3	2
	Building companies	12	5
		87	25
	Industrial companies	14	6
	Water and sanitation companies	3	1
	Sustainability consultants	8	3
	Energy companies	4	2
Public	Municipalities	71	8
	Environmental Authority	12	2
	Transportation	3	1
	Urban planning	9	2
Academy	Lecturers	18	5
Civil society	Community boards	40	7
	NGOs	11	3
	Housing buyers	226	N.A.

Source: the authors

1.4.4.2. Producing an integrative framework for understanding sustainability transitions in the built environment

The production of an integrative conceptual framework of the sustainable built environment was based on the study of original theoretical and research papers, reviews and textbooks related to analytical perspectives on sustainability transitions. Main epistemological and ontological aspects of each approach were identified and compared. Approaches based on a Multi-Level Perspective were prioritized due to their potential mutual complementarity. Each perspective was subsequently analysed to define its capacity to encompass actors, sectors, structures, processes, components, and scales within the built environment. Next, conceptual bases of each perspective are used to describe an equivalent urban subsystem, from the socio-technical, to socio-institutional, socio-economic and socio-ecological levels. Finally, all perspectives are linked in a single conceptual framework of the built environment.

Both the resulting conceptual framework and its components are described through texts and also through graphics in order to illustrate the relational aspects that give coherence and structure to the model. Perspectives incorporated into the integrative conceptual framework are listed in the table 1-3. Table 1-4. Analytical approaches and perspectives to sustainability transitions adopted in this work

Perspective	System	Sources
Multi-level perspective	Socio-technical	Geels, 2002
Deep transitions (based on the MLP)		Schot & Kanger, 2018
Multi-level perspective on societal transitions	Socio-institutional	De Haan, & Rogers, 2016
Multi-level perspective on socio-economic transitions (The Great Mind Shift)	Socio-economic	Göpel, 2016
The built environment as a socio-ecological system	Socio-ecologic	Moffatt & Kohler, 2008

Source: the autor

1.4.4.3. *Producing an integrative framework for managing sustainability transitions in the built environment*

A methodological framework for managing transitions in the built environment was produced from the study of papers, reviews and textbooks concerning sustainability transitions. In this case, similarities and complementarities were identified in terms of premises, requirements, methodological procedures and conceptual bases. The approaches used here are listed in the table 1-4.

Table 1-5. Management approaches and perspectives to sustainability transitions adopted in this work

Perspective	**System**	**Sources**
Strategic Niche Management	Socio-ecologic	Caniëls & Romijn, 2008
Transition Management	Socio-technical	Rotmans & Loorbach, 2010
Adaptive Management		Voß, & Bornemann. 2011
Urban Resilience Transition	Urban systems	Tollin, 2015
Urban Tranformative Capacity		Wolfram, 2016

Source: The autor

In a similar way, that Multi-Level Perspective was used as a cross-cutting perspective to understand transitions. Here the concept of Transformative Urban Capacity was used as the basis for connecting transition management approaches. In order to integrate the three frameworks produced as a result of this thesis, a graphic representation is used, where the components of the UTC and elements of the global agenda are placed within the integrative conceptual model for understanding transitions. Hence, each aspect of transition management can be related both to a conceptual element of the built environment and to a group of elements of the UN global agenda.

2. FROM LOW CARBON BUILDINGS

In its nationally determined contribution – NDC, Colombia proposes measures to reduce carbon emissions in the building sector, but these are limited to the scope of the sustainable building code issued in 2015, which is energy efficiency at operation stage (MVCT, 2020). The potential contribution from other measures related to materials, construction systems and solid waste composting were not considered for NDC purposes, despite of being discussed by other existing instruments at both national and local levels. Some of these instruments are not specific for the building sector, but do include it in their scope. This section explores the capacity that building-related measures considered by existing policies, would have on reducing carbon emissions by 2030 and 2050, with special emphasis on those that were not considered for NDC purposes.

2.1. GHG EMISSIONS BASELINE FOR THE BUILDING SECTOR

Under a life-cycle approach, a baseline of building emissions would include the following emission sources:

a) Extraction of raw materials and manufacturing of end materials
b) Transport of materials to construction sites
c) Use of machinery during the construction stage
d) Burning fossil fuels during operation stage
e) Electric power consumption during operation stage
f) Residential waste (see box 2-2)
g) Demolition and disposal of demolition waste

Information regarding information sources b, c and g from this list is not currently available. Basic data for the remaining emission sources are shown in Table 2-1.

97% of the area built in Colombia, is consist of three concrete based construction systems, where the system known as “confined masonry” is the most used, being also the one with the highest material intensity, as well as the highest carbon footprint (Pardo et al, 2017). As it will be seen in section 3.3, these facts are not recognized by any of the national level policies, but they are recognized by the local sustainable building policy of the Aburrá Valley. This local policy proposes specific actions to reduce emissions in the building sector that include a shift to “industrialized systems” in replacement of the “confined masonry” system.

Table 2-1. Basic data for the calculation of a building emissions baseline

Constructive system	Material intensity (ton/m^2)	Concrete content (%)	GHG emissions (ton CO_{2-eq}/m^2)	GHG emissions from concrete (%)	Built area per year (%)
Confined masonry	2,03	89%	0,505	72%	64%
Structural Masonry	1,25	92%	0,310	57%	7%
Industrialized	1,22	91%	0,323	57%	26%
Other	N.I.	N.I.	N.I.	N.I.	3%

Building activity (m^2/year)	18.051.988

Electric energy consumption. Residential buildings (Gwh/year)	24.690
Electric energy consumption. Other buildings (Gwh/year)	13.295
Average emission factor from National Electricity System (ton CO_{2-eq}/Mwh)	0,21

GHG emissions from fossil fuels. Residential buildings (Gg CO_{2-eq}/year)	3.068
GHG emissions from fossil fuels. Other buildings (Gg CO_{2-eq}/year)	1.077

Production of household waste (ton/year)	3.754.130
Emission factor from household waste (ton $CO_{2\ eq}$/ton waste)	0,88

Source: The authors, based on UPME, 2015; UPME, 2016b; UPME, 2018; UPME, 2019b; MADS, 2015; DNP; 2016; AMVA & UPB, 2015; PNUD, UPME & Ecoingeniería, 2012; Pardo et al., 2017; MME, 2019; IDEAM et al., 2016; DANE, 2019b

For detailed data supporting these calculations please refer to Appendix A

Table 2-2 shows the values of a consolidated baseline of emissions from buildings, based on data shown at table 2-1. Findings show that emissions from buildings are comparable to the single contribution from industry and transport sectors, thus playing a relevant role of national contribution to climate change. In the other hand, when decomposing the baseline of buildings, emissions from materials have a similar value as compared to emissions from electricity use and fossil fuels, while doubling those from residential waste. This is a relevant outcome, considering that emissions from materials come only from new buildings, while the remaining emissions come from the stock of all existing buildings.

Studies carried out in other contexts have concluded that 80% of the GHG emissions produced by the life-cycle of buildings come from energy consumption during operation stage (Gong & Song, 2015; Chau et al., 2015). According to findings of this work, in Colombia, this proportion is met only by hospital buildings and shopping centres. In offices and hotels, the proportion of GHG emissions from energy consumption during operational stage is close to 70%, while in housing and school buildings this proportion falls to 30%. (Figure 2-1). The fact that 77% of the construction activity in the Country is concentrated on housing buildings (table 2-2) explains why building materials for new buildings produce emissions that are comparable to electricity use by all existing stock of buildings (see table 2-2).

Table 2-2. GHG emissions baseline for the Building sector in Colombia

Whole economy		Buildings	
Sector	GHG emissions (Gg $CO_{2\text{-}eq}$/year)	Source	GHG emissions (Gg $CO_{2\text{-}eq}$/year)
Industry (including energy and industrial processes)	22.171	Building Materials	7.741
Energy (excluding transport and industry)	33,398	Indirect emissions from buildings operation stage (electricity use)	7.977
		Residential (fossil fuel burning for cooking and water heating)	5.400
		Retail (fossil fuel burning for cooking and water heating)	1.800
Transport	24.461	Not determined yet	--
Sanitation	13.069	Residential waste disposal	3.304
AFOLU	113.985		
SUM	207 084	SUM	24.422

Source: The authors, based on: Source: The authors, based on UPME, 2015; UPME, 2016b; UPME, 2018; UPME, 2019; MVCT, 2015; MADS, 2015; DNP; 2016; DNP; 2018; AMVA & UPB, 2015; PNUD, UPME & Ecoingeniería, 2012; Pardo et al., 2017; MME, 2019; IDEAM et al., 2016; DANE, 2019b
For detailed data supporting these calculations please refer to Appendix A

Box 2-1. The role of wood in the building sector in Colombia

Table 2-4 shows that 97% of buildings formally constructed in Colombia use concrete-based building systems. The use of other systems, including those based on wood, is limited. Nevertheless, wood is a transitory material that is widely used for moulding concrete structures, to be later discarded. In fact, the building sector is responsible for using 56% of wood produced by forest plantations in Colombia (Colombia, 2018b). Since these plantations absorb carbon dioxide while growing, the use of wood makes a low contribution to the national inventory of GHG emissions in Colombia. However, this inventory is not clear about transitory use and discard provided by the building sector. Therefore, this aspect of carbon emissions from the building sector remains opaque.

On the other hand, deforestation of natural forest contributes to more than 30% of the GHG emissions in Colombia. This activity is strongly related to the expansion of the agricultural frontier, both for the planting illicit crops, monocultures and livestock production, but it is also related to the illegal exploitation of wood, which would implicitly compromise several sectors, such as furniture and building. Although these and other sectors have signed a pact for legal wood, the possibility of informal building using wood from natural forests cannot be discarded.

There is not enough information available to analyse the impact of the construction sector regarding emissions derived from the use of wood, whether it comes from legal plantations or is illegally extracted from natural forests. Therefore this topic is not further discussed in this thesis.

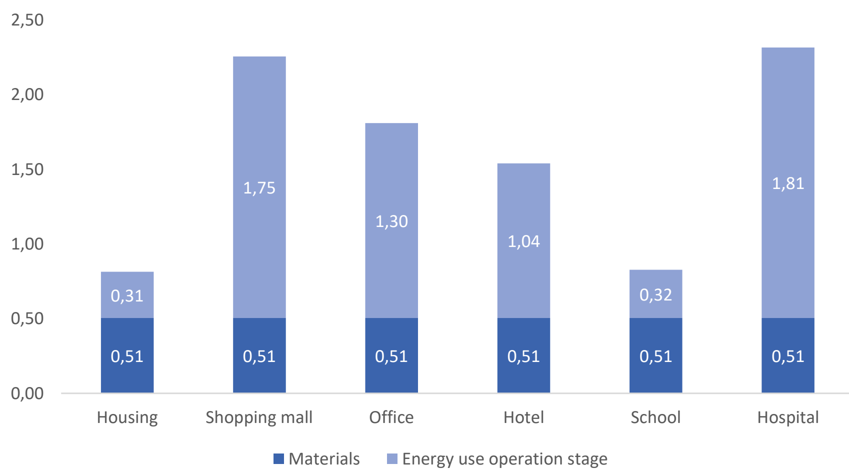


Figure 2-1. Emissions from the lifecycle of buildings in Colombia, considering the confined masonry constructive system, which accounts for 75% of floor area built every year
Source: The authors, based on MVCT, 2015; PNUD, UMPE & Ecoingeniería, 2012; Pardo et al., 2017
For detailed data supporting these calculations please refer to Appendix A

2.2. POLICIES ON BUILDINGS WITH CARBON REDUCTION POTENTIAL

At national level, eight (8) policies related to sustainable buildings were identified, where six instruments have a cross-sector scope, while two are specific to the building sector as described next:

- **the National Policy on Climate Change and the Nationally Determined Contribution to the Paris Agreement – NDC;**
- **a National Policy on Green Growth and a related National Strategy on Circular Economy,**
- **two cross-sector policies on energy efficiency (Proure and Retiq)**
- **a National Policy on Sustainable buildings and a National Code on Sustainable Buildings**.

Four policies have prospective approach, do not set baselines or reduction scenarios for carbon emissions and do not calculate implementation costs. Such policies could not be used for further analyses here. The other four policies, do not allow a Life-cycle approach because they focus on energy efficiency during operation stage of buildings. These include the two cross-sector policies on energy efficiency (Proure and Retiq), the NDC and the Code on Sustainable Buildings. While all of these set a baseline for energy consumption, only the NDC and Retiq sets a baseline for GHG emissions, as well as a cost-benefit analysis. However, it is noticeable that, concerning buildings, Colombian NDC is based on the National Code, therefore these two instruments may be considered as equivalent (see table 2-3).

At the local level, two policies concerning sustainable building were identified, one set by Bogotá, the capital city (Alcaldía Mayor de Bogotá, 2015), the other set by the Aburrá Metropolitan Area - AMVA (AMVA & UPB, 2015), which is the second largest urban area in Colombia. The Aburrá Valley policy set a baseline for GHG emissions with a lifecycle perspective and define specific actions with indicators, thus enabling calculations concerning carbon emissions reduction. Bogotá policy was not useful for such purpose. Table 2-3 provides a summary of the national and local policies identified.

In conclusion, out of ten policies, only the National Code on Sustainable Buildings (adopted by the NDC), the Retiq and the Local AMVA Policy are useful for projecting carbon emission scenarios, being the local policy the only one allowing a life-cycle approach.

Table 2-3. Summary of existing national and local policies in Colombia, which may be related to the reduction of GHG emissions in buildings

Policy	**Level**	**Scope**	**Host sector**	**Base-line of activity**	**GHG baseline and mitigation impact analysis**	**Life-cycle approach**	**Policy costing**
PPNCC	National	General Framework on Climate Change management (Mitigation and adaptation)	Cross-sector	No	No	No	No
NDC, 2015	National	National goal on GHG reduction by 2030 under the Paris Agreement (Concerning buildings, it refers to the National Code on Sustainable Building (see row 6 in this table)	Cross-sector	Yes	Yes	No	Incomplete
Proure, 2016	National	Energy efficiency for mining, industry, transport and building sectors	Energy	Yes	No	No	No
Retiq, 2014	National	Energy efficiency from eco-labelling and replacement of systems, equipment and appliances at industry and building sectors	Energy	Yes	Yes	No	Yes
Green growth policy	National	General framework for natural resource efficiency in Mining, Agro-food, Industry and Construction sector	Cross-sector	Incomplete	No	Incomplete	No
National Strategy on Circular Economy	National	General framework for circular economy. Concerning buildings, it focus on reducing Construction and Demolition Waste – CDW by integral management, including recycling	Cross-sector	Incomplete	No	Incomplete	No
National Code on Sustainable Building	National	Energy efficiency in designing new buildings, considering both passive (bioclimatic design) and active (efficient systems and appliances) measures.	Buildings	Yes	No	No	Incomplete
National Policy on sustainable buildings	National	General framework for sustainability in the building sector with a lifecycle perspective	Buildings	Incomplete	No	Yes	No
Local Policy - Bogotá	Local	General framework with general guidelines for sustainability in the building sector	Buildings	Incomplete	No	Yes	No
AMVA Policy	Local	General framework with specific measures for sustainability in the building sector, including a GHG baseline for: 1) embodied carbon in materials, 2) energy use at operational stage (based on the National Code), 3) CDW recycling and 4) residential waste	Buildings	Yes	Yes	Yes	No

Source: The author, based on: MADS (2015, 2016), MME (2019); MVCT (2015), DNP (2016, 2018), Misión de Crecimiento Verde (2018), AMVA & UPB (2015), MME (2019), UPME (2016b))

2.3. PROJECTING CARBON EMISSION SCENARIOS

Based on the policies analyzed in section 2.2, a projection of scenarios was prepared for the reduction of carbon emissions from the building sector. Specific measures deriving from these policies are listed in table 2-4. Scope and assumptions of this projection is described next:

System limits

- The baseline for building activity corresponds to average built area in the period 2015 - 2018. Only formal building activity reported by the National Department of Statistics is included (DANE, 2019). Due to the absence of updated information on informal construction activity, this is not considered.
- The area current building stock is unknown, therefore the impact of the measures on existing buildings corresponds to an extrapolation based on the Colombian Energy Balance (UPME, 2019) and the National Inventory of GHG Emissions (Pulido et.al., 2016)
- The type of buildings considered includes housing, retail, offices and educational centres
- Colombian emission factors are used when information is available (UPME, 2016c; Pulido et.al., 2016; PNUD, UPME & Ecoingeniería, 2012; Pardo et al., 2017; MME, 2019; IDEAM et al., 2016; DANE, 2019b), otherwise, emission factors provided by the Intergovernmental Panel on Climate Change are used IPCC, 2006)
- The costs of implementing analysed measures, as well as their potential economic benefits, come from supporting documents of the policies considered, data on current rates of public services are also used.

Assumptions

- The reference scenario or Business as usual - BAU is based on population growth projections from the National Statistics Department (DANE, 2018b) and the growth of energy demand from the Energy Mining Planning Unit (UPME, 2016a, 2016b, UPME, Corpoema, IREES, TEP, 2019)
- The emission factors of construction systems, materials and technologies remain constant throughout the projected period
- The cost and benefit analyses are projected as net present value, considering inflation rates equivalent to the average for the period 2015 - 2018

- In the emission reduction scenarios, a gradual adoption of measures is assumed until reaching 100% of new buildings, built each year by 2030, and reaching 100% of existing buildings by 2050

Table 2-4. Carbon reduction measures suitable for scenario projection from existing policies

Life-cycle stage	Category	Measure	Description	Related policy
Operational stage	Passive – energy efficiency	Natural illumination Natural ventilation Low solar radiation	Improving both natural illumination and natural ventilation, while reducing incoming solar radiation to in-door spaces. Based on architectural (bioclimatic) design	National code (only new buildings) AMVA (both new and existing buildings)
	Active – energy efficiency	LED illumination Efficient fans Efficient HVAC systems Efficient water pumps Heat pumps	Reducing energy consumption (electricity) by incorporating efficient systems and appliances	National code (only new buildings) Retiq (both new and existing buildings) AMVA (both new and existing buildings)
	Active – on-site energy production	Thermic solar panel Photovoltaic solar panel	Transforming solar radiation o roofs to either electricity or heat	National code (only new buildings) AMVA (both new and existing buildings)
	Residential waste	On-site composting of organic fraction from residential waste	For description see Box 2-1	AMVA (both new and existing buildings)
Materials: extraction and manufacturing	Materials	Substitution of conventional Portland Cement by Limestone Calcined Cement (LC cement) and puzzolanic materials	LC Cement and puzzolanic materials have a lower carbon footprint as compared to Portland cement, while showing equivalent performance	
Construction		Improving concrete performance by incorporating chemical additives (plasticizers)	chemical additives (plasticizers) improve performance of conventional concretes, thus leading to high-performance concretes, where less cement is required in order to gain equivalent strength	
		Shifting to industrialized building systems	Industrialized building systems have less embodied footprint as compared to more widely conventional system based on confined masonry (see table 2-4)	
Construction and demolition		Recycling concrete-derived CDW to replace natural aggregates in new concretes	Recycling CDW reduces the net material flow of a building project by decreasing both, demand for raw materials and waste production	National Strategy on Circular Economy (baseline on carbon emissions not provided) AMVA (both new and existing buildings)

Source: The author

Box 2-2. Residential waste management as a measure to reduce carbon emissions in buildings

A special feature at the Aburrá Metropolitan Policy is that, it includes on-site composting of organic residential waste as a building-related low-carbon policy.

Conventional policies for urban waste management tend to focus on collection logistics, and final disposal. In Colombia and other countries in the region, this means that urban waste management consists on collecting mixed waste to be deposited in sanitary landfills, where the recyclable materials are lost while the organic fraction decomposes under anaerobic conditions, thus producing methane. In Colombia, this process is responsible for 50% of carbon emissions related to basic sanitation.

Supporting documents for the ecourbanism and sustainable construction policy of the Aburrá Metropolitan Area argue that solid waste management should be oriented towards on-site separation of recyclable materials from the organic fraction, which does not depend exclusively on citizens decisions but also on buildings being designed with spaces that are adequate for such separation. Hence residential solid waste, and consequently waste related carbon emissions, are related to the design of the built environment.

Furthermore, considering that half of population in the large cities in the country currently lives in apartment buildings while construction activity is increasingly concentrated in this type of buildings, which must have adequate spaces for waste separation, then it is possible to use those spaces, not only for separation, but also for on-site composting of organic waste, thus avoiding anaerobic decomposition in landfills, reducing the amount of waste transported to these disposal sites and contributing to the reduction of carbon emissions.

Practical examples of this approach are provided by the policy documents (AMVA & UPB, 2015)

From the baseline described in section 3.2, using population growth projections and assuming gradual policy implementation until full adoption by 2050, scenarios for future emissions from buildings in the period 2018 – 2050 were projected (figure 2-2).

The BAU scenario shows a constant emissions growth, reaching 25 Mt $CO_{2\text{-eq}}$ by 2030 and 28 Mt $CO_{2\text{-eq}}$ by 2050. The EEDBN and CDW scenarios, do not produce a significant deviation from the BAU scenario. Only when energy efficiency criteria are incorporated into existing buildings, there is a significant carbon reduction, as proposed by the EEEB scenario, allowing to reach 23 Mt $CO_{2\text{-eq}}$ by 2030 and 24 Mt $CO_{2\text{-eq}}$ by 2050, equivalent to 8% and 14% reduction, respectively as compared to the BAU scenario. Since the NDC goal of Colombia is a 20% reduction in emissions with respect to the BAU scenario by 2030, the joint implementation of current national policies would not allow NDC compliance for building sector. In addition, emissions trends continue to grow towards 2050 at every national policy scenario, meaning that current national policies are insufficient to promote decarbonisation of this sector.

Only when introducing the LP scenario both 2030 and 2050 goals are met. This scenario allows 18 Mt $CO_{2\text{-eq}}$ of sectorial emissions by 2030 and 16 Mt $CO_{2\text{-eq}}$ by 2050, corresponding to 28% and 43% respectively, as compared to the BAU scenario, suggesting that local policy of the Aburrá Valley should be scaled up to the national level, in order to make possible for Colombia to achieve compliance with the NDC for the building sector by 2030 while also undergoing a decarbonisation path in the long-term perspective.

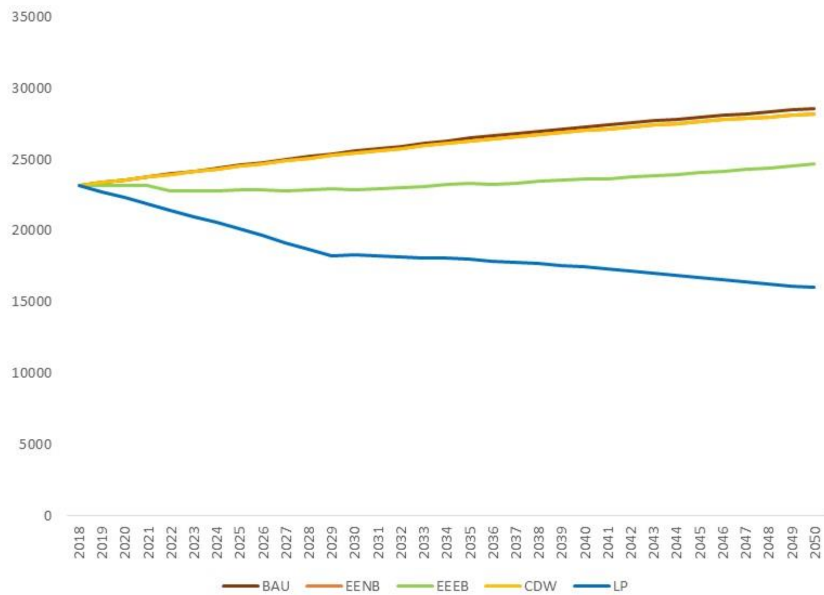


Figure 2-2. Scenario analysis on carbon reduction policies for the building sector in Colombia

Source: The authors, based on UPME, 2015; UPME, 2016b; UPME, 2018; UPME, 2019; MADS, 2015; DNP; 2016; AMVA & UPB, 2015; PNUD, UPME & Ecoingeniería, 2012; Pardo et al., 2017; MME, 2019; IDEAM et al., 2016; DANE, 2019a; DANE, 2019b; AMVA & Camacol Antioquia, 2018, Cancio et al., 2017

Legend

BAU: Business-As-Usual scenario

EENB: Energy efficiency applied to the design and construction of new buildings

CDW: Use of recycled CDW to replace concrete aggregates in construction of new buildings

EEEB: Energy efficiency applied to the design and construction of new buildings + Retrofit of existing buildings + replacement of existing inefficient appliances

LP: Full implementation of principles raised by the local policy on sustainable building from Aburrá Valley at the National level. Consisting on: EENB + CDW + EEEB + Solar energy on new building apartments + full conversion from "confined masonry" to industrialized construction systems + replacement of Portland cement with alternative cement materials + use of supplementary cement materials + separation of residential solid waste with in-situ composting of the organic fraction

2.4. ECONOMIC AND FINANCIAL ASPECTS OF REDUCING CARBON EMISSIONS IN BUILDINGS

By analysing individual measures included in national and local policies, the measure showing the highest mitigation potential by 2050 consists of separating residential solid waste with *in-situ* composting of the organic fraction. This measure has also a low investment cost, with a pay-back period of 1.7 years, allowing a positive net return for every ton of $CO_{2\text{-eq}}$ avoided (table 2-4).

The following higher mitigation potentials come from the set of measures aimed at reducing the use of Portland cement, corresponding to a complete shifting to industrialized construction systems, and the use of substitute and supplementary cementing materials. The shift of construction system does not imply an investment cost, since it actually reduces costs by reducing material intensity. In the other hand measures related to the use of substitute and supplementary cementing materials, do require additional investments, which would inevitably increase end value of buildings. On the other hand, as evidenced in the analysis of scenarios, the use of recycled aggregates, although contributing to the reduction of the material intensity of the sector, does not show any potential for reducing emissions. Hence, its economic aspects cannot be analysed from a low carbon perspective and are not shown here (table 2-4).

Measures aimed at energy efficiency during operational stage of buildings are the most expensive to implement, with values ranging from $ 101 to $ 378 by ton of $CO_{2\text{-eq}}$. However, these measures allow operational savings, with pay-back periods ranging between 4.2 and 9.7 years, producing high economic returns for each ton of $CO_{2\text{-eq}}$, this is valid for energy efficient appliances and also for photovoltaic panels, with the exception of solar water heating, whose pay-back period goes up to 37.6 years, showing no feasibility from a low carbon perspective. As shown by figure 2-2, scenario analysis, energy efficiency measures are only effective at reducing carbon emissions when both new and existing buildings are included (table 2-4).

Beyond economic viability based on investment returns, it is important to consider financial aspects of implementing low-carbon measures in buildings. National government has been incorporating recommendations of the multilateral banks regarding green financing. In this sense, national development banks have been creating instruments to finance both business and public initiatives, aimed at climate change mitigation and adaptation. Starting in 2015, private banks also began to venture into green financing. The main instrument used by both development and private banks consists on issuance green bonds to both national and international markets. In 2018 the value of such bonds reached up to 22% of the stock market nationwide. Transaction of these bonds in turn has allowed to create direct financing instruments through soft loans for investment in energy efficiency technologies, renewable energies and cleaner production (Ocampo et al, 2018). With the enactment of the National Climate Finance Strategy, issued in 2020, financial capacity is expected to continue to expand in the coming years to meet the new national goal of reducing carbon emissions by 51% by 2030 (DNP, 2020; Colombia, 2021).

Table 2-5. Feasibility and effectiveness analysis for each of the measures contained in the national and local policies included in this study

Measure	National Policy	Local policy	Capital investment (USD/ton CO_{2-eq})	Operational savings (USD/ton CO_{2-eq})*	Net revenue (USD/ton CO_{2-eq})*	Payback period (years)	Mitigation potential by 2050 (Gg CO_{2-eq})
Energy efficient building design. Residential	Yes	Yes	$ 151	$ 612	$ 461	7,4	75,4
Energy efficient building design. Other building	Yes	Yes	$ 101	$ 748	$ 648	4,0	61,7
Retrofits of existing buildings and Replacement of inefficient home appliances	Yes	Yes	$ 283	$ 680	$ 397	4,2	1028,6
Photovoltaic panel. Residential	Yes	Yes	$ 296	$ 612	$ 316	9,7	860,0
Solar water heating	Yes	Yes	$ 378	$ 201	-$ 177	37,6	250,0
Waste separation and composting of organic fraction	No	Yes	$ 8	$ 17	$ 9	1,7	7228,3
Recycled aggregates for concretes	Yes	Yes	$ 0	$ 0	$ 0	No	-0,1
Low carbon cement	No	Yes	$ 14	$ 0	-$ 14	No	1802,9
Supplementary cement materials	No	Yes	$ 34	$ 0	-$ 34	No	1307,6
Shift to industrialized system	No	Yes	-$ 68	$ 0	$ 68	No	2081,5

Source: The authors, based on UPME, 2015; UPME, 2019; DNP; 2016; AMVA & UPB, 2015; Pardo et al., 2017; MME, 2019; MADS, 2015; DANE, 2019b; AMVA & Camacol Antioquia, 2018; Cancio et al., 2017; Ospina et al., 2017

**Net present values. Increasing of energy prices and interest rates are not considered*

2.5. ¿ARE LOW CARBON BUILDINGS IN DEVELOPING COUNTRIES FEASIBLE?

Feasible Contributions from buildings to national GHG emissions in emerging economies may be comparable to the individual contributions of Industry and Transportation sectors, revealing that buildings may play a key role in achieving the goals of reducing national carbon emissions. However, this fact is evident only under a life-cycle approach.

At a single building scale, studies in other contexts have found that 80% of GHG emissions from the life-cycle of buildings are caused by energy consumption during operational stage (Gong & Song, 2015; Chau et al., 2015). This thesis shows that in emerging economies in tropical climates this proportion is met only by certain type of buildings, such as shopping-malls, hospitals, offices and hotels, but not by housing buildings and schools, where materials can contribute up to 70% of life-cycle emissions. Within this context, building materials for new buildings make a contribution to national GHG emissions that is comparable to emissions from electricity of the entire existing building stock, while doubling emissions from fossil fuels used for cooking and water heating purposes. There is no data available to calculate the contribution of residential waste to a single building scale, but it makes a relevant contribution to national emissions. This is due to the fact that solid waste emissions in Colombia mainly come from the disposal of non-separated waste in landfills, followed by anaerobic decay of the organic fraction (DNP, 2016; DNP, 2018; IDEAM et.al, 2016).

Existing policies focusing on eco-efficiency of the building sector do not provide data concerning low carbon potential. However it is possible to project a potential route for compliance with the Paris Agreement by 2030, with a decreasing trend of emissions by 2050. This route includes 1) reducing the carbon footprint of constructive systems and materials; 2) energy efficiency during operational stage of new and existing buildings; and 3) separation of residential solid waste with *in-situ* composting of the organic fraction.

Measures aimed at reducing energy consumption in new buildings, as well as measures addressing materials from recycling construction and demolition waste – CDW do not produce significant carbon abatements. Only by incorporating energy efficiency measures in existing buildings, a deviation from the BAU scenario is achieved. These are relevant findings because the current NDC from Colombia is focusing only on new buildings (MVCT, 2015; DNP, 2018; MVCT, 2020), while the main action of the National Circular Economy Strategy for the building sector is CDW recycling (Misión de Crecimiento Verde, 2018). Both measures can be important in achieving specific goals, such as the reduction of future electricity consumption and reducing material intensity in buildings, but having little or no effect on low carbon development.

Although an energy efficiency approach comprising new and existing buildings produces a deviation from the BAU scenario, the long-term trend in emissions remains incremental until introducing both building material measures (comprising industrialized construction systems, low carbon cements and high performance concretes) and on-site composting of organic waste.

Regarding mitigation impact and cost-effectiveness ratio of individual measures, results show composting of residential solid waste to make the largest potential contribution to reducing building emissions on a long-term basis, with low investment cost, while producing operational savings. After composting residential waste, the measures showing the larger mitigation potential are those related to constructive systems and building materials. Since shifting confined masonry to industrialized construction systems may in fact lessen building costs, by reducing material intensity, this may compensate increasing costs from cement substitutions and high performance concretes.

Concerning economic and financial aspects, the barriers to the development of low-carbon buildings are being removed. However, adoption of these technologies is restricted to offices, shopping malls and hotels. Housing buildings, representing 80% of the area annually built in Colombia (DANE, 2019), are still being designed and built with conventional technologies. This fact is, at least partially, related to contradictory signals from the national government itself. For example, the green building code that was discussed along this chapter applies to schools, offices, retail, hotels, and housing. However subsidized social housing is excluded from compliance. In fact, in 2014 national government launched an ambitious plan to build 100,000 fully subsidized houses for poor families across the country. The plan ended in 2018 and fulfilled the goal regarding the number of dwellings, but did not set any goal related to green building. Therefore, a valuable opportunity to leave a referent for low carbon development in the building sector was lost (Ramos et al, 2017; Coronel-Ruiz, 2018; Niño D.F, 2018; Burgos et al, 2016). In chapter 5, analysis will be expanded to understand barriers that hinder the development of low carbon buildings, elaborating from the field of Transition Theory.

Practical implementation of these results will require further exploration of several important aspects. On one hand, the success of this measure does not only depend on the design and construction of adequate spaces in buildings, it also requires an active commitment of occupants regarding waste separation (AMVA & UPB, 2015), which has had a historical cultural challenge in Colombia (DNP, 2016). On the other hand, there are alternatives for reducing waste emissions that can be implemented at disposal sites with better outcomes by economy of scale (DNP, 2016). Likewise, the composting alternative, despite its low investment cost, also has a low revenue and may have a high opportunity cost as compared to waste-to-energy measures, which have proven to be viable in other contexts (Eyre et al., 2014). However, this alternative seems unfeasible due to the low costs of generating energy from other sources in Colombia (DNP, 2016).

Another aspect requiring further exploration concerns energy efficiency during operational stage. The fact that these measures do not lead to decreasing trends in emissions is due on the one hand to the fact that Colombia is a tropical country with constant temperatures throughout the year, where the use of heating systems is marginal, while the use of air conditioning occurs predominantly in non-residential buildings (MVCT, 2015). At the same time, national electricity production is largely based on hydraulic power, with a low emission factor (UPME, 2019). However, availability of hydraulic energy is proportional to rainfall, being highly dependent on climatic variability. In fact, the emission factor of the national energy system may double during dry seasons, such as those produced by the Pacific Thermal Oscillation of "El Niño" - ENSO (UPME, 2018). Hence, the importance of energy efficiency in new and existing buildings as a mitigation strategy may actually show a long-term increase due to climate change. Likewise, considering that last ENSO event, during the 2014 – 2015 period put the production of electricity at national level at risk, this aspect also has a relevant role concerning urban resilience. This two-fold role that has not been explicitly raised by any existing policy in the Country has the potential to strengthen synergistic approaches to mitigation and adaptation goals in the building sector.

Another particular aspect requiring further exploration has to do with construction systems. All related measures analysed here relay on the use of concrete based systems, where long-term decreasing trends of emissions are possible, but complete decarbonisation is not actually achieved. The use of construction systems based on low emission materials (Nkem et al., 2014), may be the only alternative to reach actual net zero buildings.

These findings are useful for adjusting and updating policies on buildings, concerning both decarbonisation and circular economy in Colombia and are potentially useful for designing low carbon policies in other emerging economies. However, their application requires considering context-specific aspects, such as urbanization rates, prevalent construction systems and materials, climatic conditions affecting operational energy use, emission factors for electric power, as well as residential waste disposal practices.

These findings reveal the importance of science-based and context-specific policies, as compared to *a-priori* policies based on general premises. The fact that the one policy analysed here, able to produce a low carbon path, is a local policy, also reveals that top-down conventional approaches must be reconsidered and policy making at national level may by strengthened by acknowledging local referents.

An important flaw of the analysis presented here is that it refers to formal construction and leaves out informal housing, whose incidence in the urban development in Colombia and Latin America is quite significant. Currently, it is estimated that 75% of housing built annually in the region is informal (The World Bank, 2017). While, measures related to the operational phase of buildings could be applied in the informal segment as well, measures related to materials discussed here are linked to formal building systems that are currently used by construction companies, thus leaving out alternative systems used by people in informal settlements. Despite the fact that there is much information regarding informal urban development in Latin America and there are publications discussing potential measures to reduce carbon emissions in this segment, there are no quantitative data concerning national magnitudes and trends. Hence, it was not possible to make scenario projections in that direction.

3. SCIENCE, POLICY AND PRACTICE OF THE SUSTAINABLE BULT ENVIRONMENT

3.1. TRENDS

3.1.1. Research trends

The number of indexed journals concerning sustainability aspects of the built environment was gradually growing by the first decade of this century, however it significantly increased in the present decade, going from twelve titles in 2009 to twenty-six in the year 2016. The number of conferences with indexed proceedings also shows an increasing trend during the current decade, although its growth is less consistent as compared to the number of journals, due to the inherent variability of such events (figure 3-1).

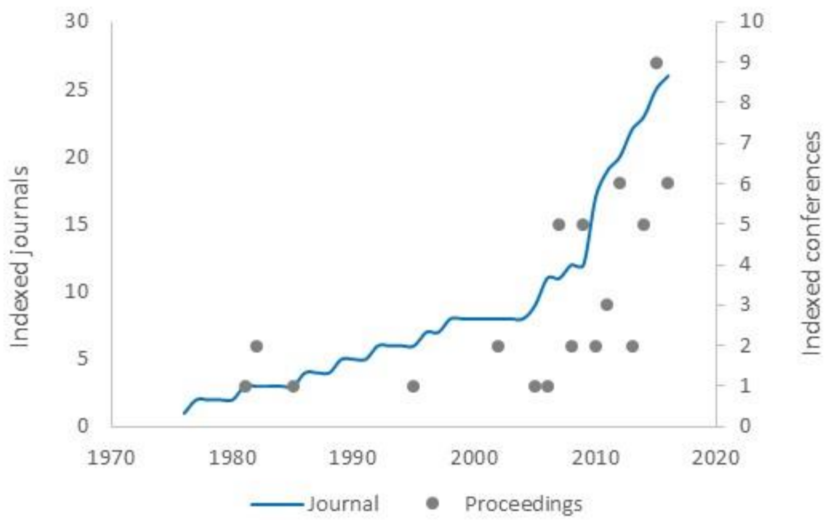


Figure 3- 1. Indexed journals and conferences
Source: the authors, based on Scopus

3.1.2. Policy trends

The search for databases related to sustainability policies in the built environment yielded results only at the building scale, corresponding to the Global Building Performance Network (GBPN, 2019) and the International Energy Agency (IEA, 2019), both focusing on energy efficiency. No similar databases regarding policy instruments at either district or infrastructure levels were found.

The list of sustainability policies in buildings includes regulatory, economic instruments, strategic plans, voluntary schemes and information and evaluation instruments. The global number of these policies showed a steady growth during the 1980s and the 1990s, but it increased significantly during the last two decades, going from 160 instruments reported in the year 2000 to 1030 in the year 2019. The Latin America and the Caribbean region show a similar trend, going from 6 instruments in the year 2000 to 67 in the year 2019 (figure 3-2).

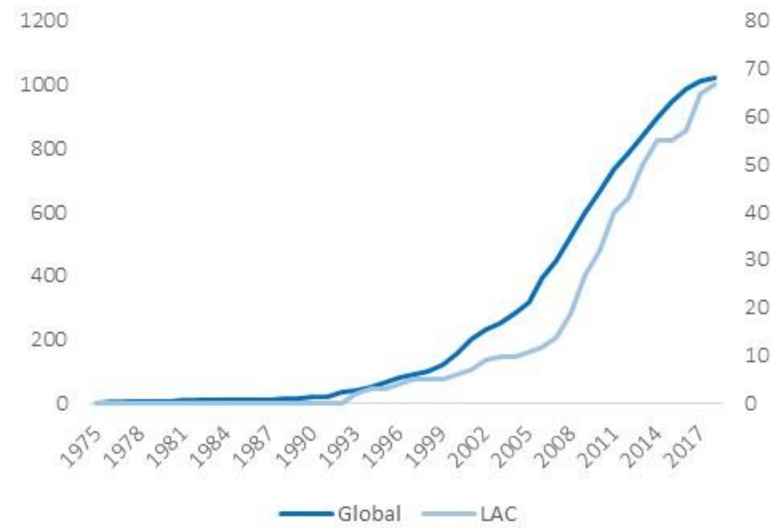


Figure 3- 2. National policies on sustainable building at global and regional (LAC: Latin America and the Caribbean) level
Source: The authors, based on IEA, 2019 and GBPN, 2019

3.1.3. Practice trends

The implementation of sustainability criteria in buildings has also shows a growing global trend (Doge & Data Analytics, 2018), going from only 96 certified projects in 2000 to more than 500 thousand in 2017, for BREEAM scheme and from 800 projects in 2005 to 90 thousand in 2017 for LEED scheme (figure 3). Other certification schemes, such as HQE and DNGB also report similar trends (data not shown). Data concerning the number of projects implementing certification schemes in Latin America and the Caribbean are not consistent and are not shown (figure 3-3).

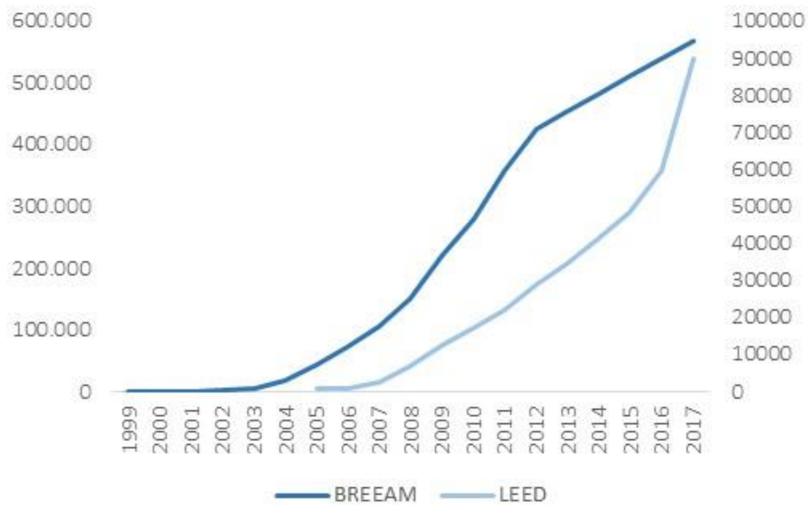


Figure 3- 3. Buildings certified under the two most widespread schemes
Source: The authors base on web sites https://www.breeam.com/ y https://new.usgbc.org/

3.2. THEMATIC SCOPES OF SCIENCE, POLICY AND PRACTICE OF THE SUSTAINABLE BUILT ENVIRONMENT

3.2.1. Thematic scope of Research on the Sustainable BE

The New Urban Agenda, used here as a reference for the global agenda on sustainable development at the city level, is organized into 22 issues divided into 6 thematic areas (UN, 2017a). These 22 issues do not express all the topics related to the sustainability of the BE, but set general lines on sustainable urban development. The review on scientific papers, policy instruments and assessment schemes, allowed to set a list of specific topics and relate them to each of the NUA issues. Results are shown in table 3-1.

Table 3- 1. BE topics addressed by research papers, policy instruments and certification schemes with respect to the structure of the New Urban Agenda

Themes of the New Urban Agenda		**BE topics addressed by research papers, policy instruments and certification schemes**
Areas	**Issues**	
1. Social cohesion and equity	1. Inclusive cities	Social inclusion
		Thermal comfort and ventilation
		Noise
		Lighting
		Accessibility
		Mental health
		Aesthetics
		Integral Wellbeing
	2. Migration and refugees	Migration
	3. Safer cities	Safer cities
	4. Urban culture and heritage	Culture and heritage
2. Urban frameworks	5. Urban rules and legislation	Urban rules and legislation
	6. Urban governance	Urban Governance
	7. Municipal Finance	Finance
3. Spatial development	8. Urban and spatial planning and design	Spatial planning and design
	9. Urban land	Land planning
	10.Urban rural linkages	Urban rural linkages
	11. Public space	Public space
4. Urban economy	12. Local economic development	Impact of sustainability criteria on investment costs
		Impact of sustainability criteria on operational costs
		Project Life-cycle costing
	13. Jobs and livelihoods	Jobs and livelihoods
	14. Informal sector	Informal sector
5. Urban ecology and environment	15.Urban Resilience	Urban Resilience
	16. Urban ecosystems and resource management	Energy
		Materials
		Water
		Waste
		GHG emissions
		LCA approach
		Green infrastructure
		Biodiversity
		Pollution
	17. Cities climate change and disaster risk management	Climate change adaptation
		Disaster risks management
6. Housing and basic services	18. Urban infrastructure and basic services	Infrastructure and basic services
	19. Transport and mobility	Transport and mobility
	20. Housing	Housing
	21. Smart cities	Education
		Innovation and technology
	22.Informal settlements	Informal settlements

Source: The authors, based on UN, 2017a

Findings show that the most common topic in scientific research in the field of BE concerns indoor thermal comfort, with 35% of annually published papers. Other aspects related to occupants' well-being in buildings, such as noise, lighting and accessibility account for 11%. The second most commonly addressed topic is energy efficiency, also at building scale, with 16% of annual publications. This means that 67% of scientific papers concerning sustainability in the built environment are focused on comfort and energy efficiency in buildings. Every other issue, as well as every other scale of the built environment, is being modestly addressed in comparison. This includes aspects of paramount relevance to the post-2015 agenda, such as climate change and natural disaster risks reduction, but also other issues of environmental relevance, such as biodiversity protection; water and material efficiency; waste and pollution reduction. Likewise, issues of social relevance, such as social inclusion, informal settlements, housing, security, culture and heritage as well as economic aspects such as local economic development and employment provision are all of them receiving marginal attention from the science of the built environment (figure 3-4).

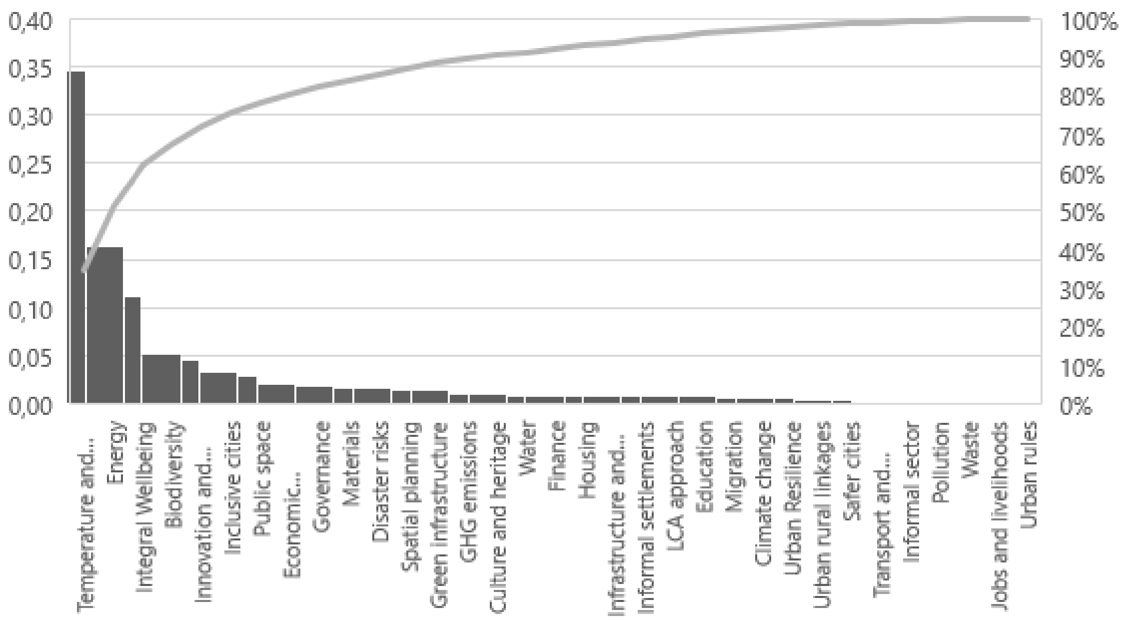


Figure 3- 4. Cumulative percentage of topics addressed by published papers
Source: The authors, based on Scopus review

3.2.2. Thematic scope of Research of Policy and practice on the Sustainable BE

Most certification schemes for sustainability in buildings tend to cover a wide range of topics, but weighing criteria are divergent. Energy efficiency is particularly important at BREEAM (BRE, 2016) and LEED schemes (USGBC, 2019a), while issues related to other natural resources, such as water and materials, as well as pollution and waste management, are consistently important in all other schemes, with the exception of WELL.

With the exception of the DGNB scheme and the ISO Standard, economic aspects of sustainability criteria receive little attention in most schemes, being even absent from some, such as LEED and

SHERPA. The reduction of GHG emissions appears only in LEED and SB Tool, while adaptation to climate change and disaster risk reduction is addressed by the SB Tool, the ISO standard and SHERPA system. Social aspects, other than indoor comfort, such as social inclusion, cultural adequacy and heritage protection, are only present in BREEAM, SB Tool and SHERPA, being the former the only one addressing the challenge of introducing sustainability criteria to informal settlements (See Appendix B).

Aspects concerning access to public space and urban services are also present in all schemes, but get low relative importance at BREEAM and LEED. Other aspects, such as green infrastructure and biodiversity protection, are present only in the BREAM, DGBN (DGNB, 2018), SB Tool (IISBE, 2015) and the ISO Standard (ISO, 2008). Likewise, while some schemes, such as DGNB and BREEAM explicitly address life-cycle assessment, no scheme addresses urban resilience.

When comparing the degree to which these schemes are addressing the post-2015 agenda, the highest comprehensiveness index is shown by SB Tool, followed by DGNB and SHERPA. The remaining schemes have similar levels as compared to each other, with the exception of the EDGE and WELL schemes, which are focused on far fewer issues (figure 3-5).

At the regional level, national sustainable policies on buildings and strategies have different focuses and degrees of thematic development. While Chile's National Strategy emphasizes technological aspects, but covers a wide range of other issues (Chile, 2013), the National Standard of Mexico has a strong focus on water, energy, waste and GHG emissions (United Mexican States, 2013) and the National Policy of Colombia focuses on social inclusion, internal well-being, energy, water, materials, transport and mobility (Colombia, 2018). On the other hand, adaptation to climate change is present, both in the National Strategy of Chile, and in the National Policy of Colombia, while disaster risk reduction is only present in the National Strategy of Chile (See Appendix B).

Social aspects, such as social inclusion and indoor well-being, are important to Colombian policy and are present in the National Strategy of Chile, but are absent in the National Standard of Mexico. Other social aspects, such as cultural adequacy and heritage protection, are absent from the three policies.

Aspects concerning the relationship between buildings and surroundings, such as land planning and urban services, but also biodiversity protection and green infrastructure, are present in the Colombian Policy and the Chilean Strategy, but not in the Mexican Standard. The issue of transport and mobility is only present in the policies of Mexico and Colombia. Finally, the only policy that considers economic aspects in the evaluation of sustainability is the National Strategy of Chile. The other two policies include economic aspects, but not as a performance topic to be evaluated, but in terms of incentives required to promote sustainable building. Among National Policies, the National Strategy of Chile shows the highest comprehensiveness index (figure 3-5).

3.2.2.1. Scope of building related instruments and tools

Concerning national and local certification schemes and guides, there is a wide diversity of approaches. Indoor comfort is, once again, is a wide prominent aspect, with the exception of SAC Colombia (Colombia, 2016) and Selo Azul of the Federal Government from Brazil (Caixa Econômica Federal, 2010), where the issue is present, but not particularly relevant. Energy efficiency shows high importance to the local Standard of Mexico City (Federal District Government, 2012) and to CASA Colombia scheme (CCCS, 2016), while materials efficiency is a relevant aspect at the Chilean certification scheme (Chile, 2014), at the two Colombian national standards, and at the Qualiverde standard of the City of Rio de Janeiro, Brazil (Prefeitura Rio de janeiro, 2012). Water efficiency shows high importance to all the schemes and standards, standing out at the local certification scheme from Bogotá, Colombia (Alcaldía Mayor de Bogotá, 2014) and with the exception of the Chilean certification scheme and the Argentine standard. On the other hand, the reduction of GHG emissions, as well as climate change adaptation, are only present in the Chilean scheme and in the local guides of the Aburrá Valley (AMVA & UPB, 2015), while the reduction of disaster risk is present in the Chilean scheme, the Argentine standard and the local Qualiverde scheme, being absent from all Mexican and Colombian standards and guides.

Social aspects other than indoor comfort, such as social inclusion, are present only in the Chilean scheme and in the SAC Colombia, while cultural adequacy and heritage protection are absent from all these instruments. On the other hand, the only instruments including economic aspects of performance are the Argentine standard, the SAC Colombia and the local guides of the Aburrá Valley. Finally, aspects relating buildings and their surroundings, such as land planning, urban services and transportation, biodiversity protection and green infrastructure are present at all instruments, with the exception of the CASA Colombia scheme (See Appendix B.1).

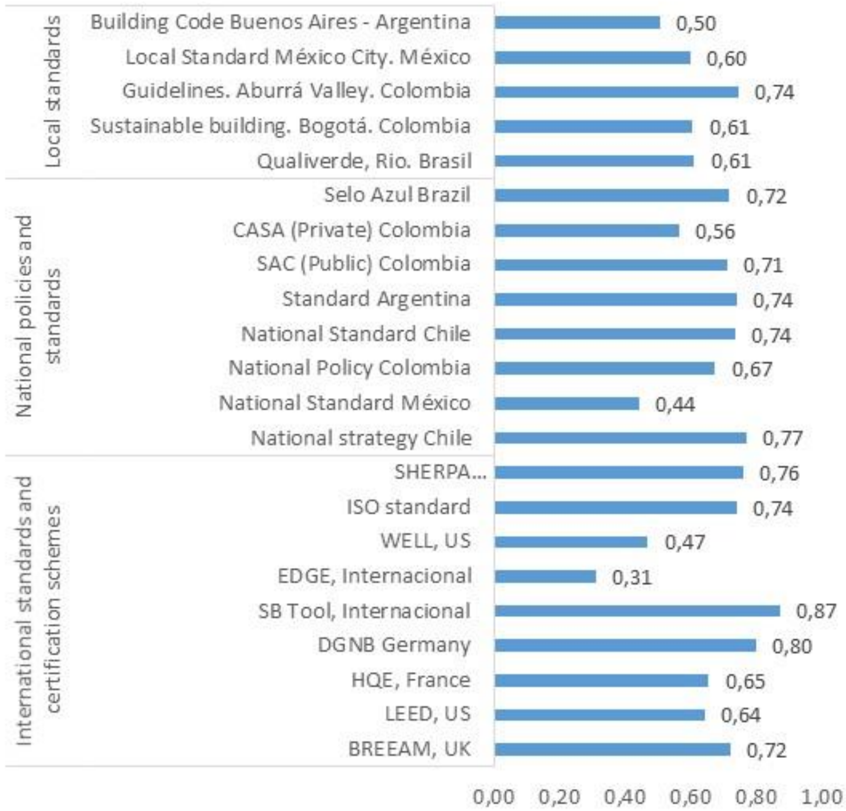


Figure 3- 5. Comprehensiveness index of policies, standards and certification schemes at the building scale, according to the Shannon H index of their thematic scope
Source: The authors, based on the contents and rating systems of the instruments listed.
IFC, 2016; BRE, 2016; USGBC, 2019a; International Well Building Institute, 2019; DGNB, 2018; IISBE, 2015; ISO, 2008; HQE, 2018; UN-Habitat et al., 2017; AMVA & UPB, 2015; Chile, 2013; Estados Unidos Mexicanos, 2013; Colombia, 2018; Instituto Argentino de Normalización y Certificación (2016); Ciudad de Buenos Aires, 2018; Colombia, 2016; Caixa Econômica Federal, 2010; Gobierno del Distrito Federal, 2012; CCCS, 2016; Chile, 2014; Prefeitura Rio de janeiro, 2012; Alcaldía de Bogotá, 2014

3.2.2.2. Scope of district-scale related instruments and tools

Instruments related to sustainability of the built environment at district scale are less abundant, but tend to show a broader thematic scope as compared to those at the building scale. Here, urban frameworks related to financing and governance, as well as aspects related to social inclusion, spatial design, transport and access to urban services gain importance as compared to energy efficiency and comfort issues.

The most relevant topic for certificates at district level is spatial design, with an explicit orientation towards urban compactness in some cases. Social and economic issues such as public space; social inclusion and occupants’ well-being; urban-rural relations; cultural adequacy and heritage protection as well as local economic development and job provision; are topics consistently addressed by all schemes, with few exceptions. The efficient use of natural resources such as energy, water and materials, as well as waste and pollution reduction; and disaster risk reduction, are all topics present at every scheme. On the other hand, GHG emissions, as well as adaptation to climate change are only present in BREEAM, HQE, Ecodistrics and the Ecosystemic framework of the Urban Ecology Agency of Barcelona (AL21 & Ecologia BCN, 2012). Finally, Innovation and technology is an aspect present in all the schemes.

Systemic issues, such as life-cycle approach to environmental and economic costs is explicitly addressed by DGNB (2016), while urban resilience is addressed only by HQE and Ecodistricts schemes. However, their approach is not systemic, and focuses on climate change.

Concerning policy instruments and certificate schemes issued in Latin America, there is a National Guide in Chile (2017), emphasizing the use of materials and water, as well as green infrastructure and addressing occupants' well-being. On the other hand, there are two local initiatives in Colombia, one in Bogotá (Alcaldía Mayor de Bogotá, 2015), the other in the Aburrá Valley (AMVA & UPB, 2015). Both focus on natural resources efficiency, green infrastructure, biodiversity protection and occupants' wellbeing. Other social aspects are absent in both cases and only the local guide of the Aburrá Valley includes economic aspects as a performance issue. In both cases, disaster risk management and adaptation to climate change are included. However the reduction of GHG emissions is only present in the local Aburrá Valley guide (See Appendix B.2).

When comparing the degree to which these schemes are addressing the post-2015 agenda, the highest comprehensiveness index is found at the Ecosystemic framework from Barcelona, followed by the local guidelines from Aburrá Valley, and the Ecodistricts approach (Figure 3-6).

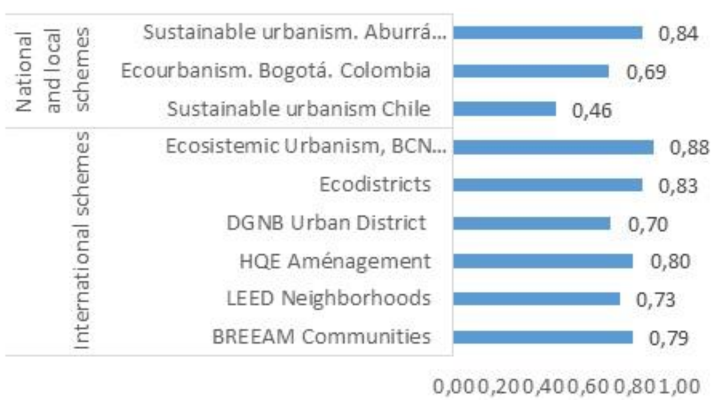


Figure 3- 6. Comprehensiveness index of policies, standards and certification schemes at district scale, according to the Shannon H index of their thematic scope
Source: The authors, based on the contents and rating systems of the instruments listed
BRE, 2012; Ecodistricts, 2018; HQE, 2011; DGNB, 2016; AL21 & Ecologia BCN, 2012; USGBC, 2019b; Chile, 2017; Alcaldía Mayor de Bogotá, 2015; AMVA & UPB, 2015

3.2.2.1. Scope of Infrastructure-scale related instruments and tools

Approaches to sustainable infrastructure are more diverse than the preceding scales. While the SURE system, gives more importance to spatial planning, pollution control and financial management (Global Infrastructure Basel, 2015), the IAB Framework places greater importance on aspects related to social inclusion, economic development and technological innovation (Inter-American Development Bank, 2018). On the other hand, the IS Rating tool system emphasizes technological innovation, biodiversity protection, pollution control, finance management, culture and heritage, while the CEEQUAL (BRE, 2019) and Envision (Institute for Sustainable Infrastructure, 2018) systems do not set specific priorities and cover a wide range of topics, conferring them similar values of relative importance (See Appendix B.3).

All instruments aimed at assessing and certifying sustainability in infrastructure projects include reducing GHG emissions, climate change adaptation, reducing natural risks, protecting biodiversity and increasing social inclusion among their topics. Likewise, issues such as boosting local economy and creating local jobs are present in most instruments. The same stands true for systemic approaches such as life-cycle analysis, life-cycle costing and resilience.

When comparing the degree to which these schemes are addressing the post-2015 agenda, the highest comprehensiveness index is found at both the CEEQUAL and Envision systems, closely followed by the IAB Framework.

At this scale, nor policy instruments, neither certification systems produced by countries or cities in Latin America and the Caribbean were found.

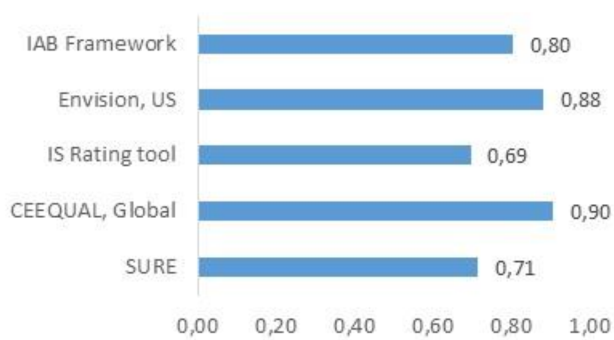


Figure 3- 7. Comprehensiveness index of policies, standards and certification schemes at the infrastructure scale, according to the Shannon H index of their thematic scope
Source: The authors, based on the contents and rating systems of the instruments listed
Global Infrastructure Basel, 2015; Inter-American Development Bank, 2018; BRE, 2019; Institute for Sustainable Infrastructure, 2018; ISCA (2017).

3.3. OVERVIEW ON SCIENCE, POLICY AND PRACTICE FOR A SUSTAINABLE BUILT ENVIRONMENT

3.3.1. Discussing thematic comprehensiveness

Findings here show that there is a growing interest concerning the sustainable development of the built environment at research, policy and practice ambits. However, this trend is still focused on the building scale, where the largest number of papers; policy instruments and certification schemes are found, whereas district and infrastructure scales account for a smaller number of papers, instruments and schemes, which are relatively more recent in comparison (IEA, 2019; GBPN, 2019; Guldager & Birgisdottir, 2018; Griffiths et al., 2018; Sharifi, 2013.

Concerning the thematic scope of scientific research related to the sustainability of the built environment, the mainstream covers a relatively narrow range of topics, focusing on indoor comfort and energy efficiency at the building scale. All other topics, issues and thematic areas raised by the UN post-2015 agenda, as well as other scales of the built environment, are undervalued in terms of the annual volume of scientific production. Marginal issues include mitigation and adaptation to climate change; disaster risk reduction; efficiency of natural resources other than energy; reduction of impacts from pollution and waste; biodiversity protection and green infrastructure; social inclusion and participation; cultural adequacy and heritage; local economic development; job provision and informal settlements, among other issues. Hence, there are important research gaps in the field, regarding comprehensive perspectives of sustainable development, which is significant, considering that understudied thematic areas are not really new, and actually have been present in the Global Agenda since the years following Agenda 21 (CIB, 1999; Plessis, 2002).

Among marginal issues in scientific research, GHG emissions are particularly noteworthy. Whereas climate change mitigation has become a crucial goal; since nearly 40% of energy related GHG emissions come from buildings (Lucon et al., 2014; IEA & UNEP, 2018), a higher proportion of research papers addressing this issue would be expected. It is likely that mainstream research concerning building energy efficiency assume that their contribution in this aspect is implicit and this fact may be mentioned within most related papers. From methods used here it is not possible to test this assumption.

Concerning the practical application of sustainability criteria in buildings, certification schemes have been in place for three decades (Guldager & Birgisdottir, 2018). While these schemes have been mainly issued at European countries and the United States, and were initially conceived for application in their country of origin, several of them have been internationalized and began to be used in Latin America and the Caribbean, even before most countries at the region issued public policies in this regard (Tellez et al., 2014). However, during the current decade, several Latin American countries and some leading cities have designed their own schemes.

All the schemes for evaluating and certifying sustainability at the building scale tend to emphasise indoor comfort. In second place, some emphasize energy efficiency, but others focus on water or material efficiency, whereas several others focus on the relation of buildings with urban planning and urban services. However, there are also some schemes that, while giving high importance to indoor comfort, also address a wide range of topics, providing a wider perspective concerning the post-2015 global agenda. It is noticeable that some of such comprehensive schemes have been in fact issued in Latin America.

At the district scale, there is a smaller number of both policies and certification schemes, as compared to the building scale. Here, aspects such as spatial planning, transport and mobility, urban services and public space, as well as innovation and technological development, gain importance, whereas topics related to resource efficiency and environmental impact, are still relevant. Perspectives provided by these schemes upon the post-2015 global agenda are variable, but again, it is noticeable that among most comprehensive approaches, there are some Latin American examples.

At the infrastructure level, certification schemes are even fewer as compared to the district scale. Here, topics such as social inclusion, cultural adequacy; project financing; economic sustainability; innovation and technological development and biodiversity protection; take more relevance. Again, resource efficiency and environmental impact continue being important topics. In contrast with the precedent scales, at the infrastructure level, there are no sustainability policies issued in Latin American countries, which is not surprising, considering that most certification schemes at this scale are relatively new, demonstrating that this is an emerging issue. Furthermore, the international schemes produced for this scale show a broader scope than in the case of buildings and districts, so they could provide a pertinent reference to update and improve existing instruments concerning districts and buildings.

In conclusion, while existing instruments and schemes cover a wide range of topics, there are still aspects of the global agenda being poorly addressed or even being neglected at both policy and practice level. In general terms, issues such as biodiversity, green infrastructure, access to urban services; local economic development, innovation, technology and education; as well as climate change and disaster risk management are present in several schemes, mainly at the district and infrastructure scale. Other issues, such as job provision, cultural adequacy and informal settlements, are addressed only by few instruments. Finally, systemic methods, such as life-cycle approaches, are also absent from most instruments, while another emerging systemic approach, such as urban resilience, is present only in instruments at the infrastructure scale and when included, it is usually related to a single aspect, such as adaptation to climate change or disaster risk reduction, without addressing the various dimensions related to this topic in the New Urban Agenda (UN, 2017a).

In Latin America, the interest on the sustainable BE has also been growing and has gone from the adoption of international certification schemes, towards the design of national and local instruments. However, most of these national initiatives underrate the same issues that are being neglected by scientific research and international certification schemes.

While it is useful to build on existing international initiatives, it is also pertinent to continue producing original schemes and instruments that overcome thematic limitations, both facing the post-2015 agenda, and the particular needs of the region. In this sense, several Latin American examples are already showing higher comprehensiveness indices, as compared to some widely used international schemes. This provides an important opportunity for south - south exchange of referential frameworks and experiences, as an alternative to the traditional north - south benchmarking that have usually guided regional policies. Instruments concerning sustainability of the built environment in Latin America must move from merely focusing on environmental performance to address interactions between poverty, spatial inequality, mobility, disaster risk reduction, environmental quality, biodiversity, climate change, urban resilience and economic productivity.

In addition to expanding the range of thematic areas, an important next step is shifting from checklists to interactions between topics and issues, enabling integration between sectors and thematic areas, thereby promoting more coherent and cost-effective policies (Le Blanc, 2015; ILO, et al., 2018; Bouyé et al., 2018). This approach demands greater integration between research, policy and practice in order to ensure that issuing new instruments as well as updating existing ones is based on socially relevant scientific information that contributes to mainstream a systemic approach to sustainable development of the built environment (Habert & Schlueter, 2016). Such instruments will certainly be more difficult to design, implement and evaluate, but shall be more effective to promote transformational change.

3.3.2. From certification schemes and policy documents to the real world

Despite of the integrative view characterizing some policies concerning the sustainable built environment, countries in Latin America have important challenges to meet concerning institutional capacity to carry out a comprehensive implementation such these instruments.

First challenge concerns with bringing together green and social policies in order to ensure that sustainability criteria is not restricted to private projects with large capitals, but are also implemented in public projects, such as schools, hospitals and public offices, but most of all in social housing. As seen in section 3.2 of this chapter, the National Sustainable Building Policy in Colombia, as well as the Local Policies, developed by the two main cities, show a significant degree of thematic comprehensiveness regarding the sustainability (see table 3-5). However, local policies are instruments of voluntary application and national policy on sustainable buildings is rather a road map than a finished instrument ready for implementation. The only mandatory instrument existing today in the country is the sustainable construction code, where subsidized housing is excluded from compliance. Hence, massive subsidized housing programs that have been developed in recent years did not set any goal concerning energy efficiency or carbon reduction (see sections 2.4 and 2.5). On the other hand, this code also has a low thematic comprehensiveness index, since it lacks a life cycle approach, only focuses on energy and water efficiency during the operational phase and does not consider aspects related to habitability or relationship of the building with the environment (see table 3-5). A successful example of the implementation of sustainable construction policies in social housing in the LAC region is Mexico, where there is a wide range of technical instruments, including evaluation and certification schemes; and financial instruments, which include soft credits, subsidies and tax exemptions. The scope of each instrument is clearly defined and its management is assigned to specific institutions, thus assuring verification, monitoring and coherence. Regarding the thematic content, this program includes three sustainability dimensions: community, housing and environment. However, recent independent studies conclude that these programs have mainly focused on economic savings from electricity, natural gas and water, thus downplaying community and environment dimensions (González-Yñigo M. & Méndez-Ramírez J., 2018; Paz et.al. 2015).

In line with harmonizing green and social policies, another important challenge consists on introducing sustainability criteria to intervention programs for informal settlements. In sections 2.4 and 2.5 this issue was discussed as a flaw in the projection of emission reduction scenarios in the construction sector. In this chapter, this topic takes on greater relevance, since here we are not discussing only low-carbon development, but sustainable urban development on a wider perspective, which forces to consider social inequality, access to water, sanitation, energy, health and education services, security of tenure, disaster risk reduction, climate vulnerability, biodiversity and ecosystem services. Intervention programs for informal settlements in the region have generally been guided by narrow visions, which focus on few of these aspects (Álvarez-Rivadulla et al, 2019). Only some evaluation schemes and policies analysed along this chapter explicitly address sustainability criteria for informal settlements.

Another important challenge consists on harmonizing green policies and land planning policies. On the one hand, there is abundant discussion about how are biased by visions from the global north, which were also produced within the framework of "modern urbanism" and therefore, do not address social issues, such as equality and inclusiveness while downplaying variables, processes and elements of the natural realm, thus being useless instruments to comply with the aspirations of sustainable development:

"Land planning instruments in the global south do not serve to: (1) visualize the future, (2) prepare for it at the urban and regional levels, or (3) guide its development. The reason for this is simple: urban planning, as it is conceived and applied, is based on precepts that were forged outside of the contexts it is intended to address. Hence its impact is limited, and impacts neither the entire urban space nor its population, and thereby directly or indirectly accentuates social disparities and territorial fragmentation. The goal of this renewal in the urban sciences and planning practices is to analyse the many forms of urban poverty (precarity, segregation, marginalization, informality, exclusion, vulnerability and growing disparities, to name a few). This vision of the city and the resulting urban and/or regional organization is historically rooted in the West. Its translation to the Global South was long replicated based mainly on technical and procedural considerations, and without taking into account the human, cultural, geographic or urbanistic realities of local and regional contexts"(Bolay J, 2020).

Finally, another challenge is the harmonization of green and financial policies, this includes, not only the need to develop mechanisms for direct financing of eco-technologies, such as those discussed in section 2.4. In the broader approach discussed in this chapter, financing the sustainable built environment is directly related to institutional capacity for spatial planning, urban management, infrastructure development, implementation of social programs, and protection of natural resources. In turn, this capacity depends on national and sub-national fiscal principles, national and sectorial planning processes, public-private partnership frameworks, multi-year budgeting, project evaluation and selection criteria, investment protection, transparency in budget execution, project management and monitoring of public assets. The IMF's assessment of institutional capacity, specifically in terms of infrastructure development, shows important differences between the different countries, but in general, the efficiency of investments in public infrastructure in LAC is lower than the average achieved by industrialized economies (Serebrisky et al, 2018). Concerning fiscal resources, Latin America and the global south in general, lack adequate institutional structures for integrated urban planning and government fiscal relations. This again introduces the issue of land planning, since very important municipal revenues come from taxes and fees derived from urban development and the efficiency of this development, which in turn, should be efficiently controlled by the planning process. In many countries, local taxes and other sources of income could be an important source of financing for development. However, taxes such as property taxes represent less than 3 to 4 percent of local income in countries of the global south, compared to 40 to 50 percent in cities in Australia, Canada, France, the United Kingdom and the United States (UN, 2017a).

The implications of these challenges for urban transformation are further discussed again in Chapter 5, from the perspective of Transition Theory.

4. THE UN AGENDA AND THE SUSTAINABLE BUILT ENVIRONMENT

4.1. THE BUILT ENVIRONMENT IN THE NEW URBAN AGENDA

The NUA is structured in 6 large areas: Social cohesion and equity, urban frameworks, spatial development, urban economy, urban ecology and environment and Housing and basic services. Each area contains a variable number of issues. The issues whose title explicitly refers to elements or processes of the BE in the NUA are listed below:

- NUA issue 8: planning and spatial design
- NUA issue 11: public space
- NUA issue 18: infrastructure and basic services
- NUA issue 20: housing
- NUA issue 22: informal settlements

However, each of the 22 NUA issue papers mentions, at least one of these five BE related NUA issues, either as a key driver for action or as part of the main concepts, with the prominent case of planning and spatial design, which is referenced by all issue papers. Infrastructure is also a key driver for ten other issues, while housing and informal settlements are relevant for other three issues. Public space is referenced by two other issues. In addition to these five BE issues, abundant references to issues of the urban-frameworks area are found. In the other hand, inclusive cities, local economic development, urban resilience and smart cities are also extensively referenced as key aspects across the whole NUA.

Findings show that scope of urban resilience and smart cities exceeds those of their respective areas, which is a relevant finding concerning cross-sectorial synergies. While urban resilience is included by NUA in the Ecology area, Smart cities is considered as an infrastructure related issue. Although, urban resilience addresses natural threats, which is within the scope of urban ecology, the concept also includes social, political and economic hazards, from a systemic approach that includes organizational, spatial, physical and functional dimensions, all of which exceeds the reach of Urban Ecology. Same reasoning applies for Smart Cities, whose scope includes infrastructure as part of a larger system, which involves transparency, governance, capacity building and civil involvement concerning knowledge and information, all of which goes far beyond the scope of Infrastructure. According to this observation, Urban Resilience and Smart Cities should be considered cross-cutting issues connecting all thematic areas within NUA (table 4-1)

4.2. THE BUILT ENVIRONMENT AND THE SUSTAINABLE DEVELOPMENT GOALS

Potential contributions of the BE to Agenda 2030 spread over 80 targets corresponding to the 17 SDGs. However, this potential is not homogeneously distributed. A first block showing an extensive number of interactions, includes SDGs 11, 12 and 10, accounting for more than 40 interactions, spread over more than 8 NUA issues. A second block, includes SDGs 9, 6, 1, 7, 8 and 13, with more than 15 interactions, spread over more than 7 NUA issues. A third block, showing a low number of interactions with the BE, includes the remaining eight SDGs (table 4-2).

By using NUA issues as categories to classify interactions with Agenda 2030, three blocks can also be distinguished. A first block of NUA issues, strongly related to SDGs comprises issues 1, 17 and 12. The correlations here exceed 40 SDG targets and 13 SDGs. A second block includes issues 5, 6, 15, 16, 18, 20 and 21, showing interactions with more than 10 targets and 5 SDGs. The remaining NUA issues show few interactions with the SGDs (Table 4-1). For a detailed support concerning the potential contribution of the BE to each SDG targets (See Appendix C.1).

4.3. THE BUILT ENVIRONMENT AND THE SENDAI FRAMEWORK FOR DISASTER RISK REDUCTION

A total number of 18 NUA issues show BE related interactions with, at least, one criteria of the four Sendai Framework priorities. As expected, the most significant correlations are found in NUA issues 15 and 17, referred to urban resilience and climate action and disaster risk reduction, which are related to 20 criteria across the four Sendai priorities. Second strongest interaction is showed by NUA issue 8, related to planning and spatial design, which is related to 5 criteria across three priorities. All other issues relate to less than four criteria at only one priority. In the other sense, priority 3 of the Sendai Framework, referred to investment in resilience, is the most widely correlated with the NUA, with a total of 27 interactions, spreading across 12 issues. The other three priorities show up to 16 interactions with up to 7 NUA issues (table 4-1). For more detail about the interaction between BE elements and processes and specific criteria in the four priorities of the Sendai Framework, see Appendix C.3.

4.4. THE BUILT ENVIRONMENT AND THE PARIS AGREEMENT

The Paris Agreement is not divided into thematic areas, goals and issues. Likewise, cities here are as considered Non-Party stakeholders and the local scale of climate change is basically considered only in terms of adaptation, being restricted to Articles 7 and 11 of the Agreement. Therefore contribution of the built environment here is less evident as compared with the remaining agreements. However, the relationship between the built environment and climate change has been proven here to be significant in the other three instruments, while the importance of sustainable urban development for climate action is widely supported (Tollin et al., 2016).

The most obvious relationship with between climate change and the built environment within the framework of the NUA is found at issue 17, which is precisely the issue showing the most extensive relationship with the SDGs and the Sendai Framework. Additionally, the NUA issues 5, 8, 15 and 16 are related to SDG 13 referred to climate action, being also related to climate change. On the other hand, targets 11.5, 11.6, 11.b and 11.c, are related to increasing climate resilience while reducing impacts upon the environment, including carbon emissions. Hence, the NUA issues 1, 8, 12, 15, 18 and 20, which are related to these SDG targets, also relate to climate change. Finally, the content of the NUA papers refers to low carbon development and climate resilience in the issues: 1, 4, 6, 8, 9, 10, 11, 15, 16, 18, 19, 20, 21 and 22. In conclusion, almost all of the NUA issues, with the exception of issues 2, 3, 7 and 14, are related to climate change, thus showing a potential contribution to the Paris Agreement (table 4- 4).

4.5. A MAP FOR A SUSTAINABLE BE IN THE FRAMEWORK OF THE GLOBAL AGENDA

Table 4-4 provides a summary of the BE related synergies connecting the four major instruments of the UN Agenda, which is further illustrated by figure 4-1. The framework for this network map is the transformative policy approach, where elements of Agenda 2030 are classified into three categories: framework conditions, corresponding to SDGs 16 and 17, transversal directions, corresponding to SDGs 1, 2, 5, 8, 10, 12 and 13 and implementation areas, corresponding to SDGs 3, 4, 6, 7, 9, 11, 14 and 15 (Schot et al., 2018).

When extended to the NUA, issues 5, 6 and 7 make the set of framework conditions, while issues: 1, 8, 12, 13, 14, 17 and 21 make the set of transversal directions and the remaining NUA issues make the set of the implementation areas (figure 4-1). Issue 16 is placed in the transversal directions, although it actually plays a two-side role of implementation area and transversal direction, as it refers to ecosystems and resource management.

Regarding the Sendai Framework, priority 2 as referring to strengthen governance, plays a framework condition role; while priorities 1 and 3, as referring to understanding risk and investing in risk reduction, are transversal directions. Priority 4, as referred to enhancing preparedness for response, recovery, rehabilitation and reconstruction is an implementation area. As for the Paris Agreement, since it is not set upon thematic areas, both mitigation and adaptation to climate change are considered as transversal directions, while aspects of finance, technology transfer and capacity building, also known as means of implementation, may be considered as framework conditions. The resulting figure is a network showing synergies connecting elements across the four instruments (figure 4-1).

For graphic purposes, not every link identified in Table 4-1 is represented in figure 4-1, which focussed on elements showing the wider range of synergies and the strongest links (based on the number of targets and related criteria). The map begins in the left-hand side with the set of framework conditions, consisting of NUA issues 5, 6 and 7, SDGs 16 and 17 and Sendai priority 2. This set is connected to SDG 11, determinant of the NUA, connecting with the set of transversal directions through NUA issue 8, which is not only the basic process of the built environment, but is also a cross-cutting element of the entire NUA, as being referenced as a key driver by every issue. Next key landmarks are the issues and goals most extensively and strongly connected with each other, corresponding to NUA issues 1, 12, 15, 16, 17 and 21, which are basically the set of NUA transversal directions. Within this same group of landmarks are the SDGs 10 and 12, showing not just the interactions with NUA issues found in this work, but also the synergies among other SDGs, found by Le Blanc (2015). Sendai priorities 1 and 3, as well as climate change mitigation and adaptation dimensions are also placed here. The map ends at the right-hand side with the whole set of implementation areas, including elements of the built environment present at NUA, such as public space, housing, infrastructure and informal settlements.

Table 4-1. Summary of the BE related synergies across the four major instruments of the global agenda on sustainable development

NUA Area	NUA Issue	BE related synergies between NUA issues	SDG targets with potential contributions from the BE	BE related criteria in Sendai Framework priorities	BE related elements of climate action and the Paris agreement
Social cohesion and equity	1. Inclusive cities	2, 5, 6, 7, 8, 12,15,16, 17, 18	1.2, 1.3, 1.4, 1.5, 2.2, 3.9, 3.d, 4.a, 5.1, 5.5, 5.a, 6.1, 6.2, 6.3, 6.b, 7.1, 7.2, 7.3, 7.b, 8.2, 8.3, 8.4, 8.5, 8.8, 9.1, 9.2, 9.4, 9.a, 9.b, 10.2, 10.3, 10.4, 10.7, 11.3, 11.4, 11.7, 11.a, 11.b, 12.1, 12.2, 12.4, 12.5, 12.8, 12.a, 12.b, 12.c, 13.1, 13.2, 13.3, 13.4, 15.4, 15.9, 16.1, 16.5, 16.6, 16.7, 16.10, 16.b, 17.8, 17.16	1.c, 1.d, 3.o	Preamble of the decision Issue related to SDG 11.b target Reference to climate change in the issue paper
	2. Migration and refugees	1, 6, 8, 13, 15, 20, 21, 22	10.7		Preamble of the decision
	3. Safer cities	1, 3, 5, 6, 7,8, 15, 21	16.1, 10.2, 10.3, 10.4		
	4. Urban culture and heritage	1, 8, 11, 12, 13, 15, 21	11.4	3.d	
Urban frameworks	5. Urban rules and legislation	6, 7, 8	1.4, 1.5, 5.a, 6.1, 6.2, 7.1, 7.3, 9.1, 10.4, 11.1, 11.7, 11.c, 12.5, 13.1, 13.b, 14.1, 15.9, 16.7, 17.14	2.d, 2.k	Issue related to the SDG 13
	6. Urban governance	1, 7, 8, 21	1.4, 1.5, 5.a, 5.5, 6.b, 9.1, 10.2, 10.3, 10.4, 11.1, 11.7, 11.c, 12.5, 13.1, 13.b, 16.5, 16.6, 16.7, 17.14	3.j, 2.a, 2.d	Reference to climate change in the issue paper
	7. Municipal Finance	6, 8, 12, 18	17.16	3.c	
Spatial development	8. Urban and spatial planning and design	1, 2, 4, 5, 6, 7, 9, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22	11.3, 11.c, 10.2, 10.3, 10.4, 13.2, 13.b	2.k, 3.h, 4.d, 4.k	Issue related to the SDG 13 Issue related to the SDG 11.c target Reference to climate change in the issue paper
	9. Urban land	1, 5, 6, 7, 8, 10, 12, 16, 18, 21, 22	11.3, 10.2, 10.3, 10.4	3.f, 4.j	Reference to climate change in the issue paper
	10.Urban rural linkages	1, 5, 6, 7, 8, 12, 15, 16, 17, 18, 21	2.2, 11.a, 15.1, 15.2, 15.3, 15.4, 15.9	1.b	Reference to climate change in the issue paper
	11. Public space	1, 3, 5, 6, 7, 8, 12, 16, 17, 18, 19, 21	11.7		Reference to climate change in the issue paper
Urban economy	12. Local economic development	1, 5, 7, 8, 10, 15, 16, 18, 19, 21	1.3, 1.4, 1.5, 3.6, 3.9, 3.d, 4.a, 5.a, 6.1, 6.2, 6.3, 6.4, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4, 9.1, 9.2, 9.4, 9.5, 9.a, 10.2, 10.3, 10.4, 11.1, 11.3, 11.5, 11.6, 11.7, 11.a, 11.b, 11.c, 12.1, 12.2, 12.4, 12.5, 12.6, 12.7, 12.a, 12.b, 12.c, 13.1, 13.2, 13.3, 13.b, 15.9, 16.5, 16.6	3.c	Art 7 of the agreement Issue related to the SDG 11.6, 11.b and 11.c targets
	13. Jobs and livelihoods	1, 2, 5, 7, 8, 21	8.3, 8.5, 8.7, 8.8, 8.9, 10.2, 10.3, 10.4	3.e	Preamble of the decision
	14. Informal sector	1, 5, 7, 8, 21	8.8, 10.2, 10.3		
Urban ecology and environment	15.Urban Resilience	1, 5, 6, 7, 8, 16, 17, 21	1.3, 1.4, 1.5, 3.9, 3.d, 6.2, 6.3, 9.1, 9.a, 10.2, 10.3, 11.5, 11.b, 11.c, 13.1, 14.2	1.b, 1.c, 1.d, 1.f 2.a, 2.d, 2.k 3.c, 3.d, 3.e, 3.f, 3.g, 3.h, 3.j, 3.o, 4.c, 4.d, 4.k, 4.j, 4.l	Issue related to the SDG 13 Issue related to the SDG 11.b, 11.c targets Reference to climate change in the issue paper

NUA Area	NUA Issue	BE related synergies between NUA issues	SDG targets with potential contributions from the BE	BE related criteria in Sendai Framework priorities	BE related elements of climate action and the Paris agreement
	16. Urban ecosystems and resource management	1, 5, 7, 8, 12, 13, 15, 18	3.9, 5.a, 6.3, 6.4, 7.2, 7.3, 8.4, 8.9, 9.1, 9.2, 9.4, 9.5, 9.a, 11.2, 11.3, 11.4, 11.6, 11.7, 11.a,11.b, 11.c, 12.1, 12.2, 12.4, 12.5, 12.6, 12.7, 12.8, 12.a, 12.b, 12.c, 14.1, 15.1, 15.2, 15.5, 15.9	1.b	Issue related to the SDG 13
	17. Cities climate change and disaster risk management	5, 6 ,7, 8, 12, 15, 16, 18, 19, 21	1.5, 2.4, 3.9, 3.d, 4.a, 6.2, 6.3, 6.4, 6.5, 6.6, 6.b, 7.2, 7.3, 7.a, 8.4, 8.9, 9.1, 9.2, 9.4, 9.5, 9.a, 10.2, 10.3, 11.2, 11.3, 11.4, 11.5, 11.6, 11.7. 11.a,11.b, 11.c, 12.1, 12.2, 12.4, 12.5, 12.6, 12.7, 12.8, 12.a, 12.b, 12.c, 13.1, 13.2, 13.3, 13.a, 13.b, 15.1, 15.2, 15.5, 15.9	1.b, 1.c, 1.d, 1.f 2.a, 2.d, 2.k 3.c, 3.d, 3.e, 3.f, 3.g, 3.h, 3.j, 3.o, 4.c, 4.d, 4.k, 4.j, 4.l	Explicit reference to climate change
Housing and basic services	18. Urban infrastructure and basic services	1, 5, 7, 8, 15, 16, 21	6.1, 6.2, 6.3, 6.4, 6.5, 6.6,7.1, 7.2, 7.3, 9.1, 9.2, 9.4, 9.5, 9.a, 10.2, 10.3, 10.4, 11.3, 11.6	2.a, 4.c, 4.l	Issue related to the 11.6 target Reference to climate change in the issue paper
	19. Transport and mobility	1, 5, 6, 7, 8, 12, 13, 15, 16, 21	3.6, 10.2, 10.3, 11.2	4.c	Reference to climate change in the issue paper
	20. Housing	1, 3, 5, 6, 7, 8, 9, 12, 15	1.2, 1.4, 1.5, 5.a, 6.1, 6.2, 6.4, 7.1, 7.3, 10.2, 10.3, 10.4, 11.1, 11.2, 11.3, 11.5, 11.6, 11.7, 11.a, 11.b, 11.c, 12.1, 12.2,12.5, 12.7, 12.c, 14.1, 17.14	3.f, 3.j	Issue related to the 11.b and 11.c SDG targets Reference to climate change in the issue paper
	21. Smart cities	1, 5, 7, 8	3.d, 4.7, 5.b, 7.a, 8.2, 8.3, 9.b, 9.c, 12.6, 12.8, 12.a, 13.3, 17.6, 17.7, 17.8, 17.16	1.b, 1.f, 3.g	Art 7 of the agreement Reference to climate change in the issue paper
	22.Informal settlements	1, 5, 6, 7, 8, 12, 13, 14, 15, 16, 18, 20, 21	1.2, 1.4, 1.5, 10.2, 10.3, 10.4, 11.1, 11.6	2.k, 3.f	Reference to climate change in the issue paper

Source: based on: UN, 2015;
UNISDR, 2015; UNFCCC, 2015 and UN, 2017a

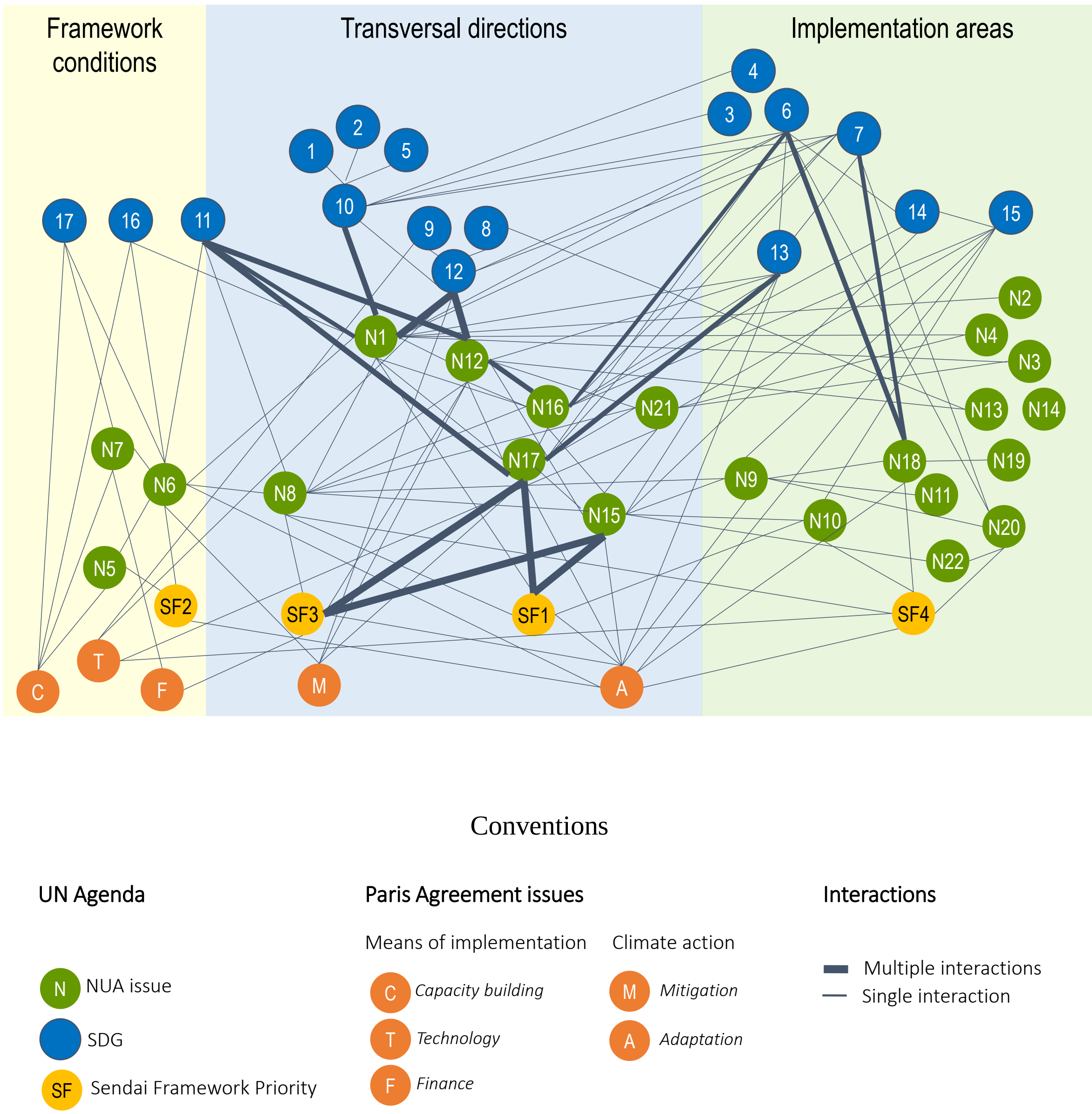


Figure 4- 1. Network map for a sustainable BE in the framework of the global agenda
Source: based on: UN, 2015;
UNISDR, 2015; UNFCCC, 2015 and UN, 2017a

Based on these findings a simplified model for the conceptual map to a sustainable BE in the framework of the global agenda is provided by figure 4-2. The model shows that urban norms, governance, institutions, alliances and finances (framework conditions: SDG 16, 17; NUA 5, 6, 7), should address spatial planning and design of cities (NUA 8) with regards to thee key goals: first is reducing inequalities (SDG 1, 2, 3, 4, 5, 10) based on inclusive cities (NUA 1, 2, 3, 4); the second is strengthening local economic development (SDG 8, 9; NUA 12, 13, 14) based on sustainable production systems and responsible consumption patterns (SDG 12; NUA 16); which is closely linked to the third goal, focussed on rational use of natural resources (NUA 16). Such principles applied to land planning (NUA 9, 10), infrastructure (NUA 18, 19), public space (NUA 11), housing (NUA 20) and human settlements (NUA 22), will help guaranteeing sustainable access to basic services (SDG 6, 7; NUA 18) and protecting local ecosystems (SDG 14, 15; NUA 16), while reducing carbon emissions as well as adapting to climate change (SDG 13, NUA 17). A systemic view on urban resilience (NUA 15), and a comprehensive knowledge and information management strategy (NUA 21) are cross-cutting issues to be involved in order to guide decision-making at every stage, scale and dimension of this approach (figure 4-2).

4.6. CONNECTING THE DOTS FOR AN INTEGRATED AGENDA

In an increasingly urbanizing world, development of the built environment is confronted with the growing challenge of satisfying human needs and boosting national and local economies, while reducing their demand of natural resources, as well as its vulnerability to climate change and other threats (Plessis et al., 2002; Emina et al., 2007; Hassan et al., 2008; Haghighat & Kim, 2009; Newton et al., 2009; Crawford R. 2011;Young R. 2012; Radovic D. 2013; Habert & Schlueter 2016; Sarshar et al., 2015; Seta et al., 2017; Dixon et al., 2018; SRBE Alliance, 2019; Alalouch et al., 2019; IEA & UN Environment, 2018; UN Environment; 2019).

The aim of this work is to highlight BE based landmarks for directions towards sustainable cities, founded on synergies across the thematic areas of the current global agenda on sustainable development. This purpose is based on approaches that: 1) have explored the role of cities and the BE on meeting the SDGs and complying the Paris Agreement (Tollin, 2017; Tollin et al., 2016; Opoku, 2016); 2) have proposed transformative innovation frameworks based on Agenda 2030 (Schot et al., 2108, Lundin et al., 2018); and 3) have approached the SDGs as a network of targets (Le Blanc, 2015). Here a comprehensive framework connecting these approaches across the four major instruments of the global agenda was used, focusing on the role of the Built Environment. *A priori*, the relationship between the BE and the global agenda is simple and restricted to specific elements of each instrument. However, we found extensive relationships making the BE a linking factor across the whole Urban Agenda, with potential contribution to meeting all the SDGs, while contributing to reduce carbon emissions, adapting to climate change and reducing natural risks.

Within NUA, all issues refer to BE related aspects as key drivers for action, with the outstanding case of issue 8, which links the entire NUA, implying that spatial planning and design, is not just relevant to BE elements, such as public space, housing and infrastructure; but it is also critical for achieving inclusive cities; protecting cultural heritage; boosting local economy and creating jobs; while optimizing the use of natural resources and protecting ecosystems; also decreasing carbon emissions, adapting to climate change and reducing natural risks. The analysis of the role of the BE in the NUA also reveals the importance of inclusive cities along the entire urban agenda, as well as the role of urban resilience and smart cities, whose thematic scopes connect all urban thematic areas.

Despite the relevant role played by BE on sustainable urban development, the relationship between the BE and Agenda 2030 has been poorly studied. While the general role of cities on achieving the SDGs has been pointed out by Tollin (2017) and the NUA provide a draft list of SDGs related to urban issues (UN, 2017a), the specific role of the BE on meeting the SDGs has been only explored by Opoku (2016), who concluded that all SDGs, can receive contributions from the BE, with the exception of SDG 14. However, his conclusions are based on SDGs at the goal level. Here we explored the potential contribution of BE to the SDGs at the target level, letting us conclude that a sustainable BE may contribute to meet all SDGs, including SDG 14 (see Annexe 1). In fact, we found that the BE may contribute to meet 80 out of 169 SDG targets, which roughly represents half of Agenda 2030. Analysing SDGs at the target level allows to identify trans-sectorial connections providing a systemic view on the Sustainable Development Agenda (Le Blanc, 2015). SDG targets are also useful not just to identify cross-cutting synergies, but also to define their strength, which we used here to identify BE related landmarks for transformative transitions towards sustainable cities.

When analysing potential contributions of BE to individual SDGs we found a high number of synergies of NUA with SDGs 11, 10 and 12. As being the most obvious link between the two instruments, synergies with SDG 11 are only useful to show coherence. On the other hand, synergies with SDGs 10 and 12 are a significant outcome, since reduction of social inequalities, and sustainable production and consumption have previously been shown as pivotal points of the Sustainable Development Agenda (Le Blanc, 2015; Lundin et al., 2018). Our work shows that this key role extends to the BE, being a less evident, yet most relevant link between the Urban and the Global Agendas. On the other hand, we also found extensive BE related contributions of NUA to Agenda 2030 on issues referred to inclusive cities, local economic development, natural resources and ecosystems, and climate change and natural risk reduction. These synergies reinforce the relevance of the BE to social equity and sustainable production and consumption while connect the BE to both the Sendai Framework and the Paris Agreement. This is just one of multiple synergies between the BE and these two instruments tough. In fact, we found interactions of the Sendai Framework and the Paris Agreement with 18 and 17 NUA issues, respectively. Shows that both are cross-cutting subjects to the Urban Agenda as the built environment is concerned.

The idea that the built environment plays a crucial role in sustainable urban development is not new and has been extensively studied and supported (Plessis et al., 2002; Emina et al., 2007; Brandon & Lombardi, 2005; Boussabaine H., 2008; Haghighat & Kim, 2009; UN Habitat, 2009; Riley, 2013; Dastbaz et al., Loftness et al., 2013; 2015; Kumaraswamy et al., 2015; Habert & Schlueter 2016; SRBE Alliance, 2019; Alalouch et al., 2019). What is underlined here is that such crucial role can be used to decode the current agenda on sustainable development by evidencing synergies connecting spatial and functional dimensions and scales across its four major instruments.

Identifying key elements connecting the BE with the instruments of the global agenda is not aimed to prioritize particular goals, targets, thematic areas or issues, but to identify elements that could serve as BE related axes towards sustainable cities by enabling cross-sector dialogues to increase policy coherence beyond a silo view (Lundin et al., 2018). This approach does not provide indicators meeting measurability and simplicity criteria, but it provides wider indicators showing links across thematic areas and sectors (Le Blanc, 2015). The extension and strength of synergies found here allows to identify BE related landmarks that are useful to draw transition directions towards sustainable cities. These directions may be summarized as from addressing spatial planning and design as a mean to: 1) reducing social inequalities trough inclusive cities, while 2) promoting local economic development through sustainable production and consumption and 3) protecting ecosystems through the rational use of natural resources. Applying these principles to the life-cycle of buildings (including housing), infrastructure and public space allows a more equitable access to urban services while decreasing carbon emissions, reducing natural risks and increasing organizational, spatial, physical and functional resilience. Strategic management of critical knowledge as well as public and real-time access to information play a key role to this approach, which also requires innovations in regulatory, financial and governance frameworks, aimed at enhancing cross-sector synergies rather than prioritizing specific thematic areas.

These findings are expected to be useful for practitioners, scientists and policy makers. Concerning practice, these outcomes may serve to update and improve existing schemes for evaluating and certifying sustainability in buildings, districts and infrastructures. In terms of scientific research, these insights would help identifying currently unaddressed gaps regarding the role of the built environment on sustainable urban development. Concerning policy, this synergistic approach may be useful for governments faced with localizing the global UN Agenda, by allowing to overcome silo approaches resulting from addressing each instrument in isolation. Understanding interactions across instruments, sectors, areas and goals would lead to more coherent policies, programs, projects and actions that will use local, national and international resources more efficiently and effectively to deliver comprehensive outcomes in line with the broad systemic perspective of sustainable development (LeBlanc, 2015).

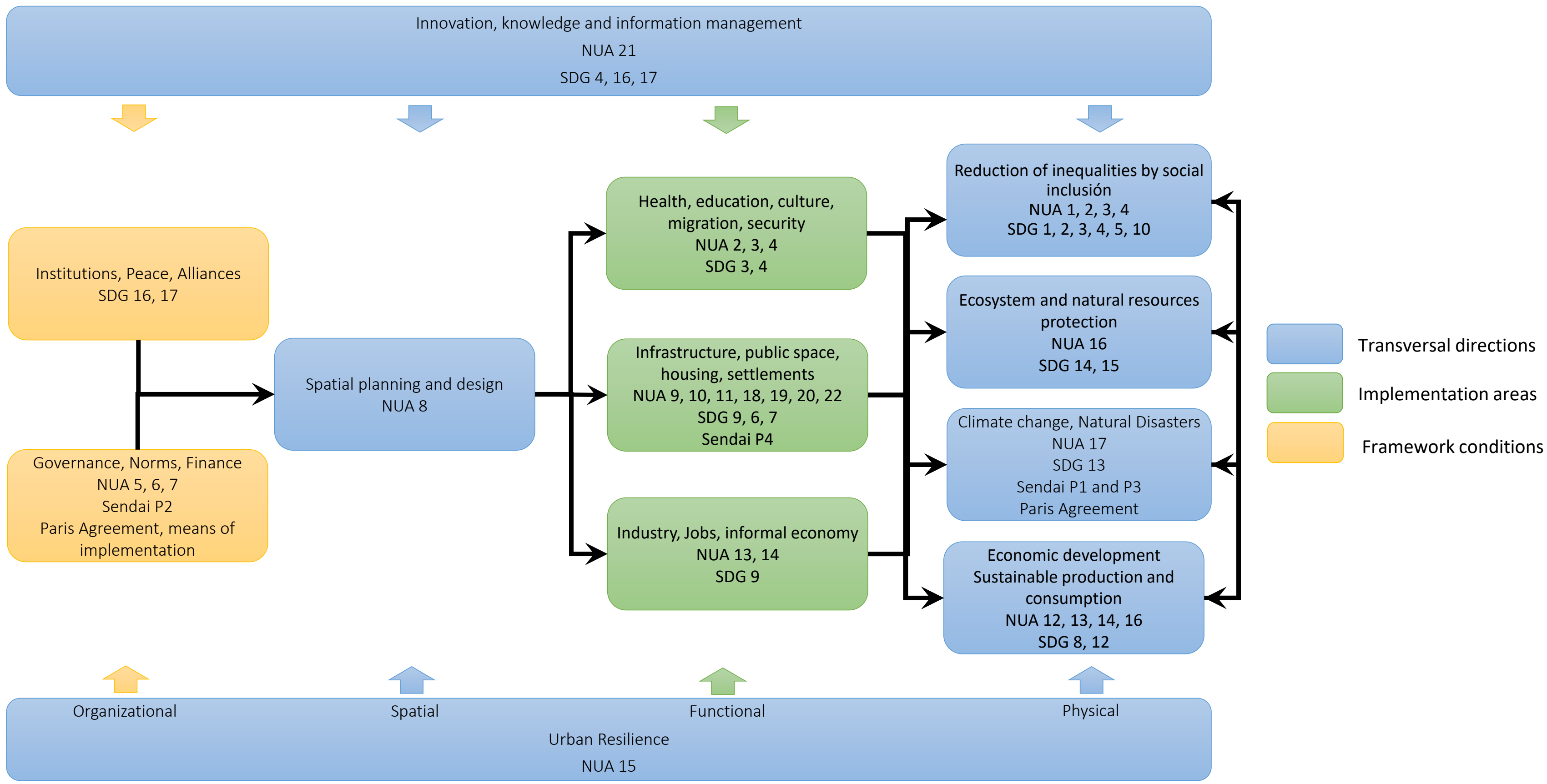


Figure 4- 2. Simplified map describing directionalities for a sustainable BE in the framework of the global agenda
Source: based on: UN, 2015;
UNISDR, 2015; UNFCCC, 2015 and UN, 2017a

5. SUSTAINABILITY TRANSITIONS AND URBAN TRANSFORMATIVE CAPACITY

Section 2.2 uses empirical observations to describe how existing policies can promote low-carbon transitions in the building sector from an Integrated Modelling Assessment – IAMs perspective. However, societal systems are shaped by the persistence of practices, structures and cultures that actively resist transformation and not following linear trajectories (Rotmans & Loorbach, 2010). On the other hand, as described by Sections 3 and 4, a city is not a sum of buildings and carbon reduction is not the sole urban challenge. Pointing towards a comprehensive view on the sustainable built environment, a proposal based on linking different conceptual tools on sustainability transitions is presented below.

First, the Multi-Level Perspective of socio-technical transitions (Geels, 2002) is used to analyse barriers and drivers for low-carbon transitions of the building sector and the role that the sustainable building policy described in the previous section could play in the process. Afterwards, scale grows to include infrastructure, public spaces, districts, cities, metropolitan areas and bioregions, while scope expands to include social equality, economic prosperity and urban resilience. This requires broadening perspectives, from socio-technical systems (Schot & Kanger, 2018), towards socio-institutional (De Haan, & Rogers, 2019), socio-economic (Göpel, 2016) and socio-ecological systems (Moffat & Kohler, 2008) to produce an integrative analytical model for understanding sustainability transitions of the built environment (shortly referred to as STAM). Subsequently, existing perspectives on managing transitions are connected with the STAM to provide insights that can be useful for designing transformative urban policies, aligned with the goals and targets of the UN Agenda.

5.1. ADDRESSING LOW CARBON TRANSITION FOR BUILDINGS

5.1.1. The socio-technical system of the building sector

The socio-technical system of building activity involves a long series of economic sectors, actors, and processes, which could be classified into three sub-systems (figure 5-1). The first sub-system comprises the material inputs for the construction of buildings, including cement, aggregates, bricks, tiles, ceramic materials, steel, wood, systems and devices required for the construction of hydraulic energy and communications systems. All of which involve mining, industrial and imports sectors. The second sub-system includes processes leading to developing buildings, related design, financing, licensing and construction. All of which involve design offices or independent architecture and engineering professionals, contractors, developers, banks, and municipal governments. Finally, the third sub-system comprises the operational phase, including real estate trading, property management, use and maintenance. Transactional processes include selling, renting and property taxation, while metabolic processes involve water and energy use as well as solid waste production. All of which involve the financial sector, the real estate sector, municipal governments and a the broad group of owners and occupants, which individually includes both citizens and organizations in their daily use of houses, schools, offices, hotels, shopping centres and stores (figure 5-1).

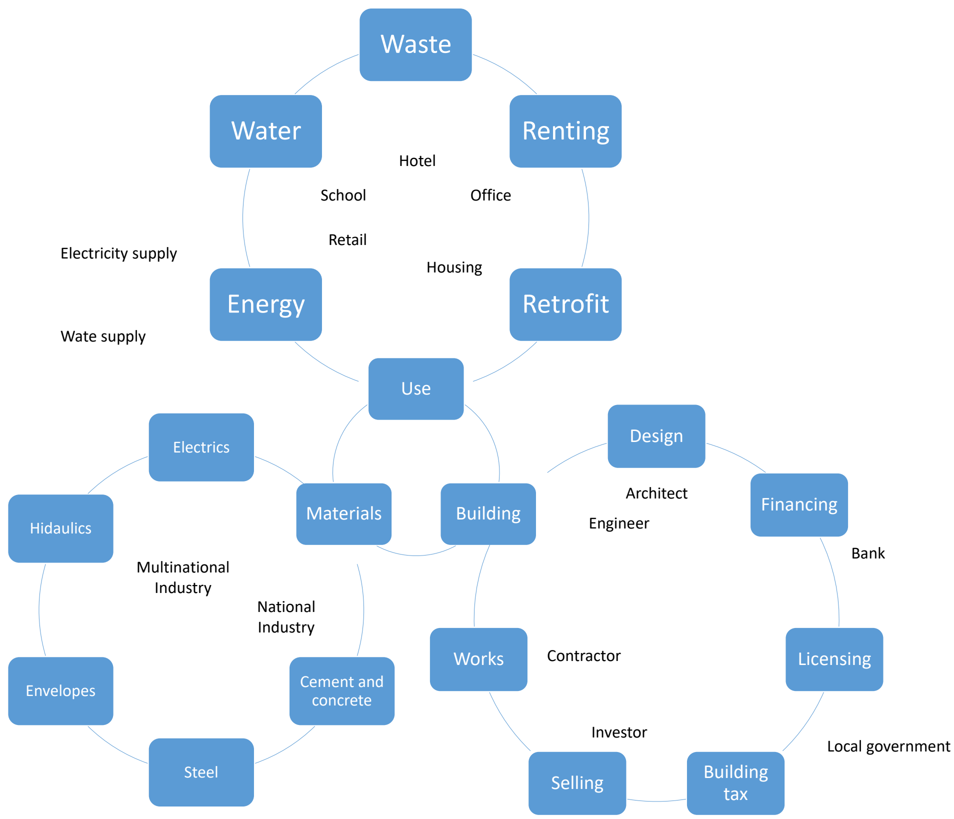


Figure 5 - 1. Socio-technical system for building planning, design and use
Source: The author

5.1.2. Socio-technical landscape forces

Landscape forces analysed here are multilateral agreements issued within the framework of the United Nations, whose focus includes, or is explicitly oriented to the reduction of GHG emissions. Currently, this agenda is determined by the Post 2015 agreements, which include the SDGs (UN, 2015), the Paris Agreement (UNFCCC, 2015) and the New Urban Agenda (UN, 2017a). However, the process begins several decades earlier with the Rio Summit (UN, 1992), when the term

“Sustainable Development” was coined as part of a global agenda. Table 5-1 shows the timeline of instruments relating carbon emissions, sustainable development and human habitat, comprising multilateral agreements, responsive national policies and independent private actions. Explicit references to the built environment or the building sector are pointed out (see table 5-1)

5.1.2.1. Multilateral Agenda

Multilateral agreements have strongly emphasized poverty reduction and disaster risk management, rather than the potential role of the built environment in reducing carbon emissions. However, in 2002, within the framework of the Johannesburg Summit, an "Agenda 21 for sustainable construction in developing countries" was published (Du Plessis, 2002). In 2006 the United Nations Environmental Program founded the Sustainable Buildings and Climate Initiative (SBCI)[1], focused on promoting energy efficiency and reducing GHG emissions. Finally, within the framework of the COP 21 climate summit, a Global Alliance for Buildings and Construction was created as a strategy to promote low-carbon buildings under a life-cycle approach[2].

In 2015, the role of the built environment in mitigating climate change would be ratified in the Sustainable Development Goals and the New Urban Agenda, with SDG 11, establishing a specific goal on sustainable buildings, and the SDG 12, establishing the 10YFP-OnePlanet program, with a subprogram on sustainable buildings and construction. The New Urban Agenda is less explicit on this regard, however the issue papers highlights the role of spatial planning and design, supply chains of materials and energy efficiency in households as potential strategies for reducing GHG emissions in cities.

5.1.2.2. Responsive policies and actions

Colombia has subscribed most multilateral agreements listed here, however only some of these have led to policy responses, which may be classified into five groups according to their legal hierarchy as follows:

• Laws issued by National Parliament, with permanent compulsory character, mainly influencing government actions.

• Policy documents, issued by the National Planning Department, with action plans that take place within one or two government periods. These documents, known as CONPES, have the legal character of government plans

[1] https://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/sustainable-buildings
[2] https://globalabc.org/index.php/about/history-timeline

• Policy documents, issued by the National Ministries, which do not have clearly defined legal implications and also have a category of plans or roadmaps

• The Nationally Determined Contribution – NDC to the Paris Agreement, adopted by means of a parliamentary law, providing a compulsory character, despite its temporary status

• Action Plans issued by sectorial Ministries as a part of the NDC, which may or may not be adopted through legal acts within each ministry

The Rio 1992 declaration (UN, 1992) resulted in a National Law from 1993 (Colombia, 1993), creating a Ministry on the Environment. This law makes no specific reference to either climate change or the built environment. Afterwards, national responsive policies have occurred several years after multilateral agreements. This is the case of the Millennium Declaration (UN, 2000), whose political response occurred five years later, under a Conpes document setting a roadmap for realizing the Millennium Development Goals in Colombia (DNP, 2005). Similarly, the national response to the Johannesburg declaration (UN, 2002) occurred six years later, by a policy document on Urban Environmental Management (Colombia. MADS, 2008). This is the first public document referring to the role of the built environment in reducing GHG emissions. However, its implementation has been limited due to the lack of policy instruments and technical specifications.

Concerning climate change mitigation, the first policy response took place in 2010, with a Low Carbon Development Strategy, whose main product was a series of Climate Action Plans by of the Ministries of Mines, Energy, Agriculture, Industry, Transportation and Housing (DNP, 2011). However, the absence of policy instruments and the lack of participation of actors different from national government, hindered an effective implementation of these plans, which are in the process of being updated in 2020, as described below.

National policy responses to the Post-2015 UN Agenda Multilateral Agreements occurred in a shorter period of time, as compared to previous agreements. However, these responses focus on the SDGs and the Paris Agreement. No policy adopting the NUA or the Sendai Framework have been issued.

A Nationally Determined Contribution was presented to the COP 21 Conference in 2015, to be ratified in 2017 by a Parliament national law. Concerning residential sector, the NDC proposes a list of energy efficiency measures in new and existing buildings. However, the Ministry of Housing, in charge of climate management in this sector, would not formally adopt these measures, because some energy uses (cooking, refrigeration and electronics) are outside its regulatory capacity, showing a lack of integration of low carbon initiatives with pre-existing regulatory framework.

In 2015 the Ministry of Housing would issue a National Code on sustainable buildings, whose scope was described in section 2.1, and will be further addressed in section 5.1.3. This code is not actually a responsive policy to the Paris Agreement, however, is being used by the Ministry of Housing in updating its Sectorial Climate Action Plan by 2020, thereby becoming the single explicit contribution from the built environment to the NDC (Colombia. MVCT, 2020).

In 2016 the Ministry of Environment would published a document for a National Policy on Climate Change (Colombia. MADS, 2016) with five strategic lines, including the "Low Carbon and Climate Resilient Urban Development", which refers to "sustainable buildings", without providing a clear definition of this term. Once again, this policy does not establish instruments for its implementation. Although this document refers to the Paris Agreement, in reality its relation to the NDC is not entirely clear.

In 2018 the Paris Agreement produced a second national response policy, consisting on a new Parliament law, ratifying both the agreement and the NDC, while establishing a National System for Climate Change Action, based on Sectorial Ministries under the coordination of the Ministry on the Environment and the National Planning Department (Colombia, 2018).

Concerning the SDGs national response occurred in 2018 by a Conpes document. Although the SDGs propose 169 targets specifying the scope of 17 goals, the Colombian adoption strategy only prioritizes one target for each goal. In the case of SDG 11, the prioritized goal was the reduction of the housing deficit, thus disregarding all other urban related targets.

In 2018 a National Sustainable Building Policy was issued by a Conpes document. Here the background references both the SDGs and the Paris Agreement, no reference is made to the New Urban Agenda. This policy refers to the role of buildings in mitigating climate change, providing baseline data on GHG emissions derived from solid waste production and energy consumption in buildings. No baseline data related to emissions from construction materials is provided. This document proposes a general list of sustainable construction criteria, assigning the Ministry of Housing the task of providing technical specificity to these criteria. Regarding instruments, this document supports the coercive mechanism of the National Code for Sustainable Buildings while proposing other mechanisms based on economic incentives. However, such mechanisms are not developed either, it is again a task assigned to the Ministry of Housing.

Last, a National Policy for Green Growth was issued in 2018 under a Conpes document, with the aim increasing eco-efficiency of different economic sectors. Based on this policy document, the Ministry on the Environment issued in 2019 a national strategy on circular economy, where the only aspect related to the building sector consists on recycling construction and demolition waste – CDW, which, as seen in section 2.3, is not a useful measure for reducing carbon emissions.

5.1.2.3. Non responsive policies and actions

Some initiatives at the national and local level concerning the built environment may not be considered as direct responsive policies to specific agreements. This is the case for the Sustainable Building Code issued by the Ministry of Housing in 2015, which has been extensively described in sections 2 and 3. Other non-responsive policies are the eco-labelling code issued in 2015 by the Ministry on Energy and Mines, whose GHG reduction potential was already analysed in section 2 However, both codes were developed independently by their respective ministry and there are no technical or policy complementarities between these.

In 2016 the Ministry of the Environment issued a voluntary certification mechanism in sustainable construction for buildings other than housing (Colombia. MADS, 2016). Unlike all other national instruments, this voluntary scheme, which was already analysed in section 2, would open participation to academia and the private sector, but it would take five years to produce an actual outcome, thus remaining almost unknown after being issued[3].

At local level, the two largest urban areas in Colombia, corresponding to the City of Bogotá and the Metropolitan Area of the Aburrá Valley, issued two Sustainable Construction policy documents in 2015, which are also analysed and discussed in section 2. In terms of governance, both policies differ substantially from national policies because of the active participation of non-governmental actors, especially local construction trade unions. However, their implementation has been limited. Concerning Bogotá, a voluntary certification system was created and has been implemented in 12 projects (table 5-4). As for the Aburrá Valley, emphasis has been put on alliances and trainings, with no projects implementing guidelines yet (AMVA & Camacol Antioquia, 2018).

[3] *National Trade Union of the Building Sector (CAMACOL), personal communication based on a rapid survey*

Table 5 - 1. Landscape forces with potential influence on low carbon transitions in the building sector

Multilateral Agreements			National responses to multilateral agreements or actions			Specific BE related policies and actions	
Year	Relevant Milestone	Specific focus on Built Environment	Year	Responsive policy or action	Specific focus on Built Environment	Year	Action
1992	Earth summit. Rio	Human settlements and poverty	1993	**National Parliament.** National law on Environment and creation of a Ministry of Environment	No focus on BE		
1996	Second UN Conference on Human Settlements	Environmental pollution, lack of sanitation, public health and human settlements		No responsive policy or action			
1997	Earth summit. Rio +5	Human settlements and sustainable development (poverty reduction)		No responsive policy or action			
1997	Kyoto Protocol	No focus on BE		No responsive policy or action			
2000	UN Millenium Declaration and the Development Goals	No focus on BE	2005	**National Planning Department** Colombian strategy on the Millennium Development Goals	Reducing housing deficit		
2001	Marrakesh Accords ratifies Kyoto Protocol	No focus on BE		No responsive policy or action			
2002	Johanesburg Summit on Sustainable Development	Agenda 21 for sustainable construction in developing countries	2008	**Ministry for the Environment** Policy document on Urban Environmental Management	Environmental quality, water resources, disaster risk management, climate change adaptation, urban ecologies, green building and GHG emissions		
2005	Kyoto Protocol Enters into Force	No focus on BE	2011	**National Planning Department** Institutional strategy on connecting actions on climate change	No focus on BE		
			2014	**Ministries for Mining and Energy, Transportation, Industry, Agriculture and Housing under the coordination of the Ministry for the Environment** Sectorial Climate Action Plans	Action Plan from Ministry of Housing refers to an upcoming sustainable building code		
2006	UNEP Sustainable Buildings and Climate Initiative (SBCI)	Focus on energy efficiency and GHG emission reduction		No responsive policy or action			
2012	UN Conference on sustainable development Rio +20	Affordable housing and infrastructure and urban planning		No responsive policy or action			
						2013	**Ministry for housing** A National decree sets general standards concerning spaces for waste separation in buildings

	Multilateral Agreements			National responses to multilateral agreements or actions			Specific BE related policies and actions
						2015	**Ministry for housing** National Sustainable Building Code. No reference to GHG mitigation potential
						2015	**Ministry for Mining and Energy** National code on Energy efficiency labelling
						2015	**Bogota Mayor office** **Aburrá Metropolitan authority** Local policies on sustainable construction issued in Bogotá and the Aburrá Valley
2015	Global Alliance for Buildings and Construction (GlobalABC) launched in the Framework of the COP21 leading to the Paris Agreement	Low carbon buildings on a life-cycle approach		No responsive policy or action			
2015	Paris Agreement on Climate Change. 195 Countries submit Nationaly Determined Contributions - NDCs	No focus on BE	2015	**Ministry for the Environment with inputs from Ministries for: Mining and Energy, Transportation, Industry, Agriculture and Housing** Colombian NDC to the Paris Agreement	Energy efficiency at operation stage of buildings.		
			2016	**Ministry for the Environment** National Policy for Climate Change	A strategy on low carbon and resilient urban development, including sustainable buildings. No further technical development of the statement		
			2017	**National Parliament** Law 1844 formally adopts the Paris Agreement and the Colombian Nationally Determined Contribution	No focus on BE		
			2018	**National Parliament** Law 1931 on Climate Change ratifying the Paris agreement and the NDC, creating also a National System for Climate Change	No focus on BE		
			2020	**Ministry for the Environment with inputs from Ministries for: Mining and Energy, Transportation, Industry, Agriculture and Housing** Colombian NDC updated based on New Climate Action Plans issued by National Ministries	Existing Sustainable building code from 2015 proposed as mitigation measure in the built environment		
			2018	**National Planning Department** National policy document for sustainable buildings (Conpes 3919)	Life-cycle approach. Sustainable building criteria at indicative, general level		

Multilateral Agreements			National responses to multilateral agreements or actions			Specific BE related policies and actions	
2015	Sustainable Development Goals	SDG 11 sets goal 11.c. on sustainable building SDG 12 sets goal 12.1 to Implement the 10-Year Framework, holding a sub-programme on sustainable buildings	2018	**National Planning Department** Strategy for adopting SDGs (Conpes 3918)	Reducing housing deficit as SDG11 priority target		
			2018	**National Planning Department** National policy on green growth (Conpes 3934)	Construction and Demolition Waste reuse and recycling		
2016	New Urban Agenda	Energy efficiency in buildings as climate change mitigation strategy		No responsive policy or action			
						2016	National strategy on Integrated Solid Waste Management. No focus on BE
						2016	Voluntary certification for non-housing sustainable buildings (NTC 6112)
						2016	10YFP to support implementation of the Aburrá Valley local policy on sustainable construction

Source: The author

5.1.3. Socio-technical regime

The socio-technical system of the building activity operates under a set of regulatory, normative and cognitive rules, partially aligned with each other, forming a socio-technical regime,that will be described next.

5.1.3.1. The low productivity of the construction sector as a regime element

This work focuses on socio-technical aspects relative to GHG emissions, however the low productivity characterizing the building sector, strongly contrasting with its high participation on the global economy, is a general aspect that needs to be considered (Barbosa et al., 2017). These findings have led the sector to propose a roadmap for increasing productivity, called "The sustainability imperative", which indicates the need to produce substantial changes concerning concept and design; contracting and acquisitions; project execution and capacity building.

Although this roadmap, does not make any reference to the role of buildings on global carbon emissions, the “increasing market demands regarding the introduction of sustainability standards” is included as driver (Barbosa et al., 2017), thereby opening a window for potential synergies between sustainability and productivity agendas. In fact, some central elements of the roadmap for increasing productivity are also part of the global agenda for low-carbon buildings (GlobalABC / IEA / UNEP, 2020), as listed below:

- Life-cycle perspective
- Integrative design processes
- Modular design methods and standardization
- Prefabrication and pre-assembly methods

Under a MLP perspective, the low productivity of the construction sector could then be considered as relevant regime element while the "productivity imperative" roadmap may be considered as a potential landscape force.

5.1.3.2. Low carbon measures at material stage of buildings

These measures involve the production of raw materials (mining), the manufacture of materials (industry), structural design (structural engineer) and construction (developer and contractor). The effectiveness of these measures is outside the intervention of property owners and occupants.

Regulatory aspects

One important barrier concerning regulatory aspects, consists on technical rules and standards on buildings being issued by national government. While local governments are responsible for approving construction licenses, they have no regulatory power on issues concerning construction systems and building materials, their role here is restricted to verify compliance with national standards. While this helps standardize systems, technologies and practices to ensure safety and durability of buildings, it also prevents the emergence of local low-carbon building initiatives. However, regulations concerning industrialised building systems, low carbon concretes and low carbon cement are not restrictive in this context, thus being potential enablers. Nevertheless, these alternatives are not actually perceived by the sector as potential GHG reduction measures (Table 5-2).

Normative aspects

Most business practices and rules in the building activity tend to act as barriers to decarbonisation. These include the absence of high-performance materials in engineering training curricula; the conventional method of project budgeting, which prevents the identification of global-project benefits over unit costs and the predominant use of industrialized systems in subsidized housing projects (see table 5-2).

Cognitive aspects

Based on the responses obtained through surveys and interviews, the cognitive elements of the socio-technical regime all tend to act as barriers for decarbonisation measures in the building sector. This includes the general perception by owners and occupants regarding confined masonry as the safest systems, while industrialized systems, dominant in subsidized housing projects, are associated with poverty. Concerning high-performance concretes, engineers, developers and contractors fear that the resulting structural optimization could be misinterpreted as quality reduction (see table 5-2).

Innovation readiness

Innovations relative to carbon reduction measures from building materials have been fully developed and are available on the market. In fact, the measure related to industrialized construction systems cannot be considered as an innovation, since it is already part of the common practice, which is simply restricted to a particular segment, corresponding to subsidized housing. The most recently developed innovation is low-emission cement, launched to the national market at early 2020.

Table 5 - 2. Low carbon measures at operational stage of buildings with respect to the socio-technical regime

Measure	Institutions: Character and description Character (Ct): Barrier (B), Enabler (E), Policy, regulation or action that may act as enabler but actually acting as barrier when formulation or implementation is incomplete (E/B)						Related innovation: Type, readiness and description Type (Ty): Process innovation (PC) or Product innovation (PD) Readiness (Rd): Research (R), Development (D), Available at Market (A) or Incorporated to Common Practice (CP)		
	Ct	Regulative	Ct	Normative	Ct	Cognitive	Ty	Rd	Description
	B	**Technical rules and standards on buildings are issued by national government. This includes construction systems and building materials. Local governments have no regulatory power on this issues. While this helps standardize systems, technologies and practices to ensure safety and durability of buildings, it also prevents the emergence of local low-carbon building initiatives.**							
Substitutive cement materials	E	National regulation provides a broad definition of "cementing material", enabling the use of Portland cement substitutions.	B	Cement substitutions and high performance concretes are still out of engineering curricula.	B	Structural engineers prefer to specify conventional concrete, whose performance they are more familiar with.	PD	A	Fly ash and pozzolans already entering in common practice. Indigenous adaptation of existing technology
							PD	D	Low-emission cement in production from 2020 by the largest national producer. Indigenous adaptation of existing technology
High performance concrete	E	National regulation admits the use of chemical additions leading to high-performance concretes	B	Conventional budgeting procedure approaches building projects by sections, activities and unit prices, thus hindering effects of high performance materials on the overall project costs.	B	Developers fear about public discontent concerning technological alternatives resulting in reduced structures. Recent events concerning unsuccessful attempts to optimize building structures, resulting in and material and human losses, are currently contributing to strengthen a lock-in in this regard.	PD	A	Import of existing technology via local providers. No indigenous technology
Shift to industrialized system	E	Regulatory framework allows the use of prefabricated and industrialized construction systems without restrictions on the use or budget of the building	E/ B	Industrialized and prefabricated systems are mostly used for subsidized housing projects as a way to reduce times and costs	B	Industrialized and prefabricated systems may be considered unsuitable for use in projects different from subsidised housing	PC / PD	A	Industrialized construction systems adopted as part of the common practice.
			B	Existing practices on industrialized and pre-fabricated systems make resulting buildings to transmit both sound and heat more easily, affecting privacy and comfort	B	Confined masonry system, known "traditional" system appreciated by owners as a safer construction system			

Source: The author

5.1.3.3. *Low carbon measures at operational stage of buildings*

These measures involve energy efficient design and operation of buildings, as well as residential waste management. The effectiveness of these measures involve architects, engineers, developers and occupants.

Regulatory aspects

As previously discussed concerning material related measures, technical rules and standards on buildings are issued by national government. This includes electric installations, illumination, ventilation and HVAC systems. Local governments have no regulatory power on this issues. While this helps standardize systems, technologies and practices, it also prevents the emergence of local low-carbon building initiatives. Although local governments are supposed to verify compliance with the national sustainable building code before issuing construction licenses, in reality the only documents requested to process such licenses are architectural and structural plans. Technical designs actually related to the sustainable building code, such as electrical installations, illumination, ventilation and HVAC systems do not go through verification by local governments. Therefore, there is currently no real mechanism to verify and monitor compliance with energy efficiency requirements in new buildings.

Several regulations concerning the operational stage of buildings may act as enablers for GHG reduction measures. However, by lacking technical specificity or entering in contradiction with pre-existing technical codes, these regulations end up acting as barriers. This is the case of laws regulating professional practice of architecture and engineering, the Sustainable Building Code and the regulation on residential waste separation and management (see table 5-3).

There are also regulatory aspects tacitly acting as barriers for decarbonisation, simply because of inexistence. These include the absence of regulations related to retrofits, the concentration of economic stimuli on photovoltaic solar energy, and the absence of incentives for solar thermal energy. Likewise, the absence of a national code for thermic installations and the complete absence of energy efficiency criteria in the existing national code of electrical installations also act as a barrier (see Appendix D).

Normative aspects

Most business practices and rules in the building activity act as barriers to decarbonisation measures. The most evident is the fact that investments on energy efficiency, either made by developers in new buildings or by owners in existing buildings, create economic benefits for occupants and there are no incentives to transfer benefits to investors or costs to beneficiaries (see table 5-3).

Likewise, the temporary nature of the organizations around a constructive project means that the power structures are not pre-established, but rather have to be negotiated in-situ. Considering that architects and engineers are not trained on sustainable building, external sustainability consultants are required, thus deforming power structures and creating resistance. This effect is increased by the fact that dominant building design processes are non-integrative but linear. Hence, technical professionals, including sustainability consultants, must just adopt first design decisions made by architects, even if contradicting sustainability principles. At the same time, design decisions are conditioned by the fact that fees are based on floor areas and additional concerning efficiency or sustainability are not rewarded (Hoffman & Henn, 2008).

Concerning economic and financial issues, as seen in section 2.4, measures aimed at energy efficiency during operational stage of buildings require higher capital investment as compared to material related measures. However, by allowing operational savings these measures yield high economic returns for each ton of $CO_{2\text{-eq}}$, this is valid for energy efficient appliances and also for photovoltaic panels. Furthermore, both development and private banks have created financial instruments to promote implantation of these technologies. However the long pay back periods and the absence of mechanisms to transfer costs and benefits along the value chain, from investors to occupants, remain as barriers preventing the mainstreaming of energy efficiency in the building sector.

Cognitive aspects

Based on the responses obtained through surveys and interviews, the cognitive elements of the socio-technical regime all tend to act as barriers to the implementation of decarbonisation measures in the building sector. This includes the general perception of sustainability criteria rising building costs, being restrictive for conventional projects, or even prohibitive, in the case of subsidized housing projects (see Appendix D).

Likewise, there is a general lack of market confidence on sustainability measures. This applies for distributed generation of renewable energy; as well as on-site composting of solid waste (see table 5-3).

Innovation readiness

Innovations required to implement GHG reduction measures concerning the operational stage of buildings are fully developed and available in the national market. However, these innovations involve not just the use of new products, but changing current design processes, thus requiring participation of a greater number of actors, while also involving occupants' behaviour, which is not subject of regulations and may pose even more cognitive barriers (see table 5-3).

Table 5 - 3. Low carbon measures at material stage of buildings with respect to the socio-technical regime

Measure	Institutions: Character and description Character (Ct): Barrier (B), Enabler (E), Policy, regulation or action that may act as enabler but actually acting as barrier when formulation or implementation is incomplete (E/B)						Related innovation: Type, readiness and description Type (Ty): Process innovation (PC) or Product innovation (PD) Readiness (Rd): Research (R), Development (D), Available at Market (A) or Incorporated to Common Practice (CP)		
	Ct	Regulative	Ct	Normative	Ct	Cognitive	Ty	Rd	Description
	B	**Technical rules and standards on buildings are issued by national government, this includes electric installations, illumination, ventilation and HVAC systems. Local governments have no regulatory power on this issues. While this helps standardize systems, technologies and practices, it also prevents the emergence of local low-carbon building initiatives.**							
			E	**Financial resources available from both private and national development banks to implement energy efficiency measures. This enabler holds validity for all energy efficiency measures listed below**					
Energy efficient building design. Residential and other building	E/B	National laws regulating professional activity of architects and engineers setting sustainable design as an ethical duty. No further development	B	Design professionals, both architects and engineers are not trained on sustainable design.	B	Presumed association of an energy efficient building requiring significantly higher investment costs as compared to conventional projects. Therefore, sustainability criteria are only applicable to certain projects with large budget, while restrictive to conventional projects and even prohibitive to subsidised housing projects	PC/PD	A	Energy models, green building certification systems and Building Information Management Systems available, but still far from common practice. Low indigenous research
	E/B	National code on sustainable building in force from 2016 (Resolution 549 from Housing Ministry). National code on sustainable building in contradiction with pre-existing technical codes and not aligned with on-going up-dates	B	Building projects as temporary organizations where sustainability requires the entrance of new actors that may threaten power structures. Developer is asked to make additional investments, while operational benefits of energy efficiency are perceived by occupants.					
	B	National code concerning electric systems design with no considerations towards energy efficiency	B	Linear design process dominant over integrative design practices					
	E	National code concerning lighting having a section oriented towards energy efficiency	E/B	In the absence of a national code on thermic installations, ASHRAE standards (not designed for tropical environments) are used			PC/PD	A	Import of existing technology via local providers No indigenous technology
			E/B	The two main urban centres issued policy documents and local guides for sustainable construction with a more comprehensive approach than that of the national code for sustainable buildings. However, its character is not regulatory, but voluntary and its implementation has been strongly influenced by local political cycles					
	B		B	Design fees based on floor area, no additional efforts from architects or engineers are rewarded					

		Technical codes on spatial design issued at municipal scale. No national code on spatial design	E	Concerning corporative new building projects, as investor becomes owner and occupant, is prone to make additional investments on energy efficiency					
Retrofits of existing buildings and Replacement of inefficient home appliances	E	There is an eco-labelling standard for household appliances, in force since 2017	B	Owners are only interested on investing in energy efficiency when they are also occupants and therefore, responsible for energy bills.	B	Common perception of Sustainability related practices as restricted to new buildings.	PC/PD	A	Energy models, green building certification systems and Building Information Management Systems available, but still far from common practice
			B	Market structure has not created incentives on retrofits. ESCOs business, already growing in the Industrial sector, not yet developed for building sector					
	B	No sustainability codes concerning retrofits	B	Eco-labelling on appliances is not been actively promoted. Purchasing decisions still motivated by prices.			PC/PD	A	Import of existing technology via local providers No indigenous technology
			B	Low market share of retrofits as compared to new buildings. Existing retrofits focusing on aesthetic aspects rather than energy driven improvements					
Photovoltaic panel. New building. Residential	E	National regulation created tax benefits for the installation of renewable energy generation systems.	B	These are still expensive technologies, considering the purchasing power of the national economy. The payback period is around 8 years	B	Most people consider conventional interconnected systems as more reliable than self-energy production	PD	A	Solar panels imported. No indigenous technology
	E/B	National regulation allows the selling energy surplus to the operators of the interconnected system. However, the criteria for defining prices have not yet been established.	B	The investment costs are high. The payback period may be over 20 years					
Solar water heating	B	National regulation does not actively stimulate this type of use of solar energy	B	Over the last two decades, a government programme has substituted electric energy for natural gas on thermal uses in the residential sector (cooking and water heating). Current coverage of this service in the urban ambit is above 80%	B	Given the strong national government campaign for gasification of heat energy in the residential sector, it has ended up being considered as a source of clean energy			
Waste separation and composting of organic fraction	B	No national regulation on areas required for separating and managing waste in buildings	B	When existing, municipal regulations on areas required for separating and managing waste in buildings are unknown to architects, while comply is not reviewed by relevant authorities.	B	General perception concerning on-site composting is that it will produce bad odours and it will attract nuisance animals	PC/PD	A	Some new buildings with double trash shutdown systems to facilitate waste separation. National company developed composting systems with forced aeration, suitable for use in buildings.
	E/B	National regulation concerning waste management primarily focus on responsibilities of service providers and municipalities rather than on waste producers. National regulation make compulsory to separate waste on-site, but no stimulus or compliance verification mechanisms have been set.	B	Existing tariff model favours disposal of non-separated waste in landfill over integrated management Recent economic stimulus created to finance waste management projects, but the mechanism is not attractive to service providers as compared to business-as-usual activity.					
			B	Organic waste composting practices have been implemented in some residential complexes, but non-technical manual systems predominate, leading to operating inefficiencies	B	Since landfills are located far from urban centres, citizens are unaware of environmental impacts of inadequate waste management	PC/PD	A	Small companies designing waste management plans for buildings, but rarely including composting activities

Source: The authors, based on both Inquiries and Interviews as well as Grey literature, as listed next: UPME, 2015; UPME, 2019; DNP; 2016; AMVA & UPB, 2015; Pardo et al., 2017; MME, 2019; MADS, 2015; DANE, 2019b; AMVA & Camacol Antioquia, 2018; Cancio et al., 2017; Ospina et al., 2017; Colombia (1998, 2003)

5.1.4. Socio-technical niches

Both material and operational innovations related to decarbonising buildings are fully developed and available in the national market. However, most of these were not really developed in Colombia, but rather are adoptions of innovations produced in other countries. Consequently, niches here may not be considered as protective spaces responsible for the development of innovations, but spaces that can promote their implementation. Three types of such spaces promoting change are identified here:

- Spaces fostered around certification schemes
- Spaces fostered around agreements and alliances
- Spaces fostered by national actors of the regime in coordination with international niche actors

5.1.4.1. Spaces fostered around certification schemes

As discussed in section 3 certification schemes have been the main vehicle to promote the practical implementation of sustainability criteria in buildings. However, GHG reduction within most schemes is considered an implicit outcome from operational energy efficiency. Therefore low-carbon materials and carbon reduction from residential waste composting are not an explicit criteria. In this sense, these schemes are only partially aligned with the set of low carbon measures analysed here.

On the other hand, although certified projects have been growing over recent years, this practice continues to be reserved almost exclusively for emblematic corporate projects (see table 5-4). Hence, their implementation is residual, considering that average licenced building projects in Colombia are around 600 thousand, while the stock of certified projects between 2011 and 2019 barely exceeds 500.

Despite the lack of explicit emphasis on low-carbon development and its limited level of implementation, certification schemes promoted by the private sector are useful for promoting networking, learning and experimentation, which are necessary conditions to trigger societal transitions (Rotmans & Loorbach, 2010; Karvonen & van Heur, 2014; Torrens et al, 2018; Raven et al, 2019). As a result, international certification schemes have been more successful in their implementation than public schemes (see table 5-4).

In general terms, spaces promoting change around these certification schemes are shaped as follows:

- An international entity promoting the certification scheme

- A Private Sector Organization, which may have been specifically created for this purpose, or it may also be a pre-existing trade union, which acts as a local partner, being in charge of administrating and disseminating the scheme among target audiences, while providing training for implementation
- A set of technical experts who are trained within the scheme, intervening as sustainability consultants at the design stage of building projects.
- A set of firms, whose products may contribute to fulfil certification requirements.
- Recently, the financial sector has become a promoter for certification schemes by providing financial incentives to certified projects, including those using public certification schemes.

The importance of these spaces promoting change around certification schemes becomes evident by comparing implementation of public versus private ones. The Ministry on the Environment issued its scheme in 2016, but did not promote it by any mean, has not provided training on its use, nor has formed any network around it. As a result, by 2020 there is no single project certified under this scheme[4]. Concerning Bogotá public scheme, there is no active promotion and there are no networks around it either, however training is provided upon request. Only 12 projects have been certified under this scheme (see table 5-4).

[4] *National Trade Union of the Building Sector (CAMACOL), personal communication based on a rapid survey*

Table 5 - 4. Socio-technical niches fostered by certification schemes

Criteria	Private				Public	
	International			National	National	Local
Name	LEED	EDGE	HQE	CASA Colombia	NTC 6112	PRECO
Certified projects	151 granted 253 in process	52 granted 85 in process	4 granted	6 granted	No certifications granted	12 granted
Year of introduction or issuing	2011	2017	2017	2017	2016	2015
International promoter	World Green Building Council	International Finance Corporation	French Government			
Leader	Colombian Green Building Council	CAMACOL National board	TERAO Consultancy	Colombian Green Building Council	Ministry for the Environment	Bogota Mayor Office
Participants	Industry Developers Consultant experts	Developers Consultant experts	Developers Consultant experts	Developers Consultant experts		Developers
Low carbon focus	Implicit				No	No
Low carbon scope	Mainly as by-product from energy efficiency at operation stage				No	No
Verification	Design and operation stage				Not established	Design and operation stage
Learning	Courses provided by the leader		No	Courses provided by the leader	No	Courses provided by the leader
Networking	Based on jointly activities by both the leader and the participants		No	Based on jointly activities by both the leader and the participants	No	No
Experimenting	151 certificates granted and 253 in process	52 certificates granted and 85 in process	4 certificates granted	6 certificates granted	No certifications granted	12 certificates granted

Source: The author

5.1.4.2. Spaces fostered around agreements and alliances

At the national level, private alliances and private-public agreements concerning sustainable building and explicitly addressing GHG emissions have been emerging over recent years under the leadership of the Colombian Green Building Council. This is the case of "Agenda Construcción Sostenible 2030”, a private alliance launched in 2016, including 200 companies, aimed capacity-building, issuing protocols, supporting public policies and creating financing schemes. On the other hand, the global programme "Building Efficiency Accelerator" looks for engaging local governments to take actions on energy efficiency. Although this program has focused mainly on promoting the implementation of the National Code of Sustainable Buildings, it does not have the active participation of the Ministry of Housing.

At local level, the city of Bogotá (CAMACOL Cundinamarca, 2020) and the Aburrá Valley (CAMACOL Antioquia, AMVA & Corantioquia, 2018) have been developing alliances and agreements that could be considered as spaces promoting change with the potential to promote networking, experimentation and learning. Since these local alliances are not based on prescriptive certification schemes, international programs or specific regulations, they provide flexibility for collective visioning, which is a favourable condition for sustainability transitions (Rotmans & Loorbach, 2010).

As seen in table 5-4, subnational offices of the Building Trade Union CAMACOL play an important role in local alliances. However the two processes have been different and independent. In fact, these two spaces also differ in aspects such as the type of participating firms, their scope, their goals, verification means, learning processes and experimentation, as shown in table 5-5.

5.1.4.3. Socio-technical niches fostered by regime actors

Major companies of the construction sector take part in innovation projects with low carbon potential. This is the case of the the potential to align with low carbon transitions. This is the case of the main cement company in Colombia, which began industrial production of LC3 cement in 2020 (see tables 2-4 and 5-2)

This innovation consists of an adaptation of a product previously developed within the framework of an international project called LC3 - Low Carbon Cement. Actors participating in this project include an international NGO, the Swiss Agency for Development and Cooperation, as well as Swiss, Indian and Cuban Universities[5], constituting a space promoting change that may actually be called an innovation niche. Given its international nature and the fact that this project is part of a series of global efforts that have been taking place to reduce the carbon footprint of cement, it can also be considered as a cosmopolitan niche.

This incorporation of a low carbon innovation by one of the regime's actors is not aligned with policies analysed here as landscape forces. However, from an MLP perspective this is not a spontaneous action. Considering that the company in question is a major player at national level, while also having operations in other Latin American countries and the United States, it is exposed to a global environment, being influenced by international forces. In this sense, the global cement industry is currently seeing the low-carbon development as a major challenge but also as an important opportunity (WCA, 2020). This is evidence of a global landscape force influencing both niches and regimes.

[5] *https://www.lc3.ch/media/news/*

Table 5 - 5. Socio-technical niches fostered by agreements and alliances

Criteria	National	Local			
		Bogotá Cali Montería	Bogotá	Aburrá Valley	
Name	Alliance 2030. Agenda for sustainable building	Building Efficiency Accelerator Program	Agreement for sustainable construction	Agreement for competitiveness and environmental efficiency	Alliance for Sustainable Construction
Issuing year	2016		2017	2012	2018
International support		World Resources Institute	No	No	10 YFP OnePlanet. Sustainable Building and Construction Programme (2016 – 2018)
Leader	Colombian Green Building Council	Colombian Green Building Council	CAMACOL Cundinamarca (local section)	AMVA (Metropolitan authority) CAMACOL Antoquia (local section)	AMVA (Metropolitan authority) CAMACOL Antoquia (local section) UPB (University)
Participants	Manufacture Industry Developers	Local governments	Manufacture Industry Developers	Developers	Developers
Aim	Transforming the value change of the construction sector Supporting policy making Promoting financing frameworks	Facilitating local implementation of the National Green Building Code	Promoting sustainability on the base of sharing experiences on initiatives individually developed by each firm	Guaranteeing compliance with minimum environmental standards, while promoting improvement towards mutually agreed higher standards	Promoting the use of local guidelines for sustainable construction, issued in 2015
Low carbon focus	Implicit	Implicit	Implicit	No	Explicit
Low carbon scope	Materials Operation stage	Operation stage	Unspecific	No	Materials Construction stage Operation stage Demolition
Verification	Not defined	Building licences	Not defined	Inspection visits	Not defined
Learning	Courses provided by the leader	Unspecific	Capacity building initiatives individually taken by each firm	Practical courses jointly provided by CAMACOL and the Metropolitan Authority	Conceptual courses jointly provided by CAMACOL and the Metropolitan Authority
Networking	Based on jointly activities by both the leader and the participants	No	Actions taken individually by each participating firm	Actions taken individually by each participating firm	Not established
Experimentin g	Unclear	Mainly based on compliance	Research on technical issues	Collective governance based on standards agreed by participants	Not established

Source: the author

5.1.5. The MLP perspective on low carbon for buildings

The Multi-level Perspective proposes that the transitions of socio-technical systems occur when landscape forces exert pressure on socio-technical regimes, thereby opening windows of opportunity for innovations at the niche level to take over regimes. Based on this premise, the MLP academics propose a typology of socio-technical transitions, based on the joint dynamics of landscape forces and innovations (figure 5-2).

Concerning landscape forces, relevant variables are:

1) frequency: number of disturbances per unit of time;

2) amplitude: magnitude of the deviation from the initial conditions caused by a disturbance;

3) velocity: rate of change of disturbance; and

4) scope: number of dimensions that are affected by simultaneous shocks.

The combination of these variables results in five types of external exchange:

1) regular,

2) Hyperturbulence,

3) Specific Shock,

4) Disruptive and

5) Avalanche (see table 5-6)

Table 5 - 6. Attributes of Change and Resulting Typology

Frequency	Amplitude	Speed	Scope	Type of external change
Low	Low	Low	Low	Regular
High	Low	High	Low	Hyperturbulence
Low	High	High	Low	Specific Shock
Low	High	Low	Low	Disruptive
Low	High	High	High	Avalanche

Source: Suarez and Oliva, 2005: 1022

According to section 5.1.2 most multilateral agreements concerning low carbon and sustainable development have been adopted by the national government via responsive policies. However, there is just one policy explicitly addressing sustainable buildings, which is a national code. The attributes and the type of change being promoted by this policy is analysed below:

- Frequency: As the only event actually influencing the building sector is the National Building Code, frequency of landscape disturbances is low
- Amplitude: The prescriptive nature of this code does not oblige design teams to adopt integrative methods or to use analytical tools, such as energy modelling. Compliance is reached upon conventional design methods by simply selecting efficient equipment and devices from a checklist. In other words, the code does not really motivate a substantial modification of the design processes. Therefore, its amplitude is low.
- Speed: Although this code entered into force in 2016, the lack of means of verification and technical gaps requiring adjustments, has already given several years for the assimilation by regime actors. Consequently, its speed has been low.
- Scope: This code focuses on energy efficiency, in the operational phase, in new buildings and in some uses of energy. In other words, it only covers one aspect of GHG emissions and in a single phase of the life-cycle. Hence, its scope is low.
- Type of change: As every attribute from landscape forces is low, the resulting change may be considered regular (Suarez & Oliva, 2005). Regular changes are not transitions promoters because do not exert pressure on the regime, thus maintaining existing trajectories and remaining refractory to low carbon innovations due to the set of barriers listed in tables 5-2 and 5-3.

Figure 5-2 shows a graphic representation of the MLP perspective applied throughout this work, with an "X" axis that represents the temporal evolution of the system between 1992 and 2020, and a "Y" axis that represents the level of structuring of the system, which It goes from the upper level of the landscape, passing through the intermediate level of the regime and the lower level corresponding to the niches, which are here called spaces that promote change.

The landscape is shown in turn stratified into four levels, where the upper level represents the multilateral agenda of sustainable development, the intermediate level represents responsive national policies at the level of laws, the next level represents responsive policies at the level of sector plans and documents, the lower level, closer to the socio-technical regime, corresponds to policies specifically related to low carbon buildings. Although several multilateral events and responsive national policies address this issue, the lack of technical specificity, as well as the weakness or absence of implementation instruments, prevent any of these policies from reaching the regime. The only exception here is the sustainable buildings code. Regime is shown as a hexagon, representing alignment between regulatory, normative and cognitive elements that interfere in the implementation of low carbon measures. The stability of the regime in time is represented by a succession of lines parallel to the "X" axis, which is used to represent a stable trajectory, which has not been visibly altered by any external influence.

The niche level or spaces promoting change is represented by a set of circles of promoters and participants taking part in certification schemes; national and local alliances and cosmopolitan innovation niches describes in section 5.1.4. Low carbon measures analysed here appear as an intermediate level between the spaces that promote change and the regime (see figure 5-2).

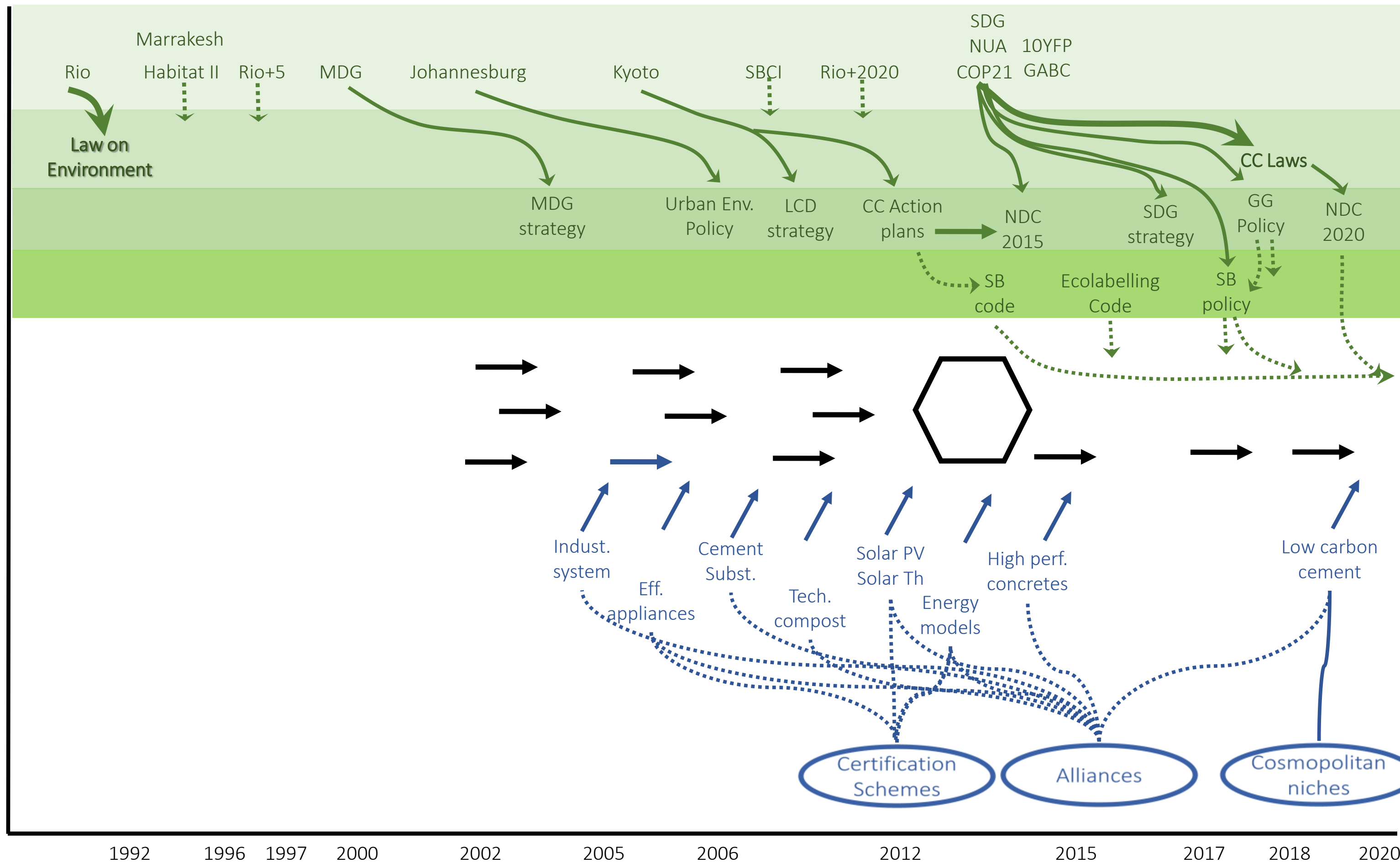


Figure 5 - 2. The MLP perspective on low carbon transitions for buildings
Source: The author, built on Geels (2002)

Abbreviations: MDG: Millennium Development Goals; SBCI: Sustainable Buildings and Climate Initiative; GABC: Global Alliance on Buildings and Construction; LCD: Low Carbon Development; CC: Climate Change

5.1.6. Introducing the MLP in National policies on buildings to foster low carbon transitions

In 2018 the National Planning Department formulated a policy document to promote sustainable buildings. This document lacks technical specificity and its policy instruments are not fully developed. Hence it is not currently exerting any influence on the socio-technical regime. However, if this policy comes to implementation under a Multi-Level perspective, it may help creating conditions to destabilize existing regimes to foster a low-carbon transition of the building sector in Colombia. General guidelines are provided next:

5.1.6.1. Using alternative landscape forces

Building sector is strongly dependent on national and local conditions concerning urban planning, land availability and real estate market. However, it is also influenced by global forces. Clear evidences of the global nature of this sector are the "Productivity imperative" referred in section 5.1.3 and the LC3 cement initiative already being implemented at industrial scale in Colombia. Similar situations are occurring with the steel industry[6] and other construction suppliers[7] that have issued low carbon roadmaps. On the other hand, specific multilateral initiatives concerning sustainable buildings are emerging in the framework of the most general multilateral agreements. This is the case of the Global alliance for buildings and construction, launched in Paris COP21, and the 10YFP initiative created in the SDG framework. The sustainable building policy could make use of both private and multilateral initiatives as potential landscape forces for a low carbon transition by subscribing to them and actively promoting them nationwide.

5.1.6.2. Exerting active influence on the socio-technical regime

Section 5.1.3 presents a series of regulatory, normative and cognitive elements that can act as enablers or barriers for the transition to low-carbon buildings. General guidelines for exerting active influence on those elements are provided next:

Managing regulatory elements

According to the table 5-2 numerous regulatory elements act as enablers for the implementation of low carbon measures in buildings. However, others act as barriers due to their lack of technical

[6] *https://www.worldsteel.org/en/dam/jcr:66fed386-fd0b-485e-aa23-b8a5e7533435/Position_paper_climate_2018.pdf*
[7] *https://www.weforum.org/agenda/2020/06/heres-how-aluminium-can-help-to-build-a-green-recovery/*

specificity and their contradictions with pre-existing technical standards. These aspects must be reviewed and adjusted in each case, with particular emphasis on the elements of the regime related to the operational phase of the buildings, such as:

- A specific and clear regulation of the ethical responsibility of architects and engineers regarding sustainable design (Iyer-Raniga &, Andamon, 1996; Iyer-Raniga, 2019)
- A review on contradictions between the sustainable building code and pre-existing technical standards as well as the expansion of its prescriptive approach to promote both the use of analytical tools (energy models) and strengthen the introduction of passive design criteria
- Updating technical regulations that have not yet incorporated sustainability criteria, such as the electrical installations code
- Regulation of the sale of surplus energy by micro generation from renewable sources
- Reviewing and updating waste disposal policies in order to incentive on-site separation and treatment
- Empowering local governments to mainstream low carbon development in the building sector. This includes: 1) reviewing the role of these governments in verifying compliance with national green building code and 2) supporting the formulation of policies and codes based on local conditions, that may eventually exceed national standards

Managing normative elements

According to table 5-2, most regulatory elements tend to act as barriers to low carbon measures. General guidelines for exerting active influence on those elements are listed next (see figure 5-3):

- Reviewing and updating the curricula of architecture and engineering programs in order to introduce, concepts and methods concerning sustainable design
- Promoting the improvement of industrialized construction systems to increase their effectiveness in creating conditions of thermal and acoustic comfort
- Promoting the use of integrative design processes
- Reviewing conditions enabling energy efficiency criteria in existing buildings
- Improving national and local bases of information concerning the carbon footprint building materials and construction systems in order to provide tools for informed decision making from strategic to operational levels
- Promoting access to financial instruments created by both development and private banks in order to enhance the implementation of carbon reduction measures in the building sector

Managing cognitive elements

Conventional policies use either corrective or economic instruments influencing regulatory and normative elements of socio-technical regimes, but being unable to influence cognitive aspects, which depends on daily experiences of individuals, thereby requiring experimentation. Under the MLP, experimentation is an attribute of innovation niches that can be promoted by Strategic Niche Management, whose basic elements are described next (Caniëls & Romijn, 2008)

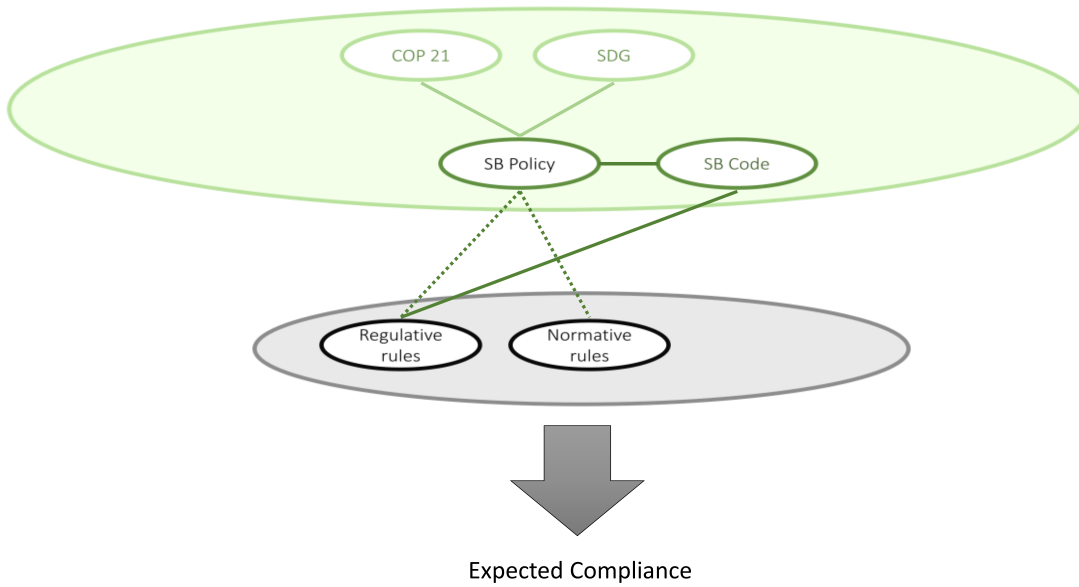
(1) Integration of expectations and visions shared by many actors and demonstrated by multiple projects

(2) Creating and strengthening networks that allow niche actors to interact, form associations and pool collective resources; and

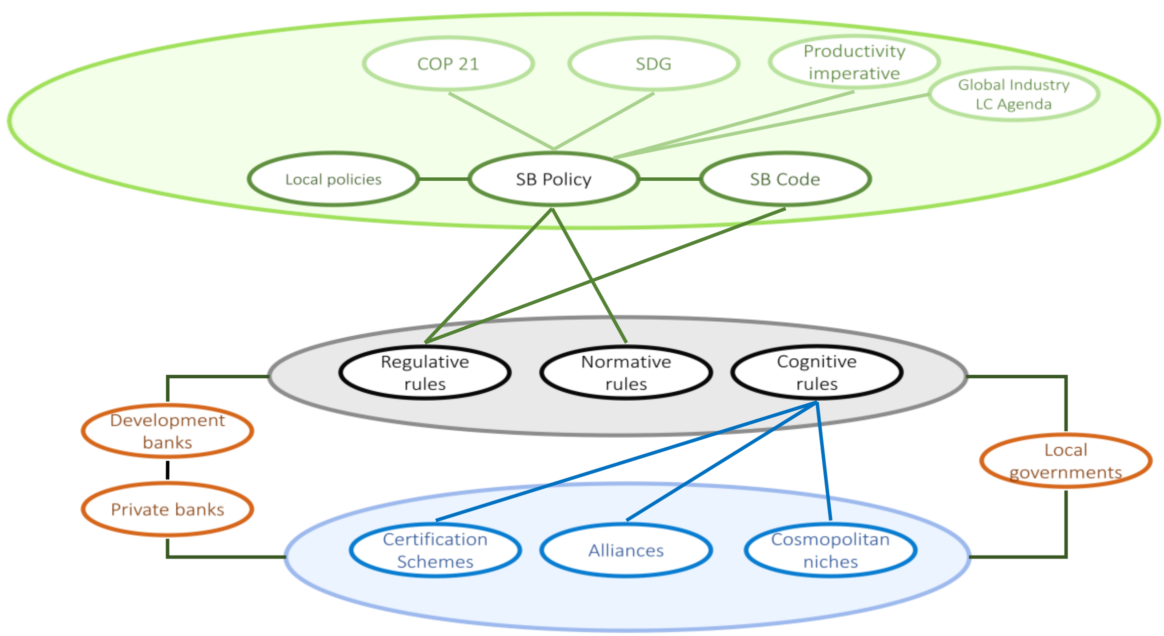
(3) Multi-dimensional learning, including aggregation of best practices and lessons from projects and initiatives, and knowledge sharing towards local experiments.

According to section 5.1.4, spaces promoting change in the building sector are already working on two out of three SNM elements, consisting on networking and promoting learning based on local experiments. Arguably, this is precisely the basis of the relative success of international certification schemes with respect to other instruments and initiatives of public origin.

Instead of just enacting coercive and economic instruments under a top-down approach. Public policies could use a gradual implementation approaches based on local experiments where niche and regime actors may interact with each other in order to build collective visions, while ensure learning and networking (see figure 5-3).



a) Current role of the existing policy on sustainable building



b) The role that the existing policy on sustainable building may play under a MLP

Figure 5 - 3. Current role of the sustainable policy compared with the role it may play under a Multi-Level Perspective on socio-technical transitions
Source: the author

5.2. CONCEPTUALIZING SUSTAINABILITY TRANSITIONS IN THE BUILT ENVIRONMENT

Section 5.1 extensively shows the application of the MLP on the socio-technical transition to low carbon buildings. However, the built environment is not only made up of buildings and carbon abatement is not the sole priority for sustainable urban development.

Developing and operating the built environment involves a long series of actors, sectors and processes of a social, technological, economic and ecological nature, interacting in spatial and temporal dimensions at different scales. Analytical perspectives of transition in socio-technical, socio-institutional, socio-economic and socio-ecological systems are analysed next to be further linked to each other in order to produce an analytical model that allows a comprehensive description of sustainability transitions in the built environment.

5.2.1. The built environment as a Socio-technical Meta-system

Designing, building and operating infrastructures, public spaces and buildings bring together similar actors, economic sectors and processes; however rules are not equivalent, and same actors play different roles in each case, giving rise to dissimilar socio-technical structures.

Concerning the source of investment capital, buildings depends to a great extent on private capital, mainly raised by banks, with the exception of social housing projects, where government subsidies play a key role. However, in Colombia for example, subsidized housing represents less than 20% of area built every year (DANE, 2019). On the other hand, both public space and infrastructure projects mainly depend on public capital, which is mainly produced from taxes, thus being highly dependent on institutional capacity (see section 3.3). Public-Private Partnerships are an exception to this rule.

Concerning disciplines involved, infrastructure developments are entirely coordinated from civil engineering, with low or even no intervention from architecture, and intervention from natural, environmental or social sciences being limited to environmental management plans, rather than participating on technical matters, such as design and construction. On the other hand, buildings and public space are mainly coordinated from architecture, with civil, hydraulic, electric and mechanic engineering playing a subordinate role, while environmental, natural or social science professionals may be completely absent. Therefore, infrastructure, public space and buildings may be considered different socio-technical systems that are linked to each other, which may be referred to as a "Socio-technical meta-system".

According to Schott & Kanger (2018) socio-technical change is not just about vertical landscape-regime-niche interactions. Horizontal influences between interlinked systems, to undergo joint transitions are also possible. This meta-system change is called a "Deep Transition and may be a suitable approach to address socio-technical transitions on the built environment.

Figure 5-4 shows a hypothetical Deep-transition starting from interlinked socio-technical regimes and niches, operating under related landscapes, thus constituting a Socio-technical Meta-system (figure 5-4a). Based on the classic MLP vertical dynamics, a transition is triggered when a landscape force exerts pressure on the regime, opening the window for niche innovations in line with such force to upscale into the regime (figure 5-4b). Under the deep transition variant, the initial landscape force will expand over the meta-system, while the first regime that entered in transition will exert horizontal pressures on the related regimes, becoming a horizontal transition force, thus initiating a synergisation stage (figure 5-4c). If niches also align each other to take advantage on the expanding landscape pressures, change will rapidly escalate over the Meta-regime, maturating a Deep transition (figure 5-4d). Such process may be used, for instance, to describe how certification schemes on sustainable construction appeared in the building sector during the 1990s decade, expanding during the 2000s decade to districts and in the 2010s decade to infrastructures (see section 3.1.3).

The built environment can be subdivided into infrastructures, public spaces and buildings, whose design, construction and operation relays on distinct socio-technical regimes that have been described in this section. However, these elements cannot be reduced to the category of technological artefacts, which are the object of study of the MLP on socio-technical transitions. In fact, elements of the built environment play a multidimensional role beyond technology, they are places where people live, work, learn and interact; they make also the physical structure throughout fluxes of urban metabolism circulate (energy, water, materials, waste and emissions) and they also embody the spatial intersection between cities and ecosystems. Hence, the perspective on socio-technical transitions is largely insufficient to address the built environment. Next sections, gradually incorporate other approaches that allow a more systemic conceptualization of urban sustainability transitions considering the multidimensional role of the built environment.

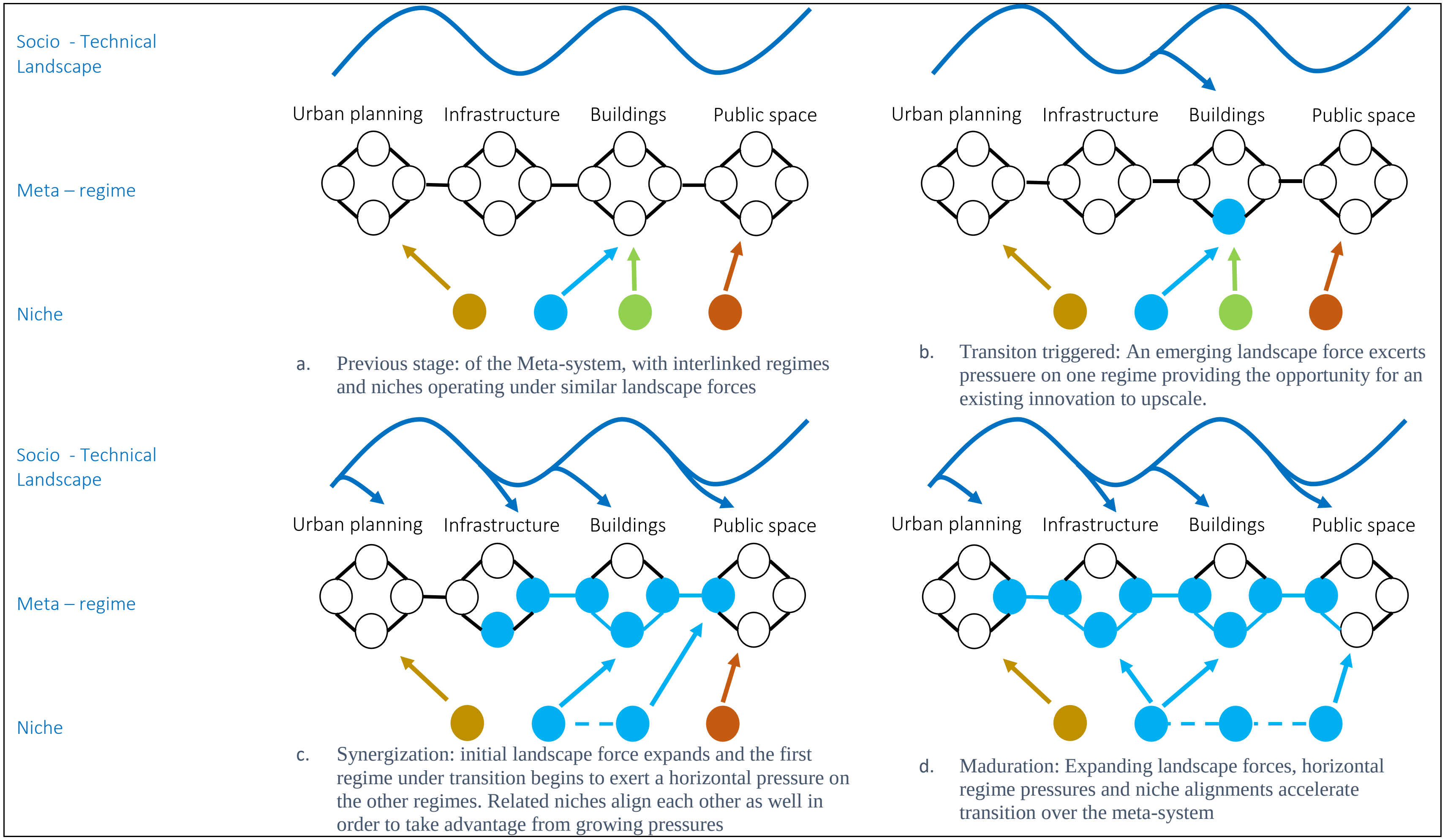


Figure 5 - 4. Multi-level perspective on socio – technical transitions at meta – system level applied to the elements composing the built environment. Transition remains incomplete since socio – technical transformation is insufficient to produce a shift on regimes concerning urban planning and open space
Source: The author. Built on Schott & Kanger (2018)

5.2.2. The built environment as a Socio-institutional system

A flaw of the MLP perspective on socio-technical transitions is that it refers to formal systems. Based on the Deep transitions perspective, the built environment may be understood as a socio-technical meta-system. However this view does not capture the whole picture, informal urban development has different actors as compared to formal construction activity. The very definition of informal urban development relates to self-construction, meaning construction activities that are carried out without by citizens, with their own capacities and resources and without the intervention from government, professional services or construction companies. Societal regimes here are not aligned by the same regulatory, normative and cognitive rules as formal construction activity, although they may use the same materials, similar technologies and even workers, social practices and cultures are different.

A transition approach that could provide insights in this sense is the Multi Pattern Perspective - MPA (Hann & Rotmans, 2011; De Haan & Rogers, 2019).

MPA is a Multi-Level based perspective on socio – institutional transitions, where:

- Institutions are the set of rules sustaining societal structures, practices and cultures (based on institutional theory)
- Structures: are formal, physical, legal and economic aspects of the operation of the system, either restricting or enabling practices
- Cultures are discursive, cognitive, normative and ideological aspects providing meaning to practices
- Practices are routines, habits, formalities, procedures and protocols followed by social actors, which can be individuals, organizations, companies, etc. and that keep societal systems running

The MPA defines landscape as an envelope constituted by other societal systems, external to the one under study. Regimes and niches, are mechanisms to satisfy societal needs, defined by their degree of power concerning the societal system, and are referred to as “constellations”. Regimes are dominant mechanisms to satisfy most social needs, while the niches are powerless constellations, satisfying some specific social needs via heterodox mechanisms. A transition begins when a niche increases influence over the system, eventually challenging the existing regime, thus becoming a “niche-regime” or intermediary constellation. If this regime-niche power continues to grow, it eventually replaces the existing regime, thus completing the transition (Hann & Rotmans, 2011).

By defining socio-institutional systems as mechanisms for satisfying social needs, the socio-technical meta-system discussed in previous section can be understood here as part of a broad set of socio-institutional systems. Likewise, the notion of "heterodox alternatives for satisfying social needs", allow taking informal urban development, as a socio-institutional system providing an alternative way of satisfying habitat needs of communities with no access to the formal socio-technical meta-system.

Both subsystems contain different regimes and niches. The socio-technical meta-system is regulated by science, technology, policies, social practice, formal market and formal education, giving rise to urban planning, infrastructure, public space and buildings regimes, with niches consisting on innovation centres, sectorial alliances and certification schemes. On the other hand, the Informal socio-institutional regimes are regulated by local land markets and social relationships emerging inside neighbourhoods, while capacities and technologies are empirically adapted from formal systems (Lombard, 2014). In the absence of planning, an emerging adaptive collective organization of space take place, while access to basic services is often assured by means of negotiations with local governments, which may lead to formal-like infrastructures. Lombard (2014) refers to this process as "Collective place-making", whose success to satisfy basic needs depends on the strength of ties between members of the local community and the distribution of such relationships across the common space, which is referred to as "The social Fabric of Space" (Carpenter, 2013). In this system, niches promoting change are constituted from Grassroots Organizations and NGOs (Enamul, 2009).

However, these two systems are not entirely separated from each other, there are some relevant interactions, which are described below:

- Workforce: The formal construction sector is a relevant non-qualified job provider worldwide. In Latin America, construction workers participating in formal projects, are informally trained on-site. Since these workers often also live in poor areas, where they often take part in self-building activities aimed at providing or improving housing, either for themselves, for their relatives or their neighbours (Lombard, 2014). In fact, it is estimated that 60% of the construction workers are either self-employed or salaried workers in small establishments (Gasparini and Tornarolli, 2009). According to other estimates, this share is as high as 75% for the construction of residential buildings (The World Bank, 2017). This way, both informal and formal sectors may share the same workforce, which leads to the next point.
- Materials and technical capacities: Dwellings built at new informal settlements are materially precarious. However, families tend to invest their scarce economic surpluses on consistently improve those initial conditions. Since both formal and informal activities share the same workforce, formal technologies may be empirically adopted and brought into informal

settlements, thus displacing vernacular materials and construction systems. Therefore, improving precarious conditions usually means introducing and progressively increasing the use of cement and bricks, while the spaces are enlarged, usually on the vertical axis (Lombard, 2014). However, empirical adoption may lead to weak structures, thereby increasing pre-existing natural risks arising from unsafe locations (Magalhães, 2016).

- Policies: In principle, informality occurs outside policy guidance. However, in practice urban policies intervene the informal system in various ways. In the first place, urban planning based on maximizing profits from land development is excluding in its very nature, being a major cause for informality. Second, policies on natural disaster risk reduction seek to prevent urban development in areas under natural hazards. Under a profit based logic, such areas loose economic value, thus becoming cheaper and more attractive for informal settlements. Hence, these policies generally end up being the justification for demolition, forced eviction and relocation actions (Alvarez-rivadulla, 2019). Finally, social policies, and housing subsidies, are frequently used for relocate informally settled communities as an attempt to produce formalization.

Currently, 160 million people, 20% of urban population in Latin America lives in informal settlements. Percentages varies between low (11% to 13%, such as in Mexico and Colombia), medium (34% to 44%, such as in Peru and Bolivia), to high (74% in Haiti) (The World Bank, 2014). It is also estimated that 75% of housing built annually in the region is informal (The World Bank, 2017). From the mainstream planning perspective, a desirable urban transition would simply consist of eradicating informality. In fact, government approaches to informal settlements in Latin America and other regions have traditionally consisted of demolitions, forced evictions, and relocations. In some cases, such initiatives have been based on risk management policies, but in many others they have been simply responses to social and economic pressures exerted by dominant groups (Watson, 2009; Lombard, 2014; Ferris, 2014). However, alternative policy options, based on improving housing, public space and infrastructure, while legalizing tenure, have been in place for several years, with contrasting levels of success (Alvarez-rivadulla, 2019; Nunez & Han-Hsiang, 2020).

The idea of a sustainable city necessarily being a planned city is a debatable premise, which implies disregarding the historical role of planning on promoting socio-spatial segregation in the first place, while overlooking the relevance of the informal city in providing an alternative to the speculative real estate market and the limited capacity of public subsidies, thereby contributing to define the current character of the urban global south (Alvarez-rivadulla, 2019). It will also imply disregarding the potential contribution of incremental place making (Lombard, 2014) and local social fabrics on sustainability and resilience (Carpenter, 2013).

Arguably, a sustainability transition of informal settlements does not consist on disappearing and being replaced by formal urban plans, but on finding innovative paths to economic prosperity, poverty reduction and social equality, while assuring ecosystem protection, resource efficiency and resilience on the base of participative governance and creative leadership.

Figure 5-5 illustrates the approach to the built environment as a socio-institutional system containing two subsystems: one that is equivalent to the socio-technical meta-system described in the previous section, the other that corresponds to informal urban development. This scheme differs from figure 5-4 since here regimes are presented in two sublevels. First level refers to the constituent elements of the built environment, which in the formal system correspond to urban planning, infrastructure, buildings, public space, while in the informal system correspond to collective-place making, negotiations for services and self-constructed buildings (Lombard, 2014). The second level presents the institutions governing regimes, where technology, technical capacities (education – training) and policies, although not equivalent, intersect each other. Whereas science, market and social practices are unrelated.

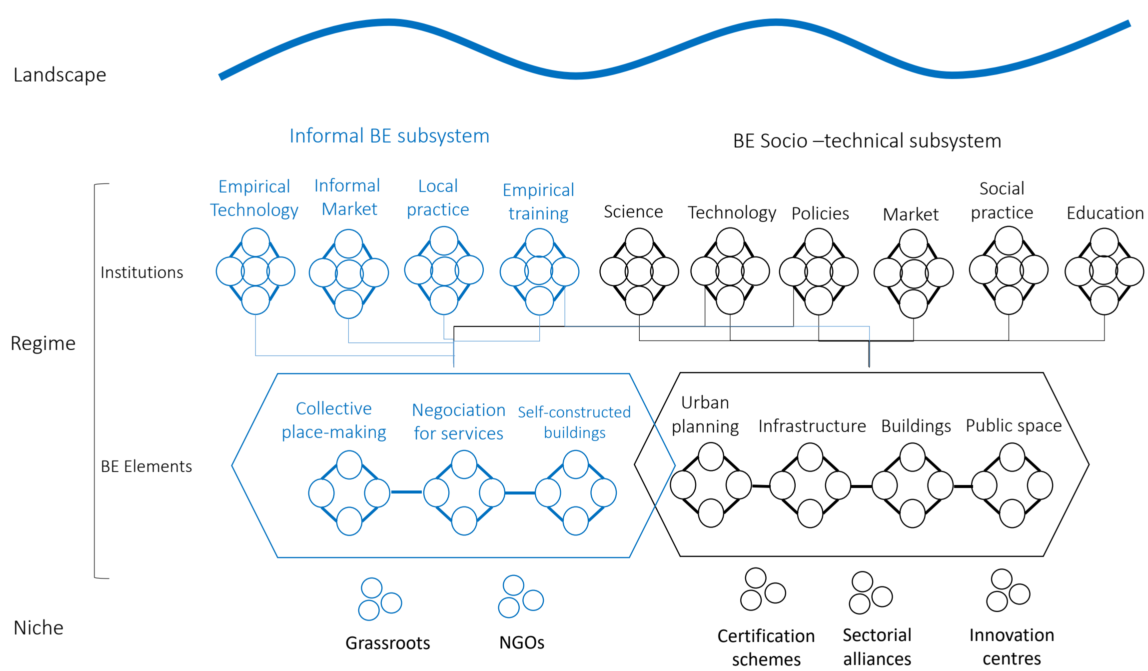


Figure 5 - 5. The BE as a socio-institutional system composed by two subsistems

Source: The author. Built on Hann & Rotmans, (2011); De Haan & Rogers, (2019) and Schott & Kanger (2018)

5.2.3. The built environment as a Socio-economic system

The implementation of the 2030 Agenda requires the mobilization of financial resources, the United Nations estimates, recent estimates are in the range of 3 to 14 trillion dollars (ECLAC, 2017). This range, in addition to being extremely wide to be considered a clear basis for mobilizing resources, is based on an estimate of the costs of compliance with each of the SDGs, seen separately and without identifying synergies between them. This flaw gives validity to the exercise developed in chapter 4 of this thesis, where the potential synergies different aspects of the Multilateral Agenda are outlined, thus helping understand interactions across instruments, sectors, areas and goals as a base for more coherent policies, programs, projects and actions that will use local, national and international resources more efficiently and effectively (LeBlanc, 2015).

Although the 2030 Agenda places particular emphasis on the need to transfer financial resources from industrialized economies to developing countries, it is essential that these countries strengthen their own financial and fiscal systems. This challenge is particularly important for Latin America, considering the low institutional capacity characterizing Countries in this region (see section 3.3.2) along with the regressive economic policies that have become real obstacles to increasing public revenues and achieving an adequate redistribution of wealth (ELAC, 2017).

Research on the financing of transitions is just in its infancy and the reflections produced are still limited in scope (Köhler et al., 2019; Naidoo, 2020). However, a number of challenges have been identified, which go beyond resource mobilization. The just transition towards circular and low-carbon economies, ensuring that social inequalities are reduced rather than exacerbated, within the peremptory period of a decade, requires a transformation of the structures, objectives, methods and concepts under which the economic and financial systems are currently operating.

Some authors consider that authentic sustainability transitions are not possible under the current economic paradigm, aspiring to an endless capital increase, based on a linear model of extraction, transformation, consumption and disposal of natural resources, which is exceeding planetary boundaries while exacerbating social inequalities (Steffen et al, 2015; Göpel, 2016). Concerning the built environment this paradigm reveals in two ways:

1. The first consists of valuing urban land based on maximizing capital profit (Hoffman & Henn, 2008; Watson, 2009; Alvarez-rivadulla, 2019; Bolay, 2020). Which, on the one hand, favours urban expansion over rural areas and natural systems and on the other hand favours profitable urban projects while excluding poor communities (UN, 2017a).

2. The second consists of the linear process of producing and operating the built environment from raw materials, to manufacture, construction, use and demolition, powered by fossil fuels, disregarding both material and water reuse, while degrading ecosystem structure and services (Sherwood, 2000; Du Plessis, 2002; Emina et al, 2017)

Sustainability transitions of the BE will require a shift from the linear-excusive to towards a new circular-inclusive economic model (Sarshar et al, 2015; Tollin, 2015), which:

1. Assigns land value from balancing private capital profits with public opportunities for protecting rural areas and ecosystem services, while increasing social cohesion by reducing spatial segregation
2. Prioritizes urban renovation and retrofitting over urban expansion, uses renewable energies, reuses water an materials while providing accessible and healthy places for people

Among various approaches sustainability transitions of socio-economic systems, the "The great mind - shift" (GMS) proposed by Göpel (2016) is selected here for being consistent with the general purpose of this thesis and offering a MLP based perspective.

The GMS differs from the MLP on socio-technical transitions by describing the landscape as the set of collective views and narratives that societies have of themselves and the world, while adding an intermediate level between this landscape and the regime level, corresponding to the planetary systems. It also adds a lower level, corresponding to values, imaginaries and identities guiding individual choices and interpersonal relationships Göpel (2016).

The original GMS states that, by including the planetary systems, transition subjects are socio-ecological systems. However, these planetary systems play here a rather passive role, as being subjected to environmental impacts and resources extraction from societal system. This view is still quite anthropocentric for the purpose of this thesis. Therefore, the GMS is not incorporated here in its original version, but is modified, leaving out the planetary systems, to incorporate them later as an autonomous system, with its own structure and function. Their intermediate place between the regime and the collective narratives is then replaced by the dominant linear-capitalist economic paradigm, because this is actually the subject being discussed by the GMS perspective. Put in such place, this paradigm both influences and is continuously reinforced from lower system levels while interferes attempts of shifting the upper level.

Göpel (2016) suggests that a socio-economic transition is already taking place, based on the following evidences:

1. Negative consequences of the dominant economic model are becoming more evident

2. At the landscape level, new trends are appearing, including the circular economy, low-carbon development and the increase in renewable energies.
3. The range of alternatives proposed by innovation niches continues to expand
4. Disagreements between related regimes and alliances between prevailing regimes and niches are becoming common

However, these elements are yet insufficient for transformational change, Göpel (2016) proposes that transformation of values at individual levels are required to overcome the interference of prevailing paradigm on collective world views. This way, the transition of socio-economic systems would imply, not only the transformation of the institutions that perpetuate the dominant regimes, but also the individual and collective ideals underlying these institutions. The main contribution of GMS to the MLP consists precisely in assigning dominant role to the relation between individual values and collective world views on sustainability transitions.

Figure 5-6 illustrates the application of the modified GMS to the socio-economic sustainability transition of the built environment. This scheme is basically the same figure 5-5, but nested the individual-values level and the current economic paradigm.

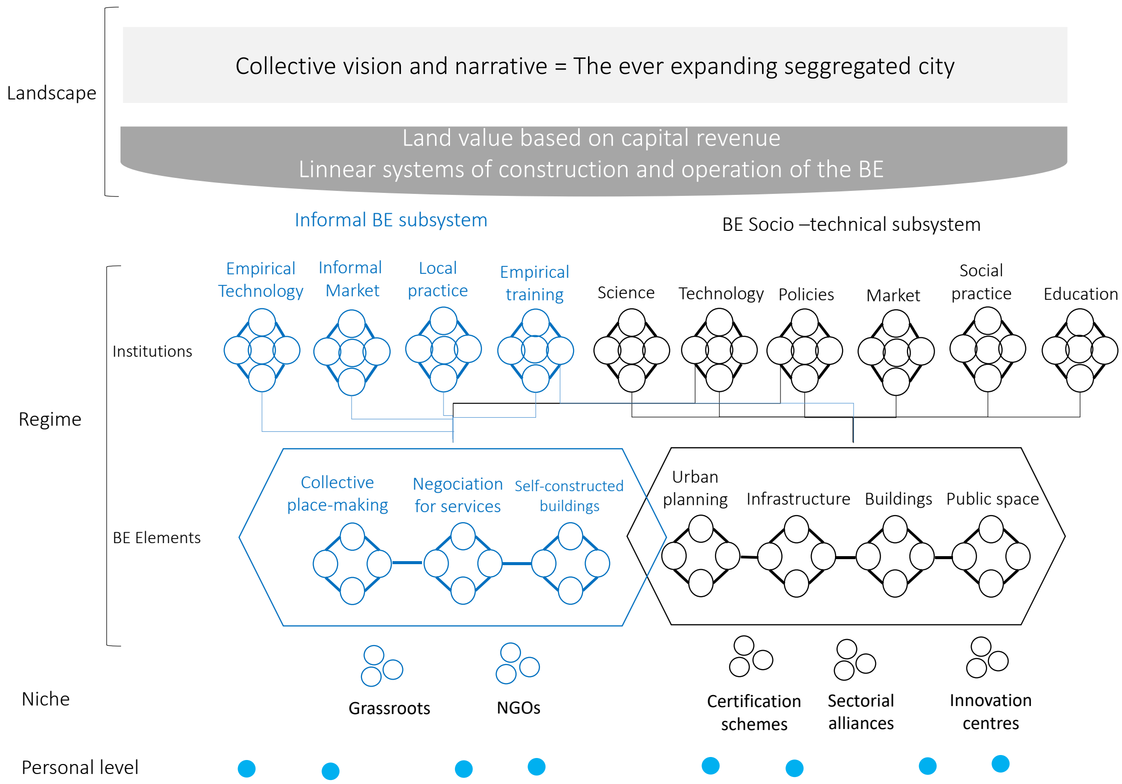


Figure 5 - 6. The Multi-level perspective applied to the sustainability transition of the built environment viewed as a socio – economic system

Source: The author. Built *on Hann & Rotmans, (2011); De Haan & Rogers, (2019) and Schott & Kanger (2018) and Göpel, 2016*

5.2.4. The role of the spatial dimension on urban transitions

Arguably, the main challenge in introducing the built environment in transition theories is related to the spatial dimension. This importance has been extensively discussed throughout this thesis. Chapter 3 described the challenge of harmonizing green policies in the built environment and land use planning policies. Chapter 4 shows how the node relating all aspects of multilateral agendas in cities is precisely its spatial dimension. Chapter 5 has also being discussing spatial implications of approaching the built environment as socio-institutional and also as a socio-economic system.

Urban extension, morphology and density has a direct influence on urban metabolism, by affecting material, energy and water flows, thus affecting urban relations to ecosystems natural resources and disaster risks. Urban spatiality also affects economic activity, job provision, social inclusion and satisfaction of basic needs. Therefore, all aspects of urban sustainability are related to this spatial dimension, thus the key urban policies for sustainable urban development are then those related to land planning and spatial design (UN, 2017a). However, as already mentioned in chapter 3 and along chapter 5, existing instruments for land planning were conceived under the paradigms of modernism, whose anthropocentric vision of the world sets a strong separation between the built domain and the natural domain (UN 2017a, Bolay, 2020). By downplaying relationships between urban morphology, urban metabolism, ecosystems integrity and social well-being, existing instruments have become vehicles of social exclusion; are insufficient to address challenges of conurbation, metropolization globalization, climate change, biodiversity loss and environmental pollution (UN, 2017a).

A clear example of the futility of existing land planning instruments to cope with sustainable development challenges is the existing land planning law from Colombia, formulated in 1997. This instrument makes no mention of the relationship between urban planning, social equality, economic prosperity and ecosystems services. Likewise, it confers autonomy to the municipalities above territorial units of higher hierarchy, thus excluding the chance of association between municipalities for the integrative planning required by both metropolitan and rural regions. Although some of these deficiencies are being adjusted by complementary norms issued during the last two decades, none of these attempts have solved the structural problems. Within these documents, the environmental dimension of land plays a residual role, mainly associated with natural disaster risk management. The relationship between economic prosperity, social inclusion and urban planning is not referred to in any complementary norm. Likewise, municipal associations that have been created under complementary laws, are all inoperative in practice, with the exception of the Metropolitan Area of the Aburrá Valley (DNP & SEI, 2017) (which was cited in chapters 2 and 3 for its local policy of ecourbanism and sustainable construction).

A recent report from Ministry of Housing, City and Territory evaluates outcomes of this law after two decades. Main conclusion is that most municipalities lack institutional capacities to both formulate and develop land plans, thus requiring support from national government (MVCT & UNal, 2017). This report does not present any critical analysis on structure, thematic contents or methodological criteria of the law itself, thus implicitly assuming that existing challenges are just related to implementation, but regulation is fine.

As long as aspirations of sustainable urban development do not become a structural part of land policies, transition to inclusive, prosperous and resilient cities will be slow and incomplete. This hypothesis has being outlined by approaching the built environment as both socio-institutional and socio-economic system. However, this vision is still fragmentary, I propose that the basis for an integrative model of urban transition, which integrally incorporates a spatial dimension, would consist of the conceptualization of the built environment as a socio-ecological system, as illustrated in next section.

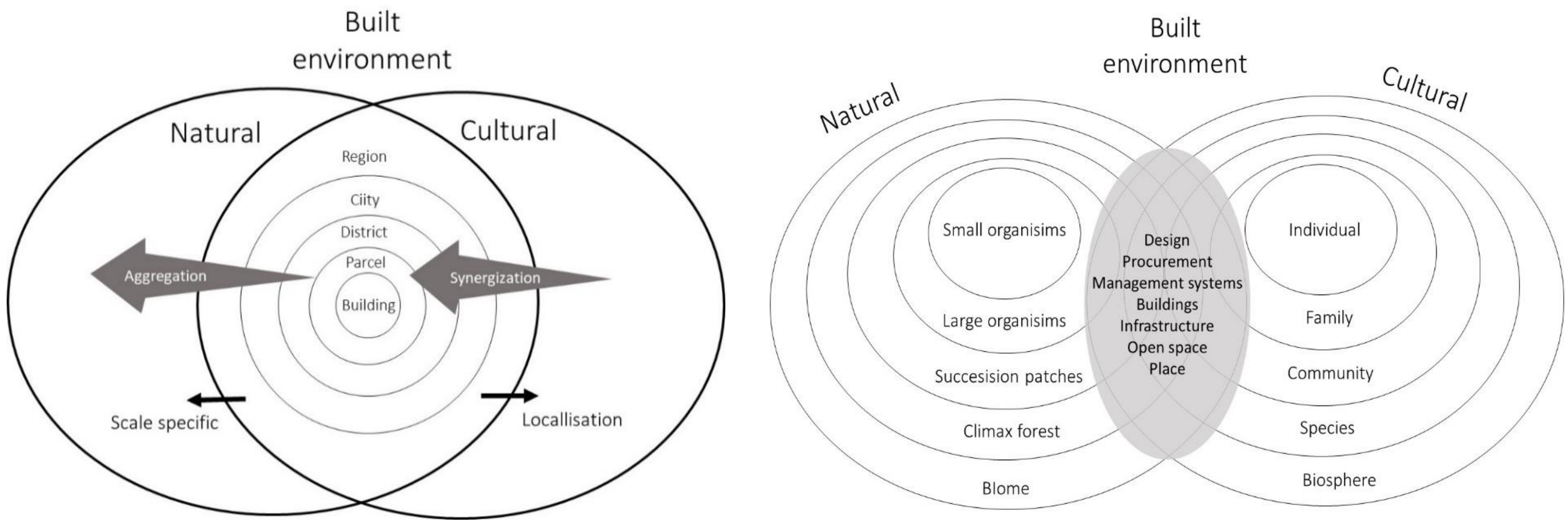
5.2.5. The built environment as a socio-ecological system

As sustainability transitions, the concept of socio-ecological systems has been evolving in different directions, giving rise to different approaches, which are not unified under the same theoretical body (Binder et al., 2013; Herrero-Jáuregui et al., 2018). Moffatt & Kohler (2008) propose a model for socio-ecological systems that explicitly addresses the built environment, being a suitable option for the purpose of this thesis. From this perspective, the built environment is a complex system emerging from a space-time intersection of metabolic financial and information flows between natural and cultural realms, which make it a socio-ecological system.

Since Moffatt & Kohler model is based on metabolic, information and financial flows, spatial scales of the built environment exceed the physical limits of urban land, going up to the region, thus defining two types of spatial relations: localization and synergization. Localization refers to local decisions made at the scale of building or parcel while synergization refers to policies, plans and projects, occurring at larger scales.

From this perspective, temporary structure of the built environment relates to a life-cycle approach, comprising design, construction, operation and maintenance of buildings, followed by developing public spaces and infrastructure. Temporal levels in the cultural realm range from individual to biosphere, passing through family and community, while in the natural realm, temporal scales range from species to biome, passing through populations and biocenosis.

Figure 5-7 illustrates the conceptual model of the built environment as a socio-ecological system proposed by Moffatt & Kohler (2008), which is used in this thesis as a framework for linking approaches previously used to describe socio-technical-institutional-economic transitions.



a b

Figure 5 - 7. Schematic representation of the built environment as a social ecological system
a) spatial dimension. b) temporal dimension
Source: Moffat & Kohler (2008).

5.2.6. An integrative model for describing sustainability transitions in the built environment

The proposal from Moffat & Kohler (2008) provides a basis for understanding the built environment as a socio-ecological system. But some major adjustments are required in order to produce a more comprehensive model that allows connecting socio-technical-institutional-economic system developed in sections 5.2.1, 5.2.2, 5.2.3 and 5.2.4. The elements for this integrative model are described below. The resulting model is illustrated in figure 5-9.

5.2.6.1. Expanding and specifying the socio – ecological frame

The natural realm

The notion of the natural world in the model is expanded to include, not just biotic elements, as proposed by Moffat-Kohler (figure 5-7b), but also other elements defining the natural context for the cultural realm, which take part in the structure and function of the built environment. This elements are:

- Location (latitude, altitude) and climate, determining life zones (Holdrige, 1947)
- Geologic and geomorphologic processes, determining the physical landscape
- The biocenosis, as the biotic component of the natural landscape

Interactions between these elements have the following implications in the built environment:

- Defining physical aptitudes and restrictions for urban development
- Shaping urban morphology
- Determining typologies, magnitudes and qualities concerning ecosystem services (which are defined next)
- Defining conditions for thermal comfort, thus influencing: energy consumption in buildings, permanence and transit in public space, as well as modes and forms of transportation
- Determining typologies, probabilities and magnitudes of natural risks (from the hazard point of view),
- Shaping the "sense of place", which is defined below (Azizul et al, 2016; Frantzeskaki et al, 2018)
- Influencing social fabrics of space (Carpenter, 2013)

Ecosystem services and green infrastructure

Ecosystem services are defined as "the direct and indirect contributions of ecosystems to human well-being." (TEEB, 2010). This concept is required in the model in order to better specify relations between the cultural sphere and the natural environment. Metabolic relations, may be defined from provision and regulation services, while non-metabolic relations may be defined from cultural services, which contribute to shaping the "sense of place". The physical manifestation of ecosystem services occurs through the green infrastructure, defined as:

"Green Infrastructure (GI) is based on the principle that 'protecting and enhancing nature and natural processes […] are consciously integrated into spatial planning and territorial development'. Accordingly, the Green Infrastructure Strategy defines GI as 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services' in both rural and urban settings" (EC, 2013).

Figure 5-8 illustrates elements defining the nature realm, as input for an integrative model of the built environment.

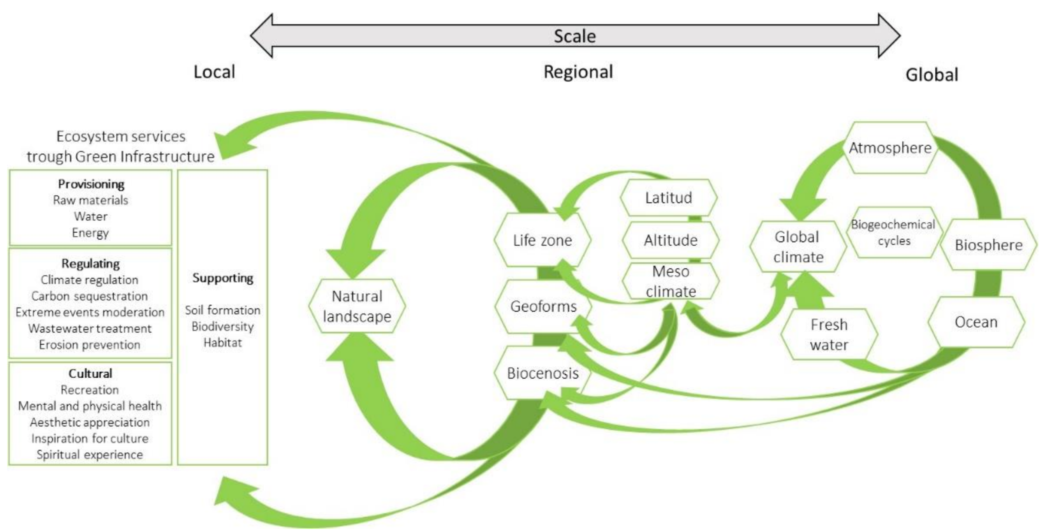


Figure 5 - 8. Elements defining the nature realm in the integrative model for sustainability transitions of the built environment
Source: the author

Cultural realm as subordinate system with open boundaries

The integrative model maintains the built environment as an intersection between natural and cultural realms. However, unlike the Moffat-Kohler model, where this realms are somehow opposed to each other, the integrative model places the cultural sphere within a natural context. Which is more consistent with reality, since human society cannot exist outside the natural world. It also seeks to exclude the culture - nature dichotomy, which is part of the collective narratives hindering transformational change (Göpel, 2016).

In the other hand, boundaries defining scales of the cultural realm and of the built environment are represented by dotted lines. The aim is to indicate that such boundaries are not solid and fixed, but open and fluid.

Scales within the cultural domain are not restricted to progression from individual to community. They also include public and private organizations, governments and all other elements, structures and institutions that are part of the socio-technical-institutional-economic systems that were described in the sections 5.2.1, 5.2.2 and 5.2.3

The urban morphology – urban metabolism loop

As mentioned previously, urban morphology is influenced by the natural context, but it is also influenced by city size, land uses, urban nexus (metropolitan regions), as well as distribution, densities, heights and shapes of built elements (cite conceptualizing to inform transitions). Urban morphology is decisive in determining:

- Demand for ecosystem services
- efficiency of natural resources use
- Socio-spatial equity and social cohesion, related to social fabrics
- Typologies, probabilities and magnitudes of natural risks (from vulnerability point of view)
- The conformation of the "sense of place", which is defined below.

From these interactions it is inferred that urban morphology and urban metabolism are related to each other, one cannot be intervened without modifying the other. Therefore, in the inetgrative model they are represented as a loop.

Metropolization

The urban phenomenon begins with individual cities, operating on municipal scales, isolated from each other within a rural matrix. However, cities grow and expand, joining together in conurbations or functionally linking to share resources, processes, infrastructures and populations, giving rise to new more complex urban systems with emerging properties arising from spatial, physical, cultural and metabolic interactions (Anderson, 2015; Knieling, 2014). Consequently, the term "urban" cannot be used as a single category, defining homogeneous systems. It is important to introduce t least two categories, one corresponding to the city within its municipal administrative limits and another corresponding to the metropolitan city, whose limits are defined by the magnitude and intensity of the interactions between the municipal cities that comprise it.

The sense of place

Defined as a set of cognitive and affective elements, defining identity, belonging and dependence relationships developed by people with respect to the places where they spend their lives (Azizul et al, 2016; Frantzeskaki et al, 2018). The sense of place contributes to the following aspects regarding urban sustainability:

- Influencing patterns of permanence, mobility and consumption;
- Shaping personal and collective notions of human needs (Papachristou & Rosas-Casals, 2019)
- Prompting individual and collective importance conferred by people to the preservation of their environment (Azizul et al, 2016; Frantzeskaki et al, 2018)
- Stimulating moods and attitudes, thus influencing interpersonal relationships and community building arising from social fabrics (Azizul et al, 2016; Frantzeskaki et al, 2018; Carpenter, 2013)

This way, the "sense of place" may have a potential role on fostering sustainability transitions, by contributing to shape both individual values and collective narratives (Azizul et al., 2016; Frantzeskaki et al., 2018), also serving as a bridge to connect the expert discourse of urban sustainability with the daily lives of people and communities (Papachristou & Rosas-Casals). In the model, the sense of place arises jointly from the interaction of people with the built environment and with the natural landscape.

The social fabric

The social fabric is a set of individuals or groups related to each other through connections such as family ties, friendships, similar interests, similar beliefs or other types of common circumstances (cita ties and the built environment). Some authors argue that the organizational and functional aspects of urban resilience depend on the nature, strength and amount of social ties. In turn, the built environment can influence the construction and permanence of social ties between individuals, families, communities and organizations (Carpenter, 2013). Hence, there is a direct relation between the social fabric and the sense of place, which may play a relevant role in urban transitions. In the model, the social fabric is represented by lines that link elements within the individual level in the Multi-Level scheme located within the cultural sphere.

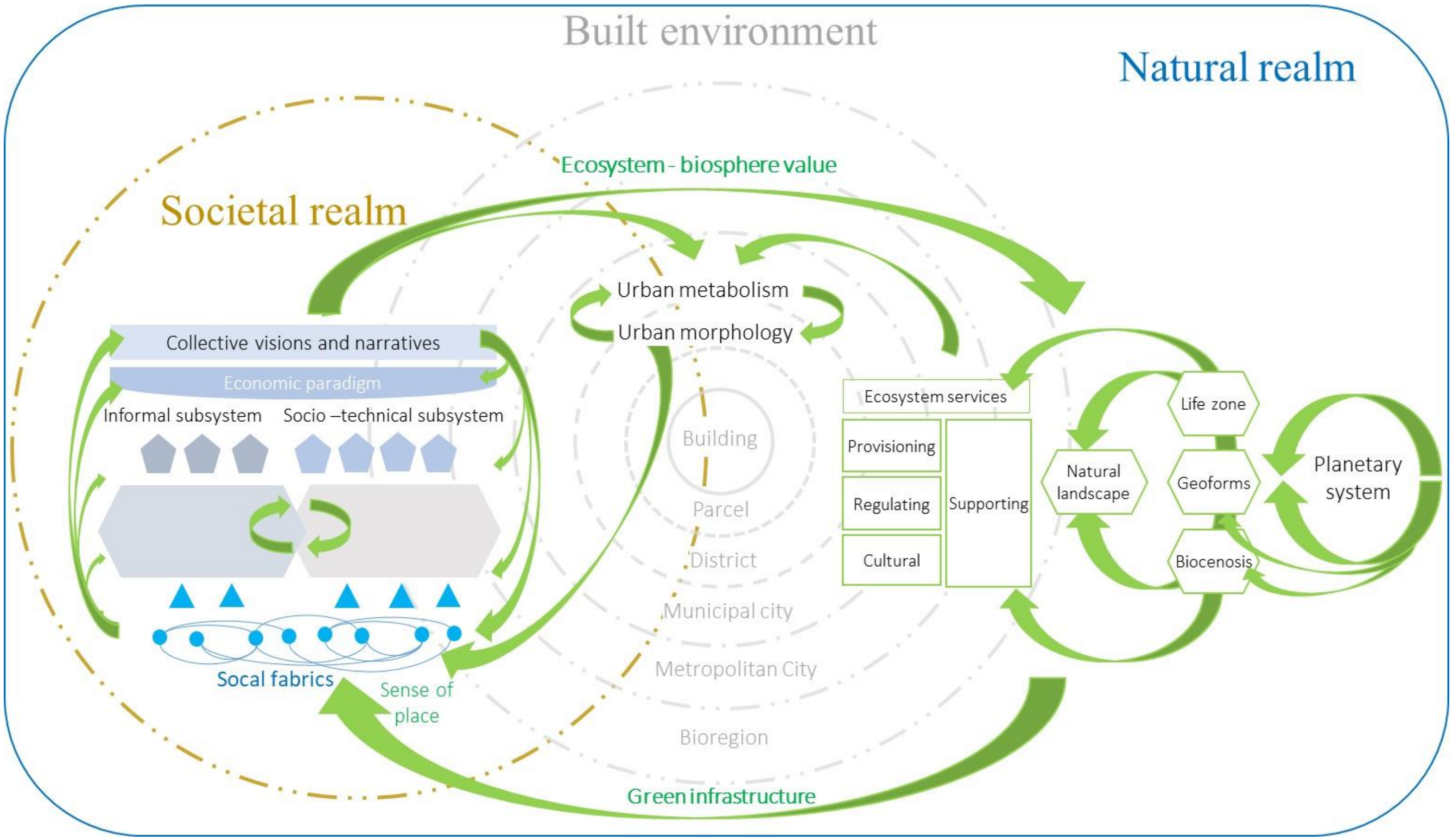


Figure 5 - 9. An integrative analytical model for understanding sustainability transitions of the built environment – STAM. Based on a socio-ecologic-economic-institutional-technical approach

Source: the author

Source: The author. Built *on Hann & Rotmans, (2011); De Haan & Rogers, (2019) and Schott & Kanger (2018) and Göpel, 2016* and *Moffat & Kohler (2008)*

5.2.6.2. *Conceptualizing urban transitions from the integrative model*

The sustainability transition of the built environment under the integrative model proposed here would arise from the following loop of events:

- Transformation of structures, cultures and practices within scientific, technical, political, social, educational and market regimes, thus enabling…
- shifting the linear-capitalist economic paradigm for a new circular-inclusive economic model,
- while replacing collective narratives of an ever growing-segregated city by a new view on a sustainable, just, resilient city, leading to...
- a change on the social value of ecosystems, with positive impact on preserving their structure and function, thereby increasing…
- ecosystem capacity to provide services to communities and organizations, thereby strengthening….
- both the sense of place and the social fabrics, arising from a healthy, nurturing environment, thus encouraging…
- participative governance on urban planning, place making, infrastructures and buildings, in order to...
- ensure that urban morphology and metabolism properly responds to environmental opportunities and restrictions, while equitably fulfil societal needs, thus reinforcing…
- both the sense of place and the social fabrics, arising from a urban development that is fair, regenerative and efficient, thereby nurturing ...
- transformation of structures, cultures and practices within scientific, technical, political, social, educational and market regimes, thereby initiating a positive feedback loop.

The integrative analytical model for understanding transitions in the built environment – STAM is shown in figure 5-9. As built on analytical approaches it does not explain how transitions can be fostered and managed. These questions require further exploration on transition management approaches, which is developed in next section.

5.3. FROM CONCEPTUALIZING TO MANAGING TRANSITIONS

Understanding transitions from an analytical view provides elements that can be useful to encourage social transformations. However, methods for managing transitions are different from conceptual approaches. In previous section, an integrative analytical model to understand sustainability transitions in the built environment based on a Multi-Level Perspective on socio-technical-institutional-economic systems, within socio-ecological systems framework. In this section, similar reasoning is used to evaluate existing methodologies for transition management in order to identify common and complementary elements for an integrative management framework, within the framework of the Urban Transformative Capacity concept (Wolfram, 2016).

Methodological frameworks for managing transitions are as diverse as analytical approaches to understand transitions. Loobarch et al (2017) identify four frameworks on managing socio-technical transitions, referred to as: 1) strategic niche management - SNM, 2) reflexive governance, 3) transition management - TM, and 4) policies for innovation systems. Voß, & Bornemann (2011) identify one perspective on managing socio-ecological transitions, referred to as: Adaptive Management – AM. In the other hand, Urban Transformative Capacity – UTC (Wolfram 2016) and Urban Resilience Transitions – URT (Tollin, 2015 are being proposed as frameworks for specifically addressing urban transitions.

SNM, TM AM, UTC and URT are used here to produce an integrative model for managing transitions. Despite addressing different systems, all these approaches share three common requirements to fostering transitions:

- Collective visions based on broad participation from different actors and sectors
- Experiments as the main mechanism for exploring transitions
- Ensuring first order and second order learning from actors taking part in transition experiments

Specific aspects of each approach are described next.

5.3.1. Strategic Niche Management

SNM is related to the MLP on socio socio-technical transitions and has been already mentioned in section 5.1.6. It focuses on protecting, diversifying and empowering innovation niches in order to drive innovations into the to the regime level, by means of three strategies (Caniëls & Romijn, 2008):

• Linking expectations and visions shared by multiple actors, whose viability must be demonstrated through multiple projects (experiments), thus attracting external support for niches

• Creating networks that allow interaction between niche actors, so that they can produce alliances and share resources

• Learning in multiple dimensions from the incorporation of best practices and lessons learned, while incorporation this learning back into subsequent experiments

Implementing these strategies is strongly linked to incorporating intermediaries and champions. Intermediaries are either individual or organizational actors helping consolidate knowledge from experiments in order to disseminate it into the regime. Champions are individuals helping overcome social and political pressures imposed over niches, while also helping promote innovations through the regime level. Champions can also act as intermediaries and vice versa. An important part of the SNM literature is related to the typologies of intermediation and championship (Martiskainen & Kivimaa, 2018; Kivimaa et al, 2018)

The SNM may be a valuable approach to promote experimentation based on innovations that are already available in the market, while empowering niches in order to diversify alternatives, based on emerging innovations.

5.3.2. Transition Management

TM is the most prominent approach referred by literature on managing socio-technical transitions (Rotmans & Loorbach 2010; Köhler J, 2019). It is based on a cycle of strategic, tactical, operational and reflexive activities, following the next steps:

• Assembling regime actors, niche actors and outsiders on a transition arena to collectively understanding and structuring the problem (strategic)

• Producing collective visions through a transition agenda (tactic)

• Implementing visions through sequential experiments (operative)

• Evaluating and monitoring outcomes arising from experiments while ensuring learning (reflexive)

The key strategy of the TM is the transition arena, consisting of bringing together regime and niche actors, as well as outsiders in order to ensure that both problem understanding and collective visions are sufficiently diverse to be transformative. However, such diversity invites dissent and conflict as much as consent and agreements. Therefore, transitions do not follow linear, predictable paths, but rather complex dynamics. Table 5-7 shows how complexity relates to transition governance

Table 5 - 7. Complexity in transition governance

Complexity characteristics	*Theoretical Principles TM*	*Systemic Instruments for TM*
emergence	creating space for niches	transition arena
dissipative structures	focus on frontrunners	transition arena and competence analysis
diversity and coherence	guided variation and selection	transition experiments and transition pathways
new attractors, punctuated equilibria	radical change in incremental steps	envisioning for sustainable futures
co-evolution	empowering niches	competence development
variation and selection	learning-by-doing and doing-by-learning	deepening, broadening, scaling up experiments
interactions, feedbacks	multi-level approach multi-domain approach	complex systems analysis
patterns, mechanisms	anticipation and adaptation	multi-pattern & multi-level analysis

Source: Rotmans & Loorbach 2010

TM was originally conceived for sociotechnical transitions. However, considering that other analytical approaches are also based on a MLP perspective. In the field of SBE transitions application of TM may be extended to socio-institutional and socio-economic systems.

5.3.3. Adaptive Management

Adaptive management is a framework for managing socio-ecological transitions (Allan & Stankey, 2009), based on a cycle of activities consisting of:

• Conceptualizing the problem and analysing current situation (baseline)

• Formulation of action plans and monitoring

• Implementation of actions

• Analysis of results and adjustment of strategies and plans

• Documentation and information sharing

The cyclical structure of adaptive management makes it similar to TM, in fact, both approaches are comparable in different aspects, such as basic assumptions and concepts of governance, although they differ in other important aspects, such as theoretical support and overall goals (see table 5-8).

Table 5 - 8. Adaptive Management and Transition Management

	Adaptive Management	Transition Management
Theoretical background	Resource management, ecology, resilience theory, “panarchy” theory	Technology and innovation studies, complexity theory, evolutionary theory
Realm of application	Socio-ecological systems (SES): functionally or spatially defined systems (natural parks, river basins, etc.)	Sociotechnical systems (STS): arrangements providing societal functions such as energy provision, agriculture, transportation
Overall goal	Adaptation	Change
	Maintain resilience of socio-ecological systems by increasing capacity to cope with complex dynamics	Transform existing sociotechnical systems by modulating ongoing innovation, leading to a sustainability transition
Basic assumptions	Complex and coevolving systems	Complex and coevolving systems
	Constant cyclic change is taking place	Transitions are taking place
	Universal cycle of collapse and renewal	S-Curve as universal pattern of change
Concept of governing	Experimentation and learning	Experimentation and learning
	Navigate through cycles of social–ecological change	Modulate sociotechnical dynamics (breed alternative systems)
	Bring heterogeneous actors together to construct and test policy hypotheses	Provide platform for frontrunners to collectively experiment and learn what works

Source: Voß, J., and B. Bornemann. 2011

Concerning transitions in the built environment, adaptive management could provide a broad framework aimed at increasing resilience in socio-ecological systems (see table 5-9)

5.3.4. Urban resilience transition – URT

Tollin (2015) provides a detailed methodological process for managing urban transitions. General process may be summarized as follows:

- Problem analysis
- Forecasting and visioning
- Backcasting and planning
- Implementation
- Replication and up-scaling
- Monitoring and evaluation

URT is a detailed method explicitly addressing urban transitions, however its general lines are similar to TM and AM. It also coincides with AM on its overall goal, consisting on increasing resilience.

5.3.5. Urban transformative capacity

Unlike the previous approaches UTC is not yet a method for managing transitions but a framework setting foundations for distinguishing incremental from authentic transformative change. It is defined as *"the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change towards sustainability within and across multiple complex systems that constitute the cities they relate to"* (Wolfram, 2016)

The framework consists of 10 interdependent components of urban transformation capacity, with 60 factors specifying components requirements. C1-C3 refer to governance and leadership, C4-C8 define transformative processes, while C9-C10 set relational aspects affecting all other components. UTC is the measure of a balanced attention between all components (figure 5-10).

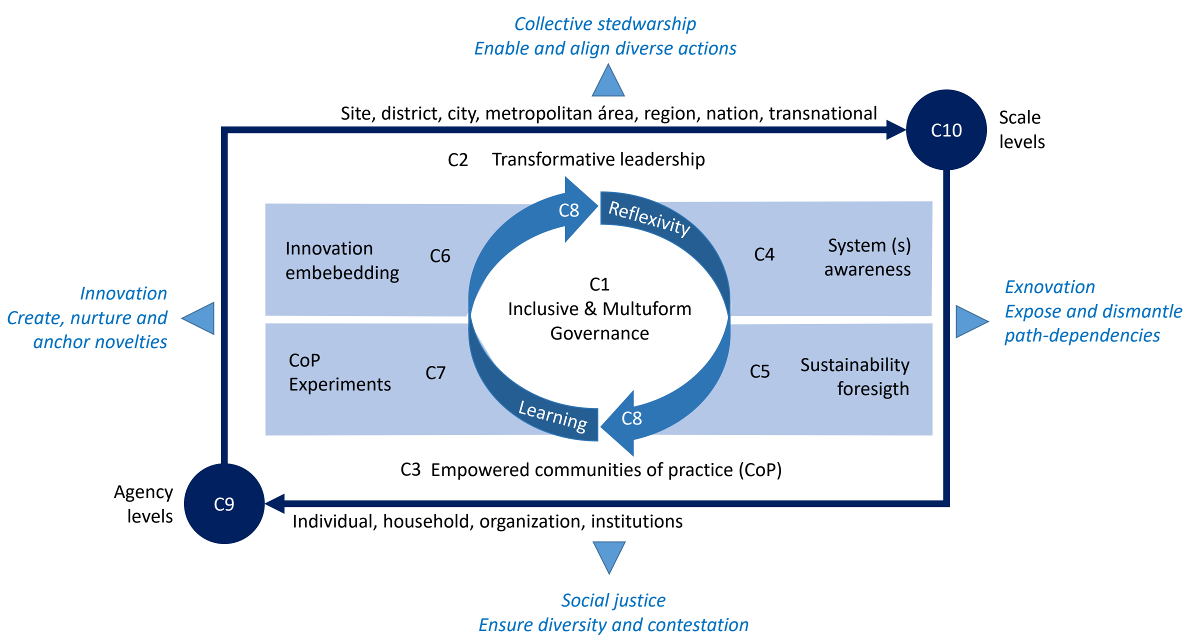


Figure 5 - 10. The Urban Transformative Capacity Framework
Source: Wolfram, 2016

As Moffat-Kohler model provided the framework for connecting analytical approaches on understanding sustainability transitions. UTC is used here as a framework to connect all approaches to transition management in order to produce an integrative model that fits into the STAM conceptual model, as described next.

5.3.6. An integrative model for managing urban transitions

Using the UTC framework it is possible to connect transition management methods as a basis for the designing transformative policies, as shown in table 5-9. While SNM approach is limited to components C6 and C7, AM, TM and URT may cover a wide range of UTC components, with specific limitations on components 9 and 10. This is because all approaches seem to assume that transitions are basically a bottom-up process where experiments can be replicated and scaled-up just by adjusting scopes according context and scale. However, the UTC 9 and 10 components indicate that transformative change arises from both bottom-up and top-down directions, where subnational, national and transnational levels, may contribute or restrict transformative capacity.

Table 5 - 9. UTC and transition managing methodologies

UTC Component		Useful methodological approach			
		AM	TM	URT	SNM
C1 Inclusive and multiform urban governance	C1.1 Participation and inclusiveness	Yes	Yes	Yes	No
	C1.2 Diverse governance modes and network forms	Yes	Yes	Yes	No
	C1.3 Sustained intermediaries and hybridization	Not explicit	Yes	Limited to knowledge brokerage	Yes
C2 Transformative leadership (in the public, private and civil society sectors)		Yes	Yes	Explicit only for civil society	No
C3 Empowered and autonomous communities of practice	C3.1 Addressing social needs and motives	Yes	Yes	Yes	Not explicit
	C3.2 Community empowerment and autonomy	Yes	Yes	Yes	No
C4 System(s) awareness and memory	C4.1 Baseline analysis and system(s) awareness	Yes	Yes	Yes	Yes
	C4.2 Recognition of path dependencies	Not explicit	Yes	Not explicit	No
C5 Urban sustainability foresight	C5.1 Diversity and trans disciplinary co-production of knowledge	Yes	Yes	Yes	No
	C5.2 Collective vision for radical sustainability changes	Yes	Yes	Yes	Yes
	C5.3 Alternative scenarios and future pathways	Yes	Yes	Yes	No
C6 Diverse community-based experimentation with disruptive solutions		Yes	Yes	Yes	Yes
C7 Innovation embedding and coupling	C7.1 Access to resources for capacity development	Not explicit	Not explicit	Yes	Yes
	C7.2 Planning and mainstreaming transformative action	Yes	Yes	Yes	Yes
	C7.3 Reflexive and supportive regulatory frameworks	No	No	Yes	Not explicit
C8 Reflexivity and social learning		Yes	Yes	Yes	Limited to niche/regime interaction
C9 Working across human agency levels		Not explicit	Not explicit	Not explicit	No
C10 Working across political-administrative levels and geographical scales		Not explicit	Not explicit	Not explicit	No

Source: The author
Built on: Wolfram (2016), Tollin (2015), Rotmans & Loorbach 2010; Voß, J., and B. Bornemann. 2011

Figure 5-11 shows how the 10 UTC components may be incorporated in the STAM model, thereby producing a new model useful for both understanding urban transitions and designing transformative capacity. Components C1 to C9 are directly related to the social realm of the STAM model, while only components C4, C8 and C5 can be related to the natural realm. Components C4 to C8 may be indirectly related to the built environment, only the C10 component can be explicitly related to BE because it refers to transformative action at different spatial scales. In this sense, the UTC provides a broad and specific framework to assess the transformative capacity of socio-technical, socio-institutional and socio-economic systems, but its usefulness to address cities as socio-ecological systems is rather implicit.

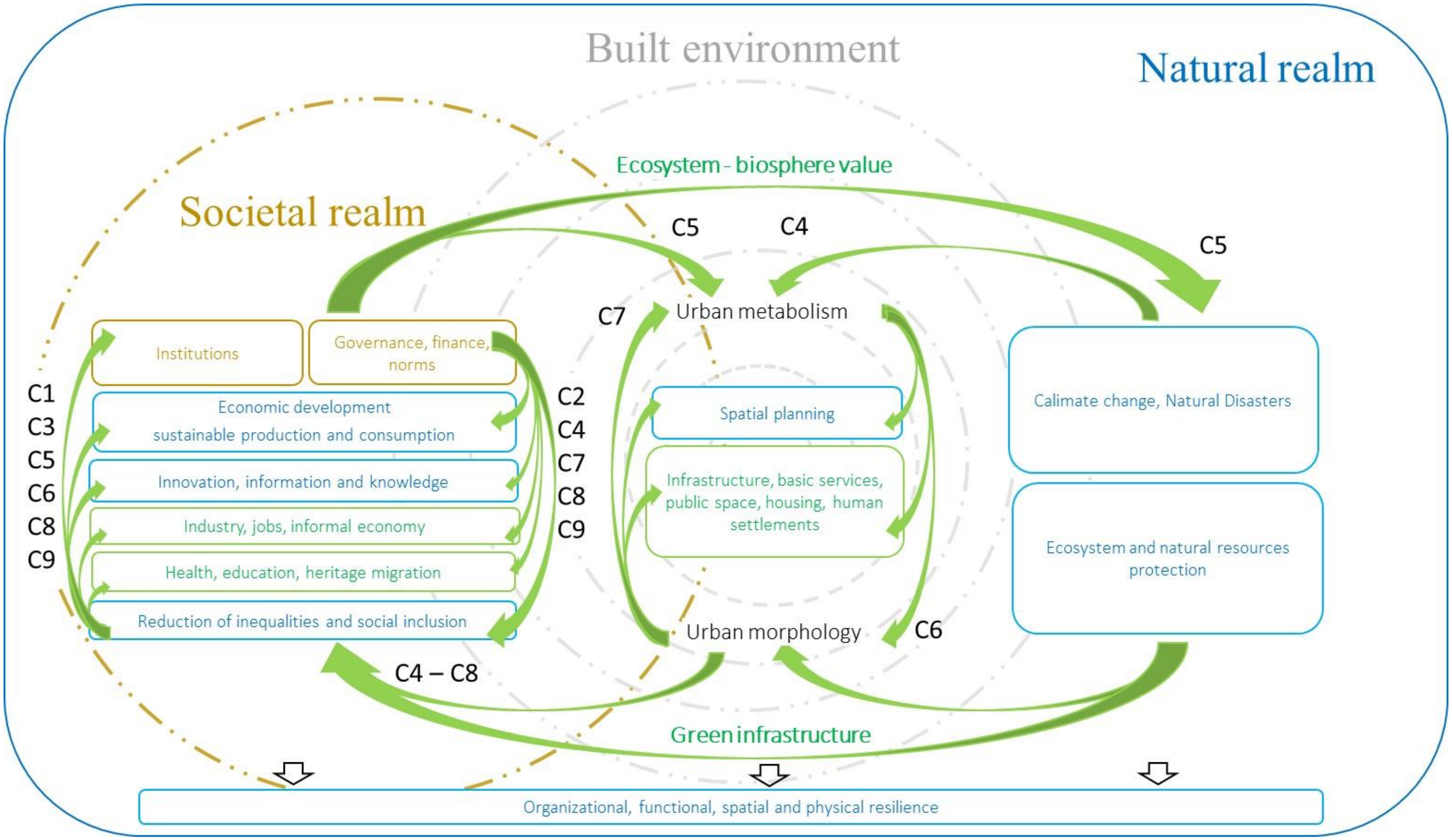


Figure 5 - 11. The integrative model under the UTC framework and the UN Agenda
Source: the author

5.4. INTEGRATING TRANSITIONS AND THE UN AGENDA

Chapter 4 focused on defining directionalities of sustainability transitions by linking and structuring elements of the UN Post 2015 Agenda for sustainable development. Section 5.3 focused on understanding transitions by connecting analytical approaches in an integrative model of the built environment. This section has focused on fostering and managing by linking transition management approaches, within the framework of the Urban Transformative Capacity. In order to provide coherence to this work, these three aspects must now be connected to each other in order to encompass transition directionalities, transition processes and paths and transition governance. Connections between elements of the UN Post 2015 agenda are expressed in figures 4-1 and 4-2, by using categories proposed by Schot et al (2018), referred to as: framework conditions, transversal directions and implementation areas. The transition management model arises from placing these categories within the model showed in figure 5-11:

- All aspects related to cultures, structures and practices within the societal systems are related to the framework conditions of the UN Agenda 2015.
- Transformational aspirations of socio-technical and socio-economic systems are related to transversal directions of the UN Agenda.
- Planetary system, natural landscapes and ecosystem services of the systemic model are related to transversal directions on ecosystems and the biosphere in the UN Agenda
- The metabolism-morphology loop of the built environment in the systemic model is related to transversal directions and areas of implementation related to spatial planning, infrastructure, basic services, housing and human settlements of the UN 2015 Agenda.
- Finally, the transition management model is transversally related to the multidimensional concept of urban resilience in the UN Agenda.

5.5. DESIGNING TRANSFORMATIVE URBAN POLICIES

The purpose of a transformative urban policy is to promote conditions for sustainability transition of the socio-technical-institutional-economic-ecological systems of the built environment. Based on the results presented and discussed throughout this work, a series of recommendations designing transformative urban policies are presented next. These recommendations also synthesize thematic guidelines from the Policy Units of the New Urban Agenda (UN, 2017b)[8], future lines of action within

[8] Throughout this work the New Urban Agenda has been approached mainly from the diagnostic documents corresponding to the issue papers (see session 1.4.3). However, the 22 key aspects of urban development collected there, were later condensed into ten documents that provide general guidelines for the effective incorporation of these 22 thematic units in the formulation of urban policies. These ten policy units are considered here as part of the recommendations.

the framework of the Transformative Urban Capacity (Wolfram et al, 2019), as well as the relationship between housing, inclusive cities and the Sustainable Development Goals (Gordyn et al, 2018; Álvarez-Rivadulla et al, 2019).

5.5.1. Defining a broad scope based on knowledge concerning local backgrounds, conditions and trends

Goals, targets and issues regarding sustainability identified by the UN Agenda are the result global scientific consensus and political agreements. However, strategies and paths for fulfilling the Agenda are context specific and should not be based on general premises, but be supported by a strong base of local backgrounds, conditions and trends.

On the other hand, the extent of challenges posed by urban sustainability does not allow silo approaches. Transformative urban policies must comprehensively and simultaneously address multiple goals, targets and issues, understanding and taking advantage of existing interactions between them. Section 3.2 of this thesis proposes a method to embrace the broad thematic scope of urban sustainability based on the 22 key aspects defined by the New Urban Agenda known as NUA issues (UN, 2017a). This method may be used as a basis to ensure comprehensiveness on designing and updating urban policies. Likewise, chapter 4 identifies interactions between elements of the existing multilateral agreements on sustainable development. Tabl4-1 and figures 4-1 and 4-2, are useful tools for designing strategies based on synergies between goals, targets and issues, thereby enabling actions that can be more effective than taking all elements separately.

This recommendation is related to the findings presented in Chapters 2, 3, and 4; is fully described by the STAM model developed along section 5.2; allows specifying C4 and C5 components of the UTC framework and it is coherent with every transition management methodologies described in section 5.2.

5.5.2. Ensuring inclusive governance schemes based on transformative leadership

Inclusive governance may be defined as the active, organized and long-term sustained participation of citizens and civil society organizations, private companies and their trade unions, as well as national and local academia in the negotiation of strategies, programs, projects and actions with government actors (UN, 2017b; Wolfram 2016; Wolfram et al, 2019; Álvarez-Rivadulla et al, 2019). Transformative leadership may be defined as the active and permanent strengthening of the participation of actors in transformation processes towards sustainability for collective problem solving, based on shared decision-making and open and transparent processes (Wolfram 2016).

Ensuring inclusive governance schemes, based on transformative leadership, is at the centre of every agenda, framework and perspective regarding both urban sustainability and transition management. This includes: NUA policy units 1, 2, 4, 6 and 7 (UN, 2017b), SDG 11 (Álvarez-Rivadulla et al, 2019), SDG 16 and SDG 17 (UN, 2015); UTC components C1, C2 and C3 (Wolfram, 2016), as well as methodologies for managing transitions described in chapter 5.3.

5.5.3. Adopting a Multi-Level Perspective in the Social Realm of Transitions

Chapter 5.1.6 provides a list of recommendations for incorporating a Multi-Level perspective in sustainable building policies. These principles can be extended to other socio-technical-institutional-economic subsystems of the built environment, such as urban planning, district development, public space and infrastructure, as well as informal urban development.

This recommendation is related to results presented in chapters 5.1.6, 5.2.1, 5.2.2 and 5.2.3, it corresponds to the social realm in the STAM model illustrated by figure 5-9; it allows specifying UTC components C4 and C5 and is part of the TM and SNM methodologies described in section 5.3.

The adoption of a Muli-Level perspective of transitions, within the framework of a transformative urban policies, include the elements that are listed below.

5.5.3.1. Understanding socio-technical-institutional-economic regimes

In order to identify those aspects that can act as enablers or as barriers to incorporate sustainability criteria urban policies should include the analysis of regulatory, normative and cognitive elements defining socio-technical-institutional-economic regimes. Here, two particular aspects must be addressed as a priority:

Ensuring specificity and coherence of the regulatory framework

According to chapter 5.1, the capacity of existing regulations to favour the inclusion of low carbon measures in the building sector is weakened by the lack of technical specificity and coherence, which generate confusing and contradictory signals to incumbent actors, thus preventing effective implementation. Extending this finding to other aspects of sustainability and other scales of the built environment, regulatory instruments must provide specific and descriptive technical guidelines while preventing contradictions and promoting synergistic actions with pre-existing regulatory instruments.

Reviewing and adjusting university curricula

One of the main regulatory barriers identified in chapter 5.1 for the implementation of low carbon measures in the building sector is the lack of knowledge from architecture and engineering professionals concerning sustainability. Extending this finding to other aspects of sustainability and to other scales of the built environment, it is important to review and adjust university curricula of all professions involved in urban development, not just including architecture and engineering, but also natural, environmental and social sciences, finance and business management.

5.5.3.2. Incorporating landscape forces for transformation

Chapter 5.1.6 describes some potential landscape forces that may help destabilizing the socio-technical regime of the building sector, including multilateral initiatives, such as the Global Alliance on Buildings and Construction and the 10 Year framework for Sustainable Production and Consumption, as well as private initiatives such as the Productivity Imperative of the construction sector and Low Carbon Roadmaps of the cement, steel and aluminium sectors. In order to strengthen its impact on transformation processes, transformative policies must identify and align external initiatives and trends that can act as landscape forces, helping destabilize socio-technical-institutional-economic regimes related to the built environment.

5.5.3.3. Coordinating efforts for collective visions, networking, experimentation and learning

As illustrated in chapter 5.1.4, local governments, private sector companies, their Trade Unions and other organizations are developing alliances, programs and innovation projects related to sustainable construction, acting as innovation niches or spaces promoting change. A transformative urban policy should identify, characterize, promote and strengthen these initiatives, working in coordination with incumbent actors in order to benefit from their technical and organizational capacity to promote gradual policy implementation based on:

- Integration of expectations and visions shared by many actors
- Creation of networks that allow niche actors to interact, form associations and use collective resources
- Multi-dimensional learning based on knowledge sharing via local experiments

This coordination of efforts for collective visions, networking, experimentation and learning are directly related to inclusive governance schemes mobilized by transformative leadership; it involves UTC components C1, C2, C3, C5 and C6 and is at the heart of transition management methodologies described in chapter 5.3.

5.5.3.4. Integrating the personal level of societal systems

Chapter 5.2.3 introduces an additional level to the classic version of the Multi-Level Perspective, consisting of a personal level, where transformation of individual values can contribute to shifting practices, structures and cultures of societal systems, thereby fostering sustainability transitions. Concerning the built environment, this transformation requires the identification, understanding, guidance and empowerment of components defining the sense of place and its impact on individuals and communities through social fabrics, as described in section 5.2.5.1.

5.5.3.5. Transforming unsustainable components of economic paradigms and collective narratives

In addition to the level corresponding to individual values, chapter 5.2.3 introduces an additional level to the Multi-Level Perspective, corresponding to the paradigm of a linear economic system where the value of urban land is determined by capital revenue, which is aligned with a collective narrative of an exclusive ever expanding city. The transformative urban policy should aim to transform these unsustainable elements towards cities where: 1) urban land value is balanced between capital revenue, social equity, ecosystem services and resilience, 2) the built environment developed and operated on the basis of a circular-economy, and 3) the collective vision aims towards a compact, efficient and inclusive city. This transformational aspiration is consistent with Policy Units 1, 2, 3, 4 and 6 of the NUA (UN, 2017).

5.5.4. Adopting a vision of the built environment as a socio-ecological system

The STAM model for sustainability transitions developed along chapter 5.2 is based on a conceptual model of the built environment as a socio-ecological system emerging from the confluence of the social and natural realms. Section 5.2.4 describes the basis of this concept based on Moffat-Kohler (2008), section 5.2.5.1 expands and specifies the elements of an adjusted model, where the natural environment define physical aptitudes and restrictions for urban development, shaping urban morphology, determining typologies, magnitudes and qualities concerning both ecosystem services and natural risks, thereby shaping both social fabrics (Carpenter, 2013) and the sense of place (Azizul et al, 2016; Frantzeskaki et al, 2018).

The adoption of this vision of the built environment as a socio-ecological system must be integrated into the territorial planning and spatial design of cities as part of a transformative urban policy. Which is consistent with Policy Units 6, 8, 9 and 10 of the NUA and with components C4, C5 and C6 of the UTC framework.

5.5.5. Translating policy recommendations in the spatial dimension through planning and design at all scales of the built environment

Since all the key aspects of urban sustainability are related to planning and spatial design (see table 4-1 and figure 4-1) and considering that the normative frameworks in this matter are based on the perspective of developed western economies and ignore the social, economic and geographical contexts of the global south (Watson, 2009; UN 2017a, Bolay, 2020), a transformative urban policy must translate all previous recommendations into decisions of a spatial nature at all scales of the built environment, from buildings, parcels, districts, municipal cities, metropolitan cities, extending beyond the physical urban area up to the metabolic limits defined by the bioregion (see section 5.2.5).

This recommendation is consistent with all NUA Policy Units (UN, 2017b) and with components C9 and C10 of the UTC framework.

Table 5-10 summarizes the list of recommendations for designing urban transformative policies, specifying the government level to be applied.

Table 5 - 10. Summary of urban transformative policies

<table>
<tr><th colspan="3" rowspan="2">Policy recommendation</th><th colspan="2">Government level</th></tr>
<tr><th>National</th><th>Local</th></tr>
<tr><td colspan="3">Defining a broad scope based on knowledge concerning local backgrounds, conditions and trends</td><td>X</td><td>X</td></tr>
<tr><td colspan="3">Ensuring inclusive governance schemes based on transformative leadership</td><td>X</td><td>X</td></tr>
<tr><td rowspan="7">Adopting a Multi-Level Perspective in the Social Realm of Transitions</td><td rowspan="2">Understanding socio-technical-institutional-economic regimes</td><td>Ensuring specificity and coherence of the regulatory framework</td><td>X</td><td></td></tr>
<tr><td>Reviewing and adjusting university curricula</td><td>X</td><td></td></tr>
<tr><td colspan="2">Incorporating landscape forces for transformation</td><td>X</td><td>X</td></tr>
<tr><td colspan="2">Coordinating efforts for collective visions, networking, experimentation and learning</td><td></td><td>X</td></tr>
<tr><td colspan="2">Integrating the personal level of societal systems</td><td></td><td>X</td></tr>
<tr><td colspan="2">Transforming unsustainable components of economic paradigms and collective narratives</td><td>X</td><td>X</td></tr>
<tr><td colspan="3">Adopting a vision of the built environment as a socio-ecological system</td><td>X</td><td></td></tr>
<tr><td colspan="3">Translating all recommendations in the spatial dimension through planning and design at all scales of the built environment</td><td>X</td><td>X</td></tr>
</table>

Source: The author

6. DISCUSSION AND CONCLUSIONS

6.1. CONCERING LOW CARBON TRANSITIONS

This work shows the existence of norms and policies at national and local levels that, implicitly or explicitly, may help promoting low-carbon buildings under feasible economic conditions, by making use of technical innovations that are fully developed and available on the market. However, the multi-level perspective of transitions shows that the existence of such norms is insufficient to produce social transformations as long as regulative, normative and cognitive rules of the socio-technical regimes are destabilized (Geels, 2002; Geels & Schot, 2010).

At the regulatory level, many standards and policies that could contribute to reduce GHG emissions in the building sector lack both technical specificity and developed instruments to allow full enforcement. In some cases, these standards also contravene pre-existing technical standards, making their implementation even more difficult. At the normative level, existing rules defining design, construction, use, maintenance, financing, sale, rental and taxation, tend to act as barriers for low carbon transitions. On the other hand, the absence of sustainability criteria in architecture and engineering curricula perpetuates conventional professional practices, thus obstructing to the entrance to sustainability innovations. At cognitive level, perceptions and beliefs from actors along the value chain also act as barriers to change persistent social practices.

According to the multi-level perspective, misalignment of rules does not occur from within socio-technical regimes, but results from external forces at higher levels in the socio-technical system (Geels, 2002; Geels & Schot, 2010). In this case, the capacity of forces produced by multilateral agreements on sustainable and low-carbon development was analysed, along with forces produced by national policies produced in response to such agreements. Findings show that these forces are actually insufficient to misalign the socio-technical regime and foster a low carbon transition. By introducing a Multi-Level Perspective in the implementation of national policies on sustainable building, it is possible to identify and take advantage of external forces that can help destabilizing socio-technical regime, while using existing spaces or niches that have already been promoting sustainable buildings at the national and local level in order to introduce low carbon measures in the building sector.

Although the building sector is highly dependent on national and local frameworks for urban planning, land availability and the real estate market, it is also strongly influenced by global forces that may eventually nurture socio-technical transitions. This is the case of the global cement, steel and other industries related to the construction value chain, which have produced roadmaps for the global reduction of GHG emissions. Even other initiatives, which are not explicitly geared towards this goal, could be helpful in driving transformation. This is the case of the global roadmap to increase productivity of the building sector (Barbosa et al, 2017), which actually shares common elements with the low carbon agenda for buildings (IEA & UNEP, 2018). Concerning spaces or niches promoting change, existing certification schemes, public-private alliances and international technological innovation programs may help implementing public policies by making use of their capacity to operate on the basis of networking, experimentation and collective learning.

Public policies must be approached essentially as tools to produce social transformations. While conventional economic and coercive instruments may continue to be useful, they are insufficient to fulfil this function. Although the multi-level perspective is an analytical conceptual framework, rather than a prescriptive tool, its rationale can be useful to strengthen the transformative capacity in the design and implementation of public policies.

6.2. SUSTAINABLE BUILT ENVIRONMENT, LAND PLANNING AND TRANSFORMATIVE URBAN POLICIES

Concerning current science, policy and practice of the sustainable built environment, results show that there is a growing interest concerning the sustainable development of the built environment at research, policy and practice ambits. However, this trend is still focused on the building scale, where the largest number of papers; policy instruments and certification schemes are found, whereas district and infrastructure scales account for a smaller number of papers, instruments and schemes, which are relatively more recent in comparison. Concerning the thematic scope of scientific research related to the sustainability of the built environment, the mainstream covers a relatively narrow range of topics, focusing on indoor comfort and energy efficiency at the building scale. All other topics, issues and thematic areas raised by the Multilateral Agenda on Sustainable Development are being poorly covered by mainstream scientific production, existing certification schemes and emerging policies, with some remarkable exceptions, of local policies and schemes from Latin American countries that are actually showing a more comprehensive view on the sustainable built environment as compared to existing certification schemes that are considered as international referents. However, important challenges to bring concepts from documents to the real world, still persist in the Region, concerning Institutional capacity to harmonize policies related to the sustainable built environment with land planning, social policies and municipal finance.

Concerning the realization of the Multilateral Agenda on Sustainable Development at urban level, results show that, spatial planning and design is also critical for achieving inclusive cities; protecting cultural heritage; boosting local economy and creating jobs; while optimizing the use of natural resources and protecting ecosystems; also decreasing carbon emissions, adapting to climate change and reducing natural risks. This way, the a sustainable built environment may contribute to meet 80 out of 169 SDG targets, which roughly represents half of Agenda 2030.

If all aspects of urban sustainability are related to this spatial dimension, the key urban policies for sustainable urban development are then those related to land use planning and spatial planning (UN, 2017). This idea is further discussed by means of different approaches concerning Transition theory, where analytical perspectives of transition in socio-technical, socio-institutional and socio-economic systems are analysed within the framework of the built environment. However, these visions are found to be still fragmentary. Hence, I propose that the basis for an integrative model of urban transition, which integrally incorporates a spatial dimension, would consist of the conceptualization of the built environment as a socio-ecological system, where transformation of structures, cultures and practices, enable shifting the linear-capitalist economic paradigm for a new circular-inclusive economic model, while replacing collective narratives of an ever growing-segregated city by a new view on a sustainable, just, resilient city, leading to a change on the social value of ecosystems, with positive impact on preserving their structure and function, thereby increasing ecosystem capacity to provide services to communities and organizations, thus encouraging participative governance on urban planning and development, in order to ensure that urban morphology and metabolism properly responds to environmental opportunities and restrictions.

By connecting perspectives on conceptualizing and managing sustainability transitions with elements of the UN Agenda, results show all these concepts and elements may be coherently integrated as base for transformative urban policies within the framework of the Transformative Urban Capacity (Wolfram et al, 2019).

These findings are useful for practitioners, scientists and policy makers. Concerning practice, these outcomes may serve to update and improve existing schemes for evaluating and certifying sustainability in buildings, districts and infrastructures. In terms of scientific research, these insights would help identifying currently unaddressed gaps regarding the role of the built environment on sustainable urban development. Concerning policy, this synergistic approach may be useful for governments faced with localizing the global UN Agenda, by allowing to overcome silo approaches resulting from addressing each instrument in isolation. Understanding interactions across instruments, sectors, areas and goals would lead to more coherent policies, programs, projects and actions that will use local, national and international resources more efficiently and effectively to deliver comprehensive outcomes in line with the broad systemic perspective of sustainable development (LeBlanc, 2015).

6.3. CONTRIBUTIONS TO THE OVERALL EXISTING CHALLENGES CONCERNING SUSTAINABILITY TRANSITIONS

The study of sustainability transitions is still a field in evolution, with multiple challenges ahead for future action. From the epistemic view, it nourishes from interdisciplinary and plurality, but it also requires building mutual coherence based on shared understanding of systemic change between different perspectives on both understanding and managing transitions (Loorbach et al 2017; EEA, 2019). This common understanding has been so far based on the review and comparison of existing approaches. The methodological approach of this thesis makes an important contribution by proposing a connection between various analytical and prescriptive approaches to produce an integrative model of the built environment.

Concerning transitions dynamics, it is important to advance in the understanding of the role of politics and power relations between governments; civil society; social movements and the private sector (Köhler et al 2019). In this sense, the various approaches seem to imply that governments tend to perpetuate established regimes. Hence, lasting social transformations only come from polycentric and participatory governance. However it is important to review within these perspectives the potential role of governments and public policies as potential transitions drivers (EEA, 2017). This thesis introduces this discussion by outlining the importance of participatory governance, collective visions, networking, experimentation and learning as bottom-up transition processes, while acknowledging the relation between public policies and the landscape forces at the multi-level perspective; thereby highlighting the importance of involving all agency levels as fundamental part of Urban Transformative Capacity (Wolfram, 2016).

In terms of scope, it is important to advance in the implementation of transition approaches in order to verify their actual use on achieving long-term sustainability goals, with emphasis on the global south (EEA, 2017; Loorbach et al 2017), which in turn requires progress in relation to the aspects of transitions in terms of social justice and poverty reduction (Köhler et al 2019). Although this thesis extensively discusses the topic of low-carbon transitions, which is at the mainstream of sustainability transitions literature; it widens the spectrum towards the multidimensional urgencies of urban transitions in the global south, including poverty social equity, ecosystems and natural resources, as well as urban resilience and climate change adaptation.

Concerning ambits of application, it is important to advance in understanding the geography of transitions in relation to spaces, scales and places (Köhler et al 2019). In this sense, despite of its importance as change engines, due to the concentration of population and resources (EEA, 2017), cities have been relatively absent from the mainstream of the transitions literature (Torrens, 2018). Therefore, urban transitions are producing their own approaches, with the UTC standing out as a comprehensive framework for both guiding and evaluating transformational urban change. The UTC identifies four key future actions: (1) promoting inclusion and empowerment as prerequisites for transformation; (2) close the intermediation gap and strengthen the local role of academia, (3) challenge and reinvent urban planning as a key arena for change, and (4) enhance reflexivity based on new evaluation techniques (Wolfram et al., 2019). The main contribution of this thesis in this regard consists of connecting socio-technical, socio-institutional, socio-economic and socio-ecological systems in one integrative model to describe urban transitions.

Conventional policy approaches relay on the assumption that governments are able to make regulations and provide economic incentives allowing market forces to foster societal transformations. However such, approach is insufficient to address normative and cognitive aspects hindering change at the level of practices, structures and cultures. Transition approaches based on complex systems may offer comprehensive concepts to allow understanding both barriers that can limit transformational change and drivers that can promote it.

During the last two decades approaches based on socio-technical systems have made valuable contributions to understanding transitions. Such approaches were used in this thesis to projecting low carbon transitions of the building sector. Being also useful to explain how urban planning, public space, infrastructure and the building sector may connect each other to undergo deep transitions, with cross-cutting impact on the built environment.

However, not every social challenge concerns technological transformations. Hence, further complementary approaches are required. This thesis uses a Multi-Level Perspective on socio-institutional and socio-economic systems to address non technological urban issues such as the role of urban planning in promoting social exclusion, thereby nurturing informal development. By introducing two further levels of societal change, corresponding to individual values and collective visions, the socio-economic version of this perspective also allowed addressing the sense of place and the social fabrics of space as potential elements to foster transitions of the built environment at community level.

Despite the cross-cutting understanding provided by the MLP, it is not a suitable tool to describe the role of biosphere and ecosystems in sustainability transitions. A valuable contribution of this thesis consists on integrating the MLP into a more comprehensive a socio-ecological approach, allowing to illustrate the subordination of societal systems within a large planetary system, while describing the built environment as a system emerging at the intersection between the natural and the cultural realm, that spreads across scales that go beyond physical and administrative boundaries, to spatial conurbations and functional connections defining metropolitan areas, up to the metabolic boundaries of the bioregion. Such integrative approach allows closing a transition loop, connecting relations of attachment, dependence and identity, defining the sense of place and shaping social fabrics, with urban morphology and metabolism, natural landscapes and ecosystem services.

Concerning transition management, findings show that main transition management approaches agree on outlining the role of participatory governance, collective visions, networking, experimentation and learning as major tools to promote transitions. This shared was used to bring together management approaches, rising from socio-technical and socio-ecological schools, into the notion of Urban Transformative Capacity - UTC, which provides a framework to both guide and qualify urban processes in relation to its ability to produce transformational change at different scales.

This thesis assembles relevant contributions made by transition scholars over the last two decades, connecting them to each other to provide an integrative approach to urban transformations, thereby providing three levels of integration:

1. First level involves approaches for understanding transitions, connected to each other by a Multi-level Perspective within the framework of a socio-ecological system, providing a first integrative model for understanding transitions
2. The second level involves approaches for managing transitions, connected to each other by common views on enabling transitions within the framework of the Urban Transformative Capacity – UTC, leading to a second integrative model for managing transitions, which can be further displayed inside the first model in order to link understanding and management
3. The third level involves the schematic model of the UN Agenda based on the interactions connecting agreements, goals and targets, based on framework conditions, transversal directions and implementation areas. By placing this scheme inside the second integration level, an integrative model for understanding and managing transitions towards the UN Agenda is obtained.

6.4. LIMITATIONS OF THIS RESEARCH

Considering the wide scope of this research, system limits were initially diffused, thus methodological approach was not completely set at the beginning and it was re-structured as conceptual bases were expanding. In fact, transitions theory, which ends up by being the core of this work, made a late appearance as a result of supervisors´ advice. Hence, the work went from the empirical approach, based on quantitative variables in first part, towards the theoretical approach, based on narrative constructions characterizing the last part. The "systematics combining" (Dubois and Gadde, 2002), provided here a flexible methodological framework allowing empiric data and theoretical base to dynamically interact with each other, thus redefining the scope of the research. On one hand, that allows proposing a distinctive low carbon path for buildings; it also identifies thematic gaps regarding science, policy and practice of the sustainable built environment; it shows synergies between areas, goals and issues of the global agenda and it brings diverse perspectives to societal change and sustainability transitions integrated under a single conceptual model. On the other hand, it also leave some methodological gaps.

There is a strong imbalance, both in qualitative and quantitative terms, between empirical information and theoretical construction. Qualitative imbalance consists on low-carbon development being the only aspect of urban sustainability that is approached empirically, while multidimensionality and complexity of urban sustainability is entirely approached as a theoretical construction. Quantitative imbalance consists on the empirical component occupying a minimum percentage of the work, while the theoretical construction ends up occupying most of it. Therefore, aspects that are relevant throughout the work, such as the spatial dimension of the built environment, the implications of informal development in urban sustainability, the role of both “social fabrics of space” and the “sense of place” on promoting urban transitions, end up being addressed in a fragmentary way.

These limitations of the research, along with a critical review on the state of the art of sustainability transitions, allow proposing future research directions, as described next.

6.5. FUTURE RESEARCH DIRECTIONS

Future research should essentially focus on both strengthening theoretical basis, as well as collecting empirical evidence on the following directions:

6.5.1. Obduracy of the built environment

Elements of the built environment differ from all other physical elements produced by human societies because these remain linked to the place they are produced. Once an element of the built environment comes to existence, it usually endures for years, decades and even centuries. Even if buildings and infrastructures can be demolished and rebuilt, the patterns of urban morphology tend to remain over time. As discussed extensively throughout this work, this morphology has direct implications on the efficiency of urban metabolism, as well as on the formation of identities, relationships and perceptions that make up the sense of place and social fabrics, at the same time urban morphology is determined by local landscapes. This obduracy of the built environment is one of the main challenges for its transition towards sustainability.

6.5.2. Informal urban development

The theoretical body of sustainability transitions has been developed mainly in the global north, with few reflections and case studies from the global south. One consequence of this bias is that the systems of analysis of transitions operate within the parameters of formal economic activities, this is particularly clear in the Multi-Level perspective of socio-technical transitions.

However, a modified version of the Multi-level perspective, applied to socio-institutional systems offers an alternative for the consideration of informal activities based “heterodox ways of satisfying social needs” as an alternative to established societal regimes. Likewise, when questioning the capacity of existing economic paradigms and structures to promote sustainability transitions, an adjusted Multi-level perspective applied to socio-economic systems was used in this work to argue that the valuation of urban land based on monetary yield as the one criterion, it is at the base of the low environmental performance of cities and is at the same time a vehicle for social exclusion that promotes informal urban development.

The integrative model of urban transitions, as the ultimate result of this thesis, proposes that urban sustainability does not consist in the suppression of informality through eviction or relocation. It also proposes that government programs to improve informal settlements are insufficient when occurring within assistance schemes, where government unilaterally decides interventions required, without considering aspects such as social fabrics and the sense of place via community participation. This is a subject whose discussion is still open, both in the field of academia, as well as in international cooperation and development finance. This thesis is far from closing and resolving the discussion, it only brings together diverse arguments that were already in place.

6.5.3. Meta governance

Since societal regimes are the main mechanisms through which social needs are solved and they are by nature resistant to change. There is a high probability that regime actors will assume dominant positions in participatory governance, thus biasing, visions, strategies and experiments in favour of their own agendas. One major challenge for implementing an integrative model for transition consists of what the UTC calls transformative leadership and what other approaches call meta-governance, consisting of the ability of organizations, not just to promote change, but to transform themselves in the process (Rotmans & Loorbach, 2010).

6.5.4. Communication

Another major challenge is the ability of transformation managers to transcend expert language and create messages accessible to people (Papachristou & Rosas-Casals, 2019), particularly in reference to distant and intangible aspects, such as planetary boundaries, ecosystem services and ecological dependence. This is a particularly important challenge for urban transitions in the global south, where the most urgent problems for many people and communities consist of ensuring daily survival. It is precisely here where notions such as the sense of place and social fabrics become very important as a fundamental part of transition processes, because they can promote communication based on perceptions and experiences, close to affections, attachments and identities.

6.5.5. Financing transitions

Adopting an approach to sustainability transitions based on complex systems, which do not follow deterministic dynamics, may face the challenge of obtaining financial resources. Considering that mainstream policy is based on approaches related to IAMs (EEA, 2017) and financing is guided by concrete and precise outcomes, it is difficult attracting cooperation and investment to finance processes with unpredictable results. In this sense, a balance between different types of perspectives can be useful, using IAMs approaches to project scenarios, but maintaining margins of variability and uncertainty calculated from approaches based on complex systems.

Research on the financing of transitions is just in its infancy and the reflections produced are still limited in scope (Köhler et al., 2019; Naidoo, 2020). However, a number of challenges have been identified, which go beyond resource mobilization. The just transition towards circular and low-carbon economies, ensuring that social inequalities are reduced rather than exacerbated, within the peremptory period of a decade, requires a transformation of the structures, objectives, methods and concepts under which the economic and financial systems are currently operating.

6.5.6. Exnovation

Common association between transformation and innovation may be also a major challenge concerning integrative transition. Innovation is understood as the incorporation of new technologies, processes or capabilities. This association leads to leaving aside an equally important aspect of transformation, proposed by the UTC framework, referred to as exnovation, defined as the conscious and voluntary dismantling of all unsustainable technologies, processes and capacities (Wolfram, 2016). This process can be much more difficult to assume as compared to innovation because it implies disappearance of practices, structures and cultures, which in turn can lead to the disappearance of business models, organizations, power relations, jobs, etc. making the expectation of win-win transformations unrealistic. Consequently, it is important to find alternative transition routes based on understanding trade-offs, allowing to anticipate future adaptation needs.

6.5.7. Winners and losers in sustainability transitions

Transformations demanded by sustainable development will inevitably make obsolete certain technologies, practices, companies and capacities that are not compatible with the new paradigms, affecting businesses, jobs and communities that cannot adapt to changes. This challenge is included in the Paris Agreement and the Guidelines of the International Labour Organization under the concept of "just transition" (UNFCCC, 2015; ILO, 2015), being one of the main areas of future action concerning theory and practice of sustainability transitions (Köhler et al, 2019). Table 6-2 describes the affectations of this type, derived from eventual implementation of findings of the present work. One of the main challenges for designing transformative urban policies will be to identify strategies that minimize or compensate for these effects.

Table 6-1. Potential losers from the eventual implementation of urban policies based on findings presented in this work

Sustainability aspect	**Potential losers**
Low carbon buildings	Companies, communities and workers taking part in the value chain of: • Non-industrialized building systems • Portland cement • Concrete of conventional performance • Low efficient energy systems Occupants and managers of existing buildings with no space for residential waste separation and treatment
Revising and updating university curricula	Professionals and workers trained before reviewing and updating professional curricula, who would not have the required skills to incorporate sustainability criteria into their activities
Shifting development and operation of the BE to circular economy	Companies, communities and workers taking part in the value chain of non-circular practices and technologies concerning construction materials, energy and water supply and sanitation
Shifting criteria for urban land value	Land owners and other actors taking part in the real estate business whose expectations concerning economic revenue will not be fulfilled when balancing the land value according to collective benefits arising from social equity, ecosystem services and urban resilience

Source: The author

6.5.8. Multidimensional aspirations vs priority-based approaches

In order to define directionalities for collective visions on sustainability transitions, current multilateral agenda is a useful guide, as being based on a global scale consensus. However, the long list of goals, targets, issues and indicators tends to promote a silo approach that may scatter and weaken transformative efforts. In this sense, interactions identified in this thesis, relating all elements of the multilateral agenda to each other, may be useful. However, interactions do not necessarily indicate synergies, they may also imply trade-offs (Yiwen Zeng et al, 2020). But this is not expressed in the integrative models proposed here. In terms of understanding transitions, it is important to advance in the definition of methods to identify or even anticipate these trade-offs. In terms of managing transitions, it is important to advance in the definition of criteria to balance contradictory aspects arising from collective visions.

Multidimensional aspirations concerning sustainability contrast with the priority-based approach conventionally used by societies to solve problems. This fact is referred to as the "Dialectic Issue Life-cycle Model", where the evolution of important issues in societal systems follows a path going from emergence and denial, followed by an increase in public concern, leading to debate and dissent. Under such dynamics, multiple problems compete with each other for public interest and resources, inevitably leading to priority-based simplification (Penna & Geels, 2012). The approach to the UN Agenda proposed by this thesis helps condensing multiple challenges into a few groups. However, the resulting list is still large enough to hinder equality of interests and resources.

This priority-based approach to societal issues was already an important challenge for sustainable development in 2019, but its relevance increased exponentially in 2020 due to the COVID 19 pandemics, which has not just killed hundred thousands of people and have threatens health systems all over the world, but has also sank entire national economies into recession, with the subsequent loss of jobs, thus exacerbating pre-existing social inequalities. It is clear that the world's attention in the coming years will be focused on the post-pandemic economic recovering. Hence, governments, private sector and societies are most likely to turn looking for answers in the old development models, whose inefficiency, dysfunction and unfairness may be disregarded at the expense of the delusion of certainty.

6.6. GENERAL CONCLUSIONS

This work discusses the relevance of the Built Environment for sustainable urban development. The discussion begins with an analytical approach on low-carbon buildings, to further embrace the different scales of the built environment while highlighting interactions between multiple sustainability dimensions, thus providing insights on potential synergies between thematic areas, goals, targets and issues of the UN Sustainability Agenda. Afterwards, an integrative theoretical model, encompassing societal, technological, institutional, economic and ecological systems, was produced in order to address sustainability transitions in the built environment. The methodological approach of this thesis makes an important contribution by proposing a connection between different perspectives on sustainability transitions as the basis for a theoretical integrative model of the built environment. Such theoretical model was further used to produce a prescriptive approach for designing transformative urban policies.

Transformative urban policies based on sustainability transition perspectives must be based on local knowledge concerning local backgrounds, current conditions and future trends, while setting a broad scope based on addressing the multiple sustainability dimensions, considering potential synergies and trade-offs between goals, targets and issues. On the other hand, such policies must go beyond conventional approaches based on coercive instruments and economic incentives in order to ensure inclusive governance schemes based on transformative leadership concerned with to managing transitions.

Furthermore, urban policies will benefit from adopting a Multi-Level Perspective, which will consist on:

- Understanding socio-technical-institutional-economic regimes;
- Ensuring specificity and coherence of the regulatory framework;
- Reviewing and adjusting professional curricula,
- Incorporating landscape forces for transformation,
- Coordinating efforts for collective visions, networking, experimentation and learning; Integrating expectations and visions shared by many actors;
- Creating and strengthening networks that allow niche actors to interact, form associations and use collective resources;
- Promoting Multi-dimensional learning based on knowledge sharing via local experiments; Integrating individual values that may contribute to shifting practices, structures and cultures of societal systems, and
- Transforming unsustainable components of economic paradigms and collective narratives, aiming towards a compact, efficient and inclusive city, whose land value is determined, on the base of social equity, ecosystem services and resilience, and whose built environment is developed and operated on the basis of a circular-economy

Despite the cross-cutting understanding provided by the MLP, it is not a suitable tool to describe the role of biosphere and ecosystems in sustainability transitions. A more comprehensive socio-ecological approach to the built environment is required in order to understand the role of planetary systems, natural landscapes and ecosystems in defining physical aptitudes and restrictions for urban development, shaping urban morphology, determining typologies, magnitudes and qualities concerning both ecosystem services and natural risks, thus shaping both social fabrics and the sense of place. This approach allows bringing policy recommendations to the spatial dimension through planning and design at all scales of the built environment at every scale, from buildings, parcels, districts, municipal cities, metropolitan cities, extending beyond the physical urban area up to the metabolic limits defined by the bioregion.

Several challenges lay ahead the path of transformative urban policies. A first challenge concerns rising funds for financing programmes and projects, considering that non-deterministic dynamics characterizing sustainability transitions, means non predictable outcomes. Second, it is important for scientists, policy makers and practitioners to transcend expert language and create messages accessible to people, particularly in reference to distant and intangible aspects, such as planetary boundaries, ecosystem services and ecological dependence.

On the other hand, incumbent organizations must develop the capacity, not just to promote change, but to transform themselves in the process, which is referred to as Meta-governance. Another required ability consist on dismantling unsustainable technologies, processes and capacities, also known as exnovation, which must be balanced with the capacity to anticipate and mitigate potential impacts of obsolescent technologies, practices, companies and capacities that are not compatible with sustainability paradigms, in order to ensure just transitions for businesses, workforces and communities.

Furthermore, multidimensional aspirations concerning sustainability contrast with the priority-based approach conventionally used by societies to solve problems. This priority-based approach to societal issues was already an important challenge for sustainable development, but its relevance increased exponentially due to the COVID 19 pandemics. Integrative models such as the ones outlined here may be useful to turn the crisis into an opportunity by promoting transition towards sustainable cities as a way to recover the economy, and creating jobs, while providing urban resilience to disruptive events. Major challenge now is to get them in the shortest term out of the theoretical state and turn them into useful tools for decision-making.

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8. APPENDICES

APPENDIX A. Data base for GHG emissions from building sector in Colombia

Table A.1. GHG emissions for building materials

Material	GHG emissions [tonn CO2-eq/tonn]
Coarse aggregates	0,01
Fine agregates	0,021
Cement	1,096
Bricks	0,243
Ceramics	0,83
Steel	2,705
Aluminium	31,4
Glass	1,859
Timber	58,17
Polyvinyl chloride	7,659
Paint	0,408
Cooper	8,622
Recycled aggregates	0,001
Concrete additives	0,25
Fly ash	0,004
Low carbon cement (LC3)	0,562

Sources: PNUD, UMPE, Ecoingeniería (2012), Pardo et al., (2017), Cancio et al., (2017)

Table. A.2. Material use in buildings classified by construction system (Kg/m^2)

Material	Industrialized system	Structural masonry	Confined masonry
Coarse aggregates	536,5	399,2	625,0
Fine aggregates	440,9	356,5	733,6
Cement	160,9	138,8	306,1
Bricks	43,9	320,8	358,1
Steel	29,5	21,0	9,4
Timber	5,4	3,3	0,1
Other (Aluminium, plastic, paint)	3,4	3,3	2,4

Source: PNUD, UMPE, Ecoingeniería (2012)

Table A.3. New building area in Colombia (millions m2/year)

Year	Housing	Shopping mall	Office	Hotel	Education	Hospital	Industrial
2014	2,45	0,29	0,03	0,05	0,05	0,05	0,17
2015	2,85	0,27	0,14	0,11	0,06	0,07	0,27
2016	2,06	0,33	0,07	0,06	0,04	0,07	0,26
2017	2,43	0,18	0,04	0,04	0,06	0,03	0,37
2018	2,24	0,28	0,10	0,02	0,19	0,04	0,11
Average	**2,41**	**0,27**	**0,08**	**0,05**	**0,08**	**0,05**	**0,24**

Source: DANE, 2019

Table A.4. Energy consumption by existing buildings in Colombia (TJ/year)

Year	Residential buildings		Non residential buildings	
	Natural Gas	Electricity	Natural Gas	Electricity
2.014	44.872	78.235	17.385	6.171
2.015	45.362	80.557	15.167	7.029
2.016	46.266	81.682	16.003	7.581
2.017	49.061	83.449	16.246	7.223
2.018	50.066	88.885	17.579	7.862

Source: UPME (2019)

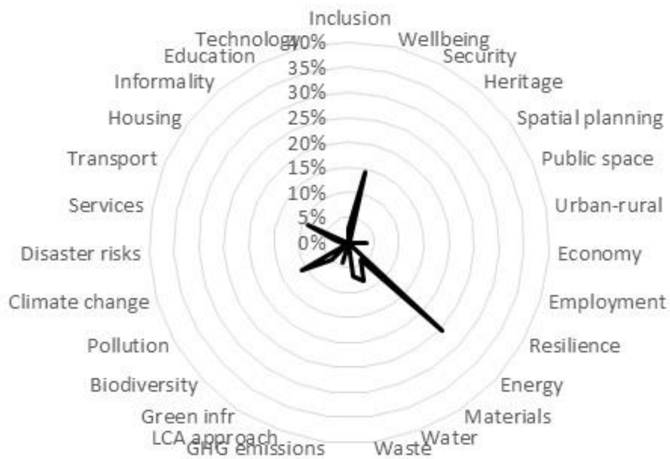
Table A.5. Relevant GHG Emission factors for fuels, electricity and residential waste in Colombia

Emission source	Emission factor	Unit
Natural gas	55,7	tonn CO2-eq/TJ
Residential Waste	0.88	tonn CO2-eq/tonn
Electricity	58,3	tonn CO2-eq/TJ

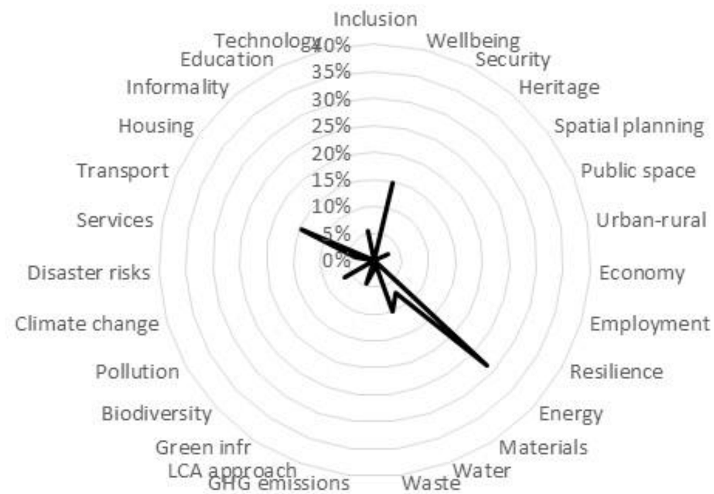
Source: IDEAM, PNUD, MADS, DNP, CANCILLERÍA (2016)

APPENDIX B. Thematic profile for policies, certifications and standards analysed in section 3

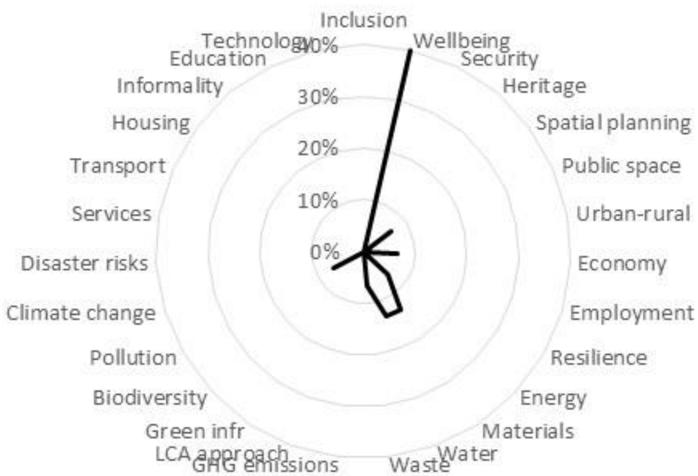
B.1. Building scale



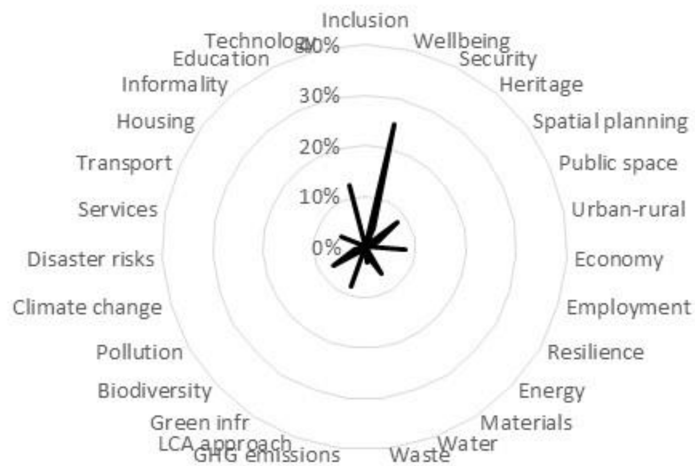
BREEAM system (BRE, 2016)



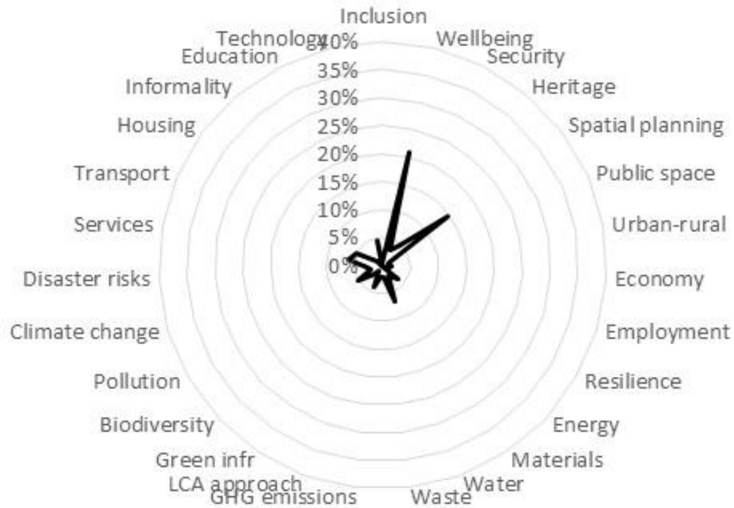
LEED system (USGBC, 2019a)



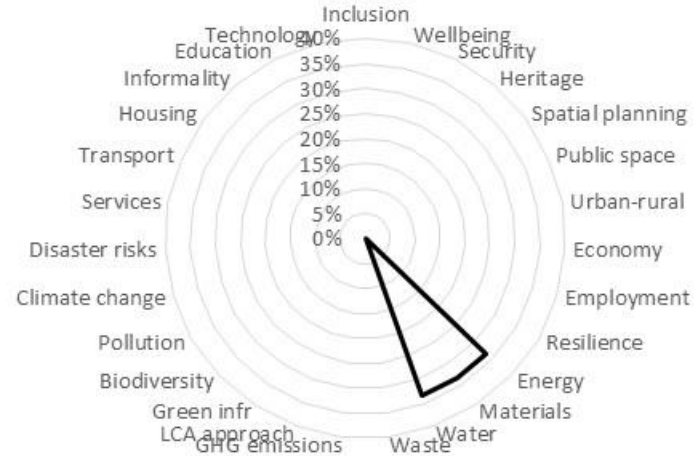
HQE system (HQE, 2018)



DGNB system (DGNB, 2018)

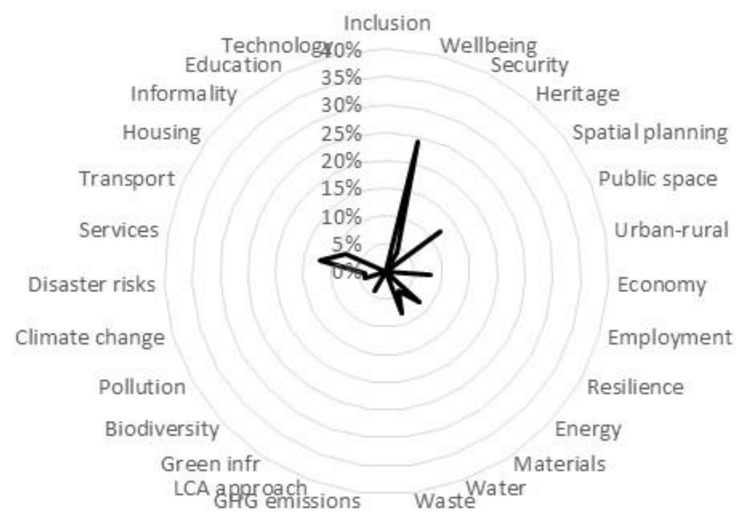


SBtool system (IISBE, 2015)

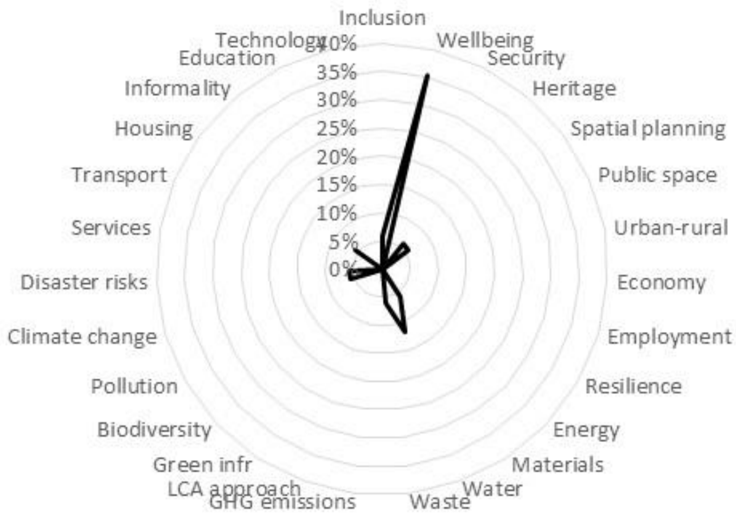


EDGE system (IFC, 2016)

WELL system (International Well Building Institute, 2019)



ISO Standard (ISO, 2008)

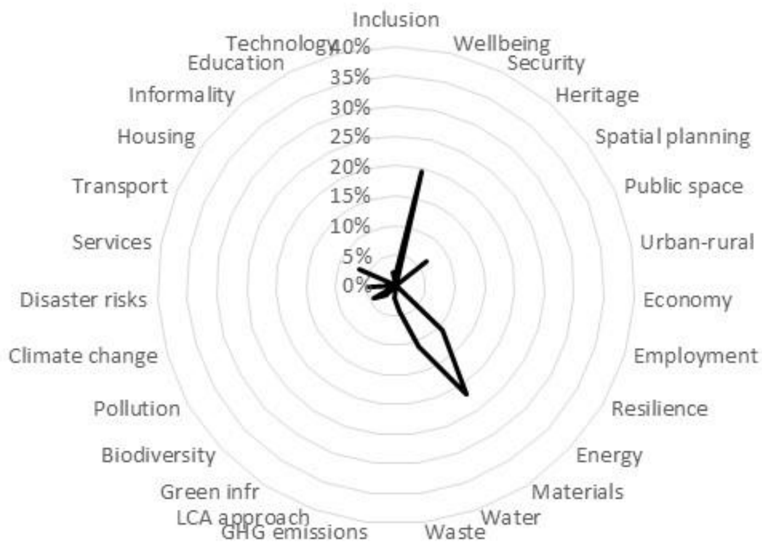


SHERPA system (UN-Habitat et.al., 2017)

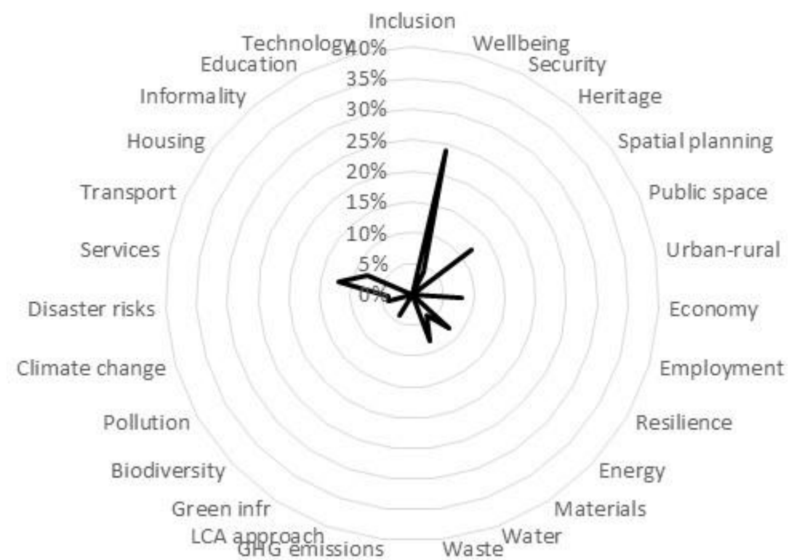
Chile National strategy (Chile, 2013)

México norm system (Estados Unidos Mexicanos, 2013)

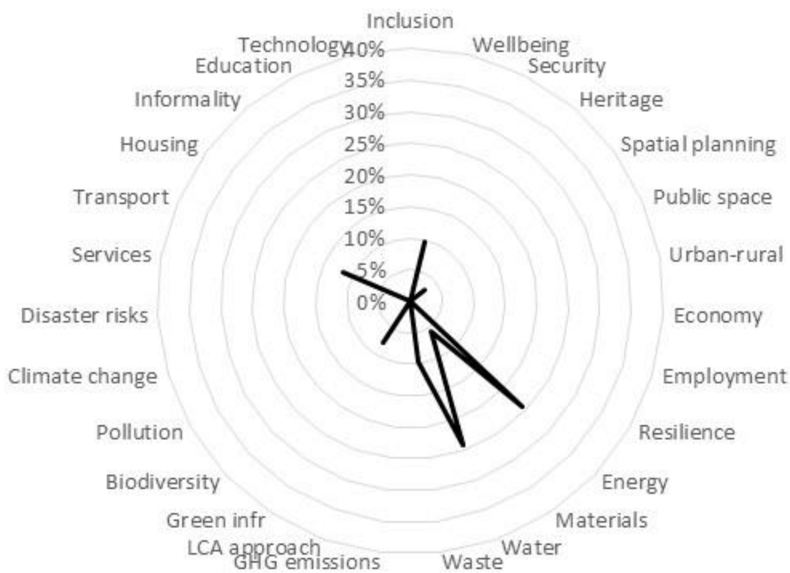
National Policy Colombia (Colombia, 2018)



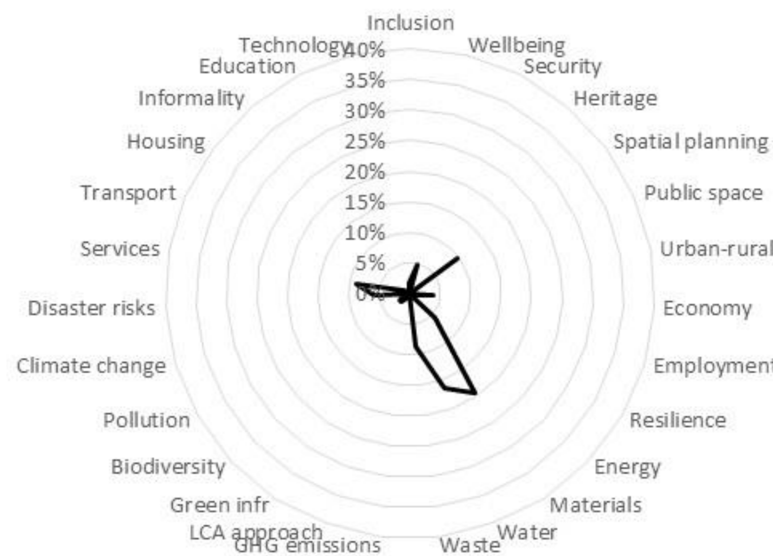
National Standard Chile (Chile, 2014)



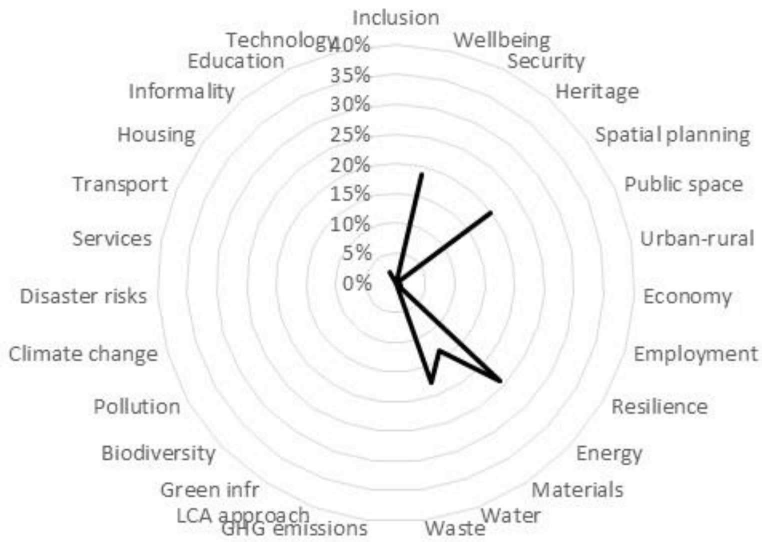
National Standard Argentina (Instituto Argentino de Normalización y Certificación, 2016))



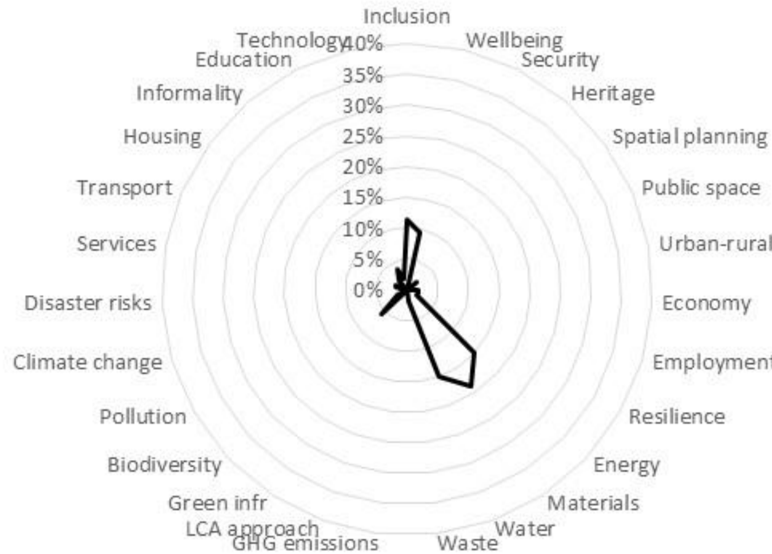
Local standard México city (Gobierno del Distrito Federal, 2012)



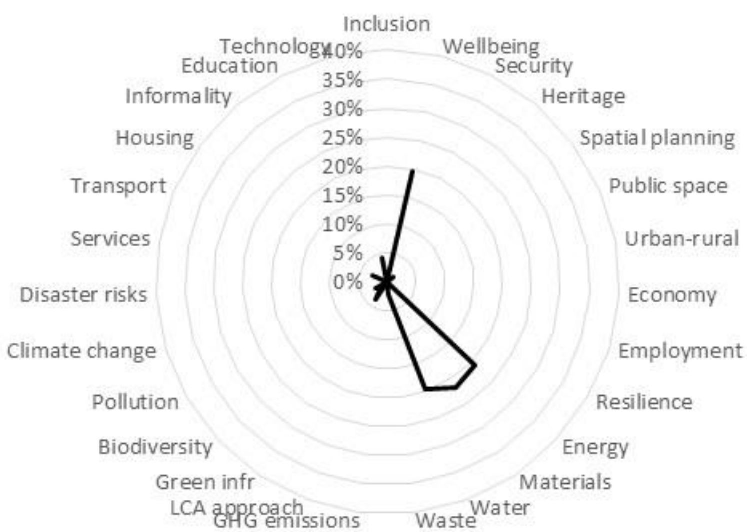
SAC system (public) – Colombia (Colombia, 2016)



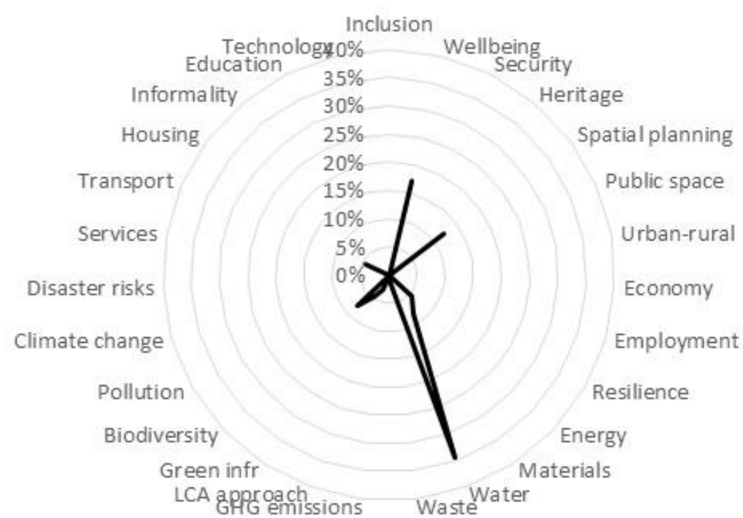
CASA system (private). Colombia (CCCS, 2016)



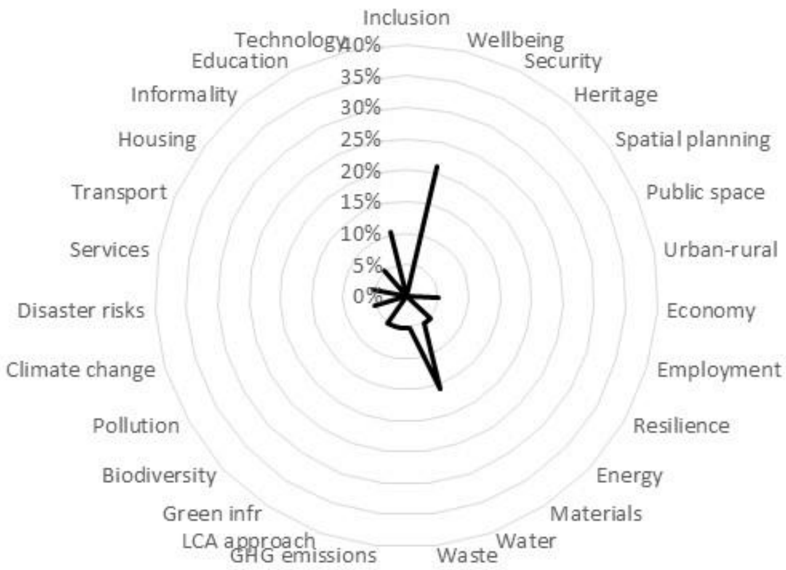
SELO Azul System. Gobierno Federal Brasil (Caixa Econômica Federal, 2010)



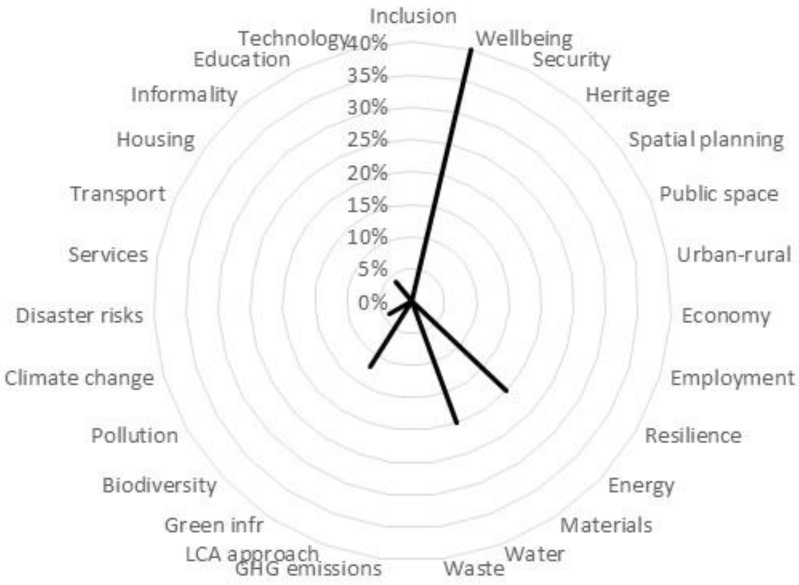
Local system Qualiverde, Rio. Brasil (Prefeitura Rio de janeiro, 2012)



Sustainable Building system, Bogotá. Colombia (Alcaldía de Bogotá, 2014)



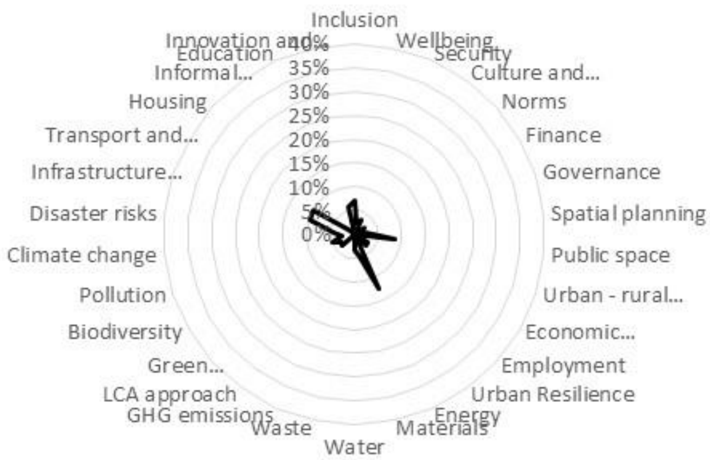
Local guidelines Aburrá Valley (AMVA & UPB, 2015)



Código de construcción Ciudad de Buenos Aires (Ciudad de Buenos Aires, 2018)

Source: The authors, based on technical support documents provided found at the respective instrument website

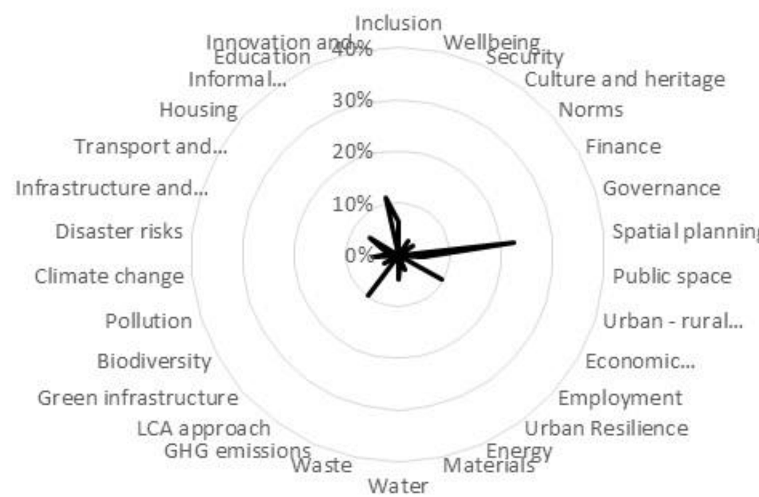
B2. District scale



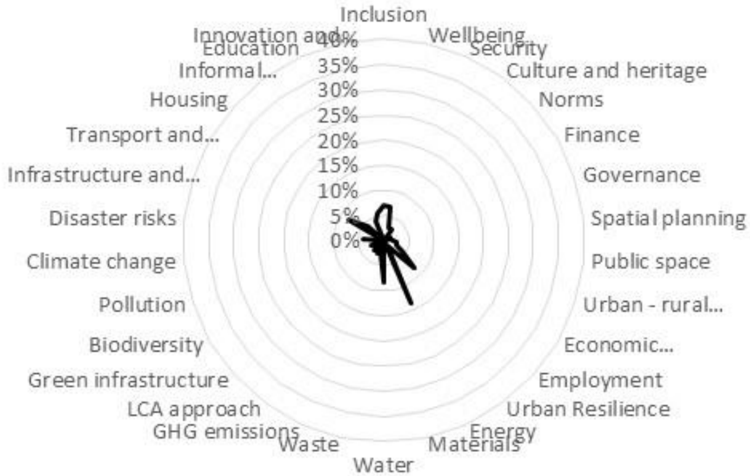
BREEAM Communities (BRE, 2012)

LEED Neigborhood Development (USGBC, 2019b)

HQE Aménagement (HQE, 2011)

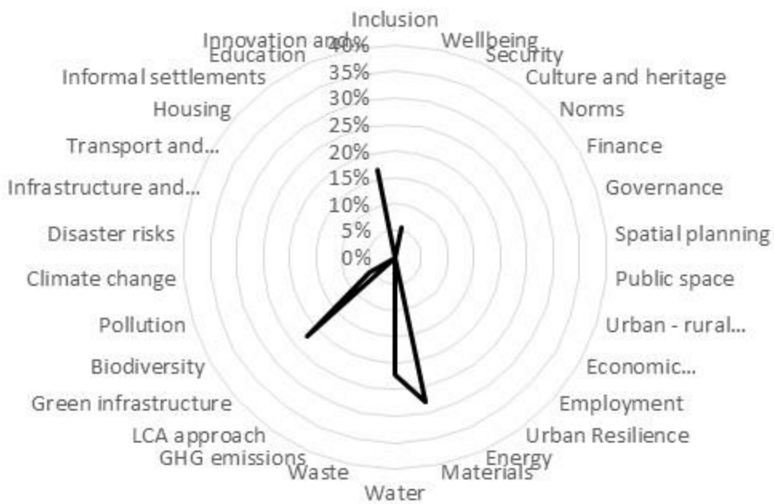


DGNB Urban District (DGNB, 2016)

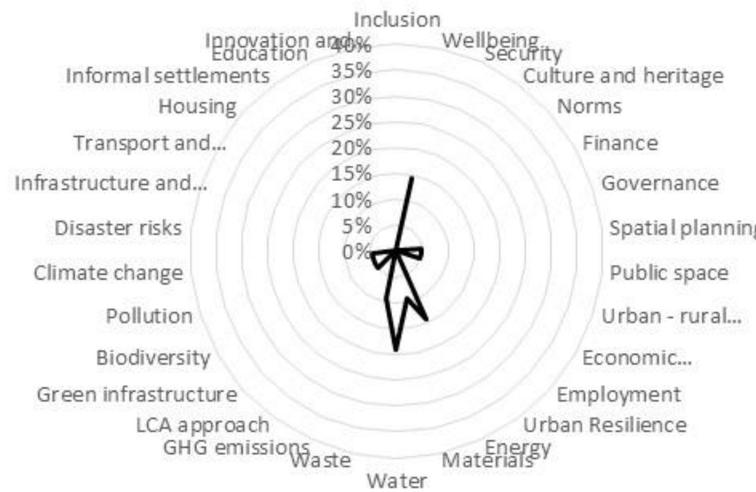


Ecodistricts (Ecodistricts, 2018)

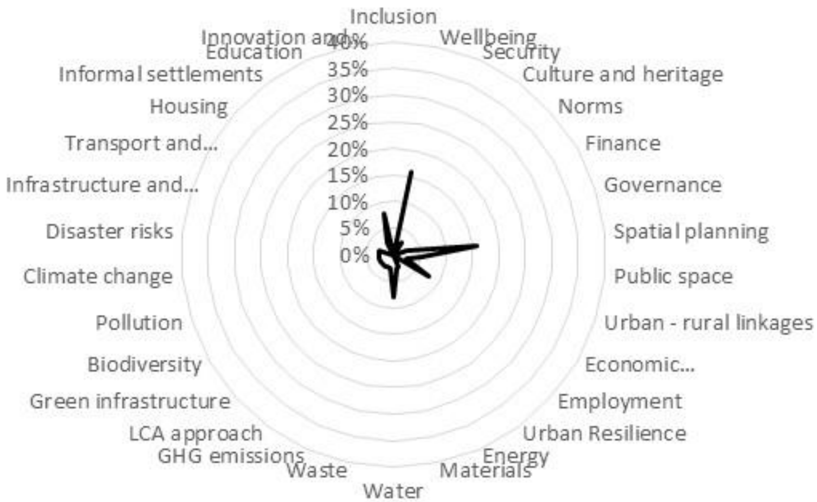
Ecosistemic Urbanism, Barcelona (AL21 & Ecologia BCN, 2012)



Sustainable urbanism Chile (Chile, 2017)



Ecourbanism. Bogotá. Colombia (Alcaldía Mayor de Bogotá, 2015)



Sustainable urbanism. Aburrá Valley. Colombia (AMVA & UPB, 2015)

Source: The authors, based on technical support documents provided found at the respective instrument website

APPENDIX C. Potential contributions of the built environment to the UN Agenda

C.1. Potential contribution of the sustainable built environment to the New Urban Agenda (NUA) and to the Sustainable Development Goals (SDG)

The New Urban Agenda. Thematic Areas and Issues		**Sustainable Development Goals by Target**	**Potential contribution from the sustainable built environment**
Social cohesion and equity	1. Inclusive cities	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	Multidimensional poverty includes housing and access to infrastructure for basic services (UNDP, 2018)
		1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	Inclusion of floors in social protection relates housing
		1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Equal right to economic resources involves opportunities dependent on spatial planning (UN Habitat, 2016)
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all	Education facilities are elements of the built environment
		5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	Access to economic resources, ownership, property, financial services and natural services means the access to specific elements of the built environment, such as housing, public space, infrastructure and basic services (UN Habitat, 2016)
		8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate partial

The New Urban Agenda. Thematic Areas and Issues		**Sustainable Development Goals by Target**	**Potential contribution from the sustainable built environment**
		8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	planning is key to promote decent job creation (UN Habitat, 2016)
		8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	Urban planning must prioritize key spatial solutions where informal enterprises benefit from the agglomeration and productive opportunities to the poor are available (UN Habitat, 2016)
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)
		10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average	Economic inequality is closely linked with spatial inequality. Improved spatial connection establishes a link between land use and accessibility, eliminates or reduces the imbalances between residential and working areas and reduces the gap between slums and consolidated neighbourhoods. Spatial planning concretes the infrastructural foundation that supports economic transitions
		10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status	
		10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard	
		10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	
		11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
		11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Urban heritage includes urban morphology, built form, open green spaces, urban infrastructure and architectural elements (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment
		11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Unplanned expansion of the built environment affects rural areas (UN Habitat, 2016)
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)
		13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	
	2. Migration and refugees	10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies	Migration policies should include spatial planning to prevent discrimination (UN Habitat, 2016)
	3. Safer cities	16.1 Significantly reduce all forms of violence and related death rates everywhere	Crime is related to poor planning, design and management of urbanization (UN Habitat, 2016)
	4. Urban culture and heritage	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Urban heritage includes urban morphology, built form, open green spaces, urban infrastructure and architectural elements (UN Habitat, 2016)
Urban frameworks	5. Urban rules and legislation	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Urban law provides predictability and order in spatial urban development (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	Access to economic resources, ownership, property, financial services and natural services means the access to specific elements of the built environment, such as housing, public space, infrastructure and basic services (UN Habitat, 2016)
		6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Equitable access to sanitation involves infrastructure, which is an element of the built environment (UN Habitat, 2016)
		6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	
		7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Since cities are major energy consumers, a sustainable built environment would be an important contributor to increasing access to affordable, reliable, modern and renewable energy by means of distributed generation, energy efficiency and demand management (GABC, 2018
		7.3 By 2030, double the global rate of improvement in energy efficiency	
		8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate partial planning is key to promote decent job creation (UN Habitat, 2016)
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	
		11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Housing stands at the centre of the built environment. Sustainable housing will support the achievement of the Sustainable Development Goals of poverty alleviation, health, economic development, social cohesion, gender equality and environmental sustainability (UN Habitat, 2016)
		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	The construction sector shows large opportunities for circular economy and waste reuse (GABC, 2018)
		13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Resilience at city level recognizes the urban area as a dynamic and complex system that can be understood across functional, organizational, physical and spatial dimensions (UN Habitat, 2016)
		13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	Sectors related to the built environment are required to rise their capacity for change-related planning (UN Habitat, 2016)
		14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	Due to the water cycle, even inland cities contribute to marine pollution via untreated sewage and urban runoff (UNEP & GPA, 2007; UNEP, 2017)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	Due to the water cycle, even inland cities contribute to marine pollution via untreated sewage and urban runoff (UNEP & GPA, 2007; UNEP, 2017)
		16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	Governance in planning recognizes that every stakeholder has the right to participate in shaping the built environment (UN Habitat, 2016)
		17.14 Enhance policy coherence for sustainable development	Urban law provides predictability and order in spatial urban development (UN Habitat, 2016)
		17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	Public-private and civil society partnerships are a way to promote a sustainable built environment (UN Habitat, 2016)
	6. Urban governance	16.5 Substantially reduce corruption and bribery in all their forms	Since the built environment requires large investments, it is is particularly vulnerable to these issue (Rics, 2018)
		16.6 Develop effective, accountable and transparent institutions at all levels	A sustainable built environment involves transparency from both public and private institutions (Fewings, 2009)
		16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	Governance in planning recognizes that every stakeholder has the right to participate in shaping the built environment (UN Habitat, 2016)
		17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	Public-private and civil society partnerships are a way to promote a sustainable built environment (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
	7. Municipal Finance	17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	Knowledge and expertise transference is required for better spatial planning, buildings and infrastructure (UN Habitat, 2016)
Spatial development	8. Urban and spatial planning and design	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)
		13.2 Integrate climate change measures into national policies, strategies and planning	
		13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	
	9. Urban land	11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
	10.Urban rural linkages	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	Urban agriculture is a process involving the built environment and it is a way to help promoting sustainable food production systems (Issue papers - NUA, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Unplanned expansion of the built environment affects rural areas (UN Habitat, 2016)
	11. Public space	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment
Urban economy	12. Local economic development	1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	Investments in streets and public space infrastructure improve urban productivity and livelihoods and allows better access to markets, jobs and public services (UN Habitat, 2016)
		1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Equal right to economic resources involves opportunities dependent on spatial planning (UN Habitat, 2016)
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	Urban form is a key determinant of transport systems and in turn is heavily influenced by transport systems (UN Habitat, 2016)
		3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	The urban environment refers to the intersection and overlay of the natural environment, the built environment and the socioeconomic environment. Spatial planning and design are important for transformative change, enabling low-carbon, energy-efficient, risk-informed and resilient urban development.
		3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	Early warning systems must be integrated into the built environment planning and management in order to enhance access to information to assist disaster risk management and promote adaptation decision making (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all	Education facilities are elements of the built environment
		5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	Access to economic resources, ownership, property, financial services and natural services means the access to specific elements of the built environment, such as housing, public space, infrastructure and basic services (UN Habitat, 2016)
		6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Equitable access to sanitation involves infrastructure, which is an element of the built environment (UN Habitat, 2016)
		6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Cities contribute to water pollution via untreated sewage and urban runoff (UNEP, 2017)
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Water efficiency is a major goal to the sustainable built environment (One Planet Network, 2016)
		7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Since cities are major energy consumers, a sustainable built environment would be an important contributor to increasing access to affordable, reliable, modern and renewable energy by means of distributed generation, energy efficiency and demand management (GABC, 2018
		7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	
		7.3 By 2030, double the global rate of improvement in energy efficiency	

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	The development of the built environment is one of the main requirements for economic growth (especially infrastructure) and at the same time, it is one of the main engines of the economy, given the large investments that usually requires (The new climate economy, 2016)
		8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)
		8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate partial planning is key to promote decent job creation (UN Habitat, 2016)
		8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	Resource efficiency is a major challenge for a sustainable built environment (UN habitat, 2016; GABC, 2018)
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)
		9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	Sustainable tourism requires sustainable infrastructure, including hotel buildings
		9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Infrastructure is a component of the built environment. In the other hand, construction supply chain includes industry. Hence, upgrading infrastructure and industry is directly related to the built environment

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	Scientific research and upgrading technological capabilities are required in order to set science-based targets that can be used to help transform the buildings and construction sector (GABC, 2018)
		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	Sustainable infrastructure is a key element of the built environment, required to achieve the Sustainable Development Goals and reducing climate risk in line with the Paris Agreement (The New Climate Economy, 2016)
		11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Housing stands at the centre of the built environment. Sustainable housing will support the achievement of the Sustainable Development Goals of poverty alleviation, health, economic development, social cohesion, gender equality and environmental sustainability (UN Habitat, 2016)
		11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Urban form is a key determinant of transport systems and in turn is heavily influenced by transport systems (UN Habitat, 2016)
		11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
		11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Building the resilience of urban systems and the built environment to withstand adverse climate impacts and disaster risks (UN Habitat, 2016)
		11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	The life-cycle of the elements conforming the built environment is a major source of the environmental impacts caused by cities (The New climate economy, 2016; GABC, 2018)
		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Unplanned expansion of the built environment affects rural areas (UN Habitat, 2016)
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)
		12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	One of the 10yfp areas, promoted by the One Planet Network is Sustainable Building and Construction
		12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Due to its intense use of energy, water and materials, the construction sector is crucial to achieve a global efficient use of natural resources (GABC, 2018)
		12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life-cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	The construction sector is responsible for a large amount of waste, wastewater and GHG emissions. Toxic substances and hazardous materials are also involved in its value chain (GABC, 2018)
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	The construction sector shows large opportunities for circular economy and waste reuse (GABC, 2018)
		12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	Companies taking part in the construction sector value chain are to be encouraged to report

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	Public procurement practices should involve sustainability criteria for infrastructure, public buildings and social housing projects (Perera et.al, 2016; GABC, 2018)
		12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	Sustainable patterns of consumption and production should involve the construction value chain
		12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	Sustainable tourism require sustainable infrastructure and sustainable accommodation practices, both involving elements of the built environment (UNEP & UNWTO, 2005)
		12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	Buildings worldwide are major users of fossil fuels (UNEP, OECD & IISD, 2019)
		15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	Urbanization is responsible for habitat fragmentation and biodiversity loss. A sustainable development of the built environment includes restoring and maintaining ecosystem connectivity (van Bueren et.al, 2012)
		16.5 Substantially reduce corruption and bribery in all their forms	Since the built environment requires large investments, it is is particularly vulnerable to these issue (Rics, 2018)
		16.6 Develop effective, accountable and transparent institutions at all levels	A sustainable built environment involves transparency from both public and private institutions (Fewings, 2009)
	13. Jobs and livelihoods	8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate partial planning is key to promote decent job creation (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate partial planning is key to promote decent job creation (UN Habitat, 2016)
		8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms	
		8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	Urban planning must prioritize key spatial solutions where informal enterprises benefit from the agglomeration and productive opportunities to the poor are available (UN Habitat, 2016)
		8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	Sustainable tourism require sustainable infrastructure and sustainable accommodation practices, both involving elements of the built environment (UNEP & UNWTO, 2005)
	14. Informal sector	8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	Urban planning must prioritize key spatial solutions where informal enterprises benefit from the agglomeration and productive opportunities to the poor are available (UN Habitat, 2016)
Urban ecology and environment	15.Urban Resilience	1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	Resilience at city level can be understood across functional, organizational, physical and spatial dimensions (UN Habitat, 2016)
		1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Equal right to economic resources involves opportunities dependent on spatial planning (UN Habitat, 2016)
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	The urban environment refers to the intersection and overlay of the natural environment, the built environment and the socioeconomic environment. Spatial planning and design are important for transformative change, enabling low-carbon, energy-efficient, risk-informed and resilient urban development pathways.
		3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	Early warning systems must be integrated into the built environment planning and management in order to enhance access to information to assist disaster risk management and promote adaptation decision making (UN Habitat, 2016)
		6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Equitable access to sanitation involves infrastructure, which is an element of the built environment (UN Habitat, 2016)
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Cities contribute to water pollution via untreated sewage and urban runoff (UNEP, 2017)
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)
		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	Sustainable infrastructure is a key element of the built environment, required to achieve the Sustainable Development Goals and reducing climate risk in line with the Paris Agreement (The New Climate Economy, 2016)
		11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Building the resilience of urban systems and the built environment to withstand adverse climate impacts and disaster risks (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)
		13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Resilience at city level recognizes the urban area as a dynamic and complex system that can be understood across functional, organizational, physical and spatial dimensions (UN Habitat, 2016)
		14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	Due to the water cycle, even inland cities contribute to marine pollution via untreated sewage and urban runoff (UNEP & GPA, 2007; UNEP, 2017)
	16. Urban ecosystems and resource management	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	The urban environment refers to the intersection and overlay of the natural environment, the built environment and the socioeconomic environment. Spatial planning and design are important for transformative change, enabling low-carbon, energy-efficient, risk-informed and resilient urban development pathways.
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Cities contribute to water pollution via untreated sewage and urban runoff (UNEP, 2017)
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Water efficiency is a major goal to the sustainable built environment (One Planet Network, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	Since cities are major energy consumers, a sustainable built environment would be an important contributor to increasing access to affordable, reliable, modern and renewable energy by means of distributed generation, energy efficiency and demand management (GABC, 2018
		7.3 By 2030, double the global rate of improvement in energy efficiency	
		8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	Resource efficiency is a major challenge for a sustainable built environment (UN habitat, 2016; GABC, 2018)
		8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	Sustainable tourism require sustainable infrastructure and sustainable accommodation practices, both involving elements of the built environment (UNEP & UNWTO, 2005)
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)
		9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	An important challenge to the construction industry is to increase productivity in the same pace as other manufacturing industries (Whandal & Ussing, 2013)
		9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Infrastructure is a component of the built environment. In the other hand, construction supply chain includes industry. Hence, upgrading infrastructure and industry is directly related to the built environment
		9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	Scientific research and upgrading technological capabilities are required in order to set science-based targets that can be used to help transform the buildings and construction sector (GABC, 2018)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	Sustainable infrastructure is a key element of the built environment, required to achieve the Sustainable Development Goals and reducing climate risk in line with the Paris Agreement (The New Climate Economy, 2016)
		11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Urban form is a key determinant of transport systems and in turn is heavily influenced by transport systems (UN Habitat, 2016)
		11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
		11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Urban heritage includes urban morphology, built form, open green spaces, urban infrastructure and architectural elements (UN Habitat, 2016)
		11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	The life-cycle of the elements conforming the built environment is a major source of the environmental impacts caused by cities (The New climate economy, 2016; GABC, 2018)
		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	One of the 10yfp areas, promoted by the One Planet Network is Sustainable Building and Construction
		12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Due to its intense use of energy, water and materials, the construction sector is crucial to achieve a global efficient use of natural resources (GABC, 2018)
		12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life-cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	The construction sector is responsible for a large amount of waste, wastewater and GHG emissions. Toxic substances and hazardous materials are also involved in its value chain (GABC, 2018)
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	The construction sector shows large opportunities for circular economy and waste reuse (GABC, 2018)
		12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	Companies taking part in the construction sector value chain are to be encouraged to report
		12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	Public procurement practices should involve sustainability criteria for infrastructure, public buildings and social housing projects (Perera et.al, 2016; GABC, 2018)
		12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Information concerning sustainable lifestyles involves energy and water consumption, which is an aspect of the built environment
		12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	Sustainable patterns of consumption and production should involve the construction value chain
		12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	Sustainable tourism require sustainable infrastructure and sustainable accommodation practices, both involving elements of the built environment (UNEP & UNWTO, 2005)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	Buildings worldwide are major users of fossil fuels (UNEP, OECD & IISD, 2019)
		14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	Due to the water cycle, even inland cities contribute to marine pollution via untreated sewage and urban runoff (UNEP & GPA, 2007; UNEP, 2017)
		15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements	The built environment has a major impact upon ecosystems, from the extraction of energy, raw materials and water to the disposal of construction waste, sewage, urban runoff and atmospheric emissions, including biodiversity loss (UNEP, 2017)
		15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	The construction sector is an important consumer of wood worldwide (Ramagea et.al, 2017)
		15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	The built environment has a major impact upon ecosystems, from the extraction of energy, raw materials and water to the disposal of construction waste, sewage, urban runoff and atmospheric emissions, including biodiversity loss (UNEP, 2017)
		15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	Urbanization is responsible for habitat fragmentation and biodiversity loss. A sustainable development of the built environment includes restoring and maintaining ecosystem connectivity (van Bueren et.al, 2012)
	17. Cities climate change and disaster risk management	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	The life-cycle of the elements conforming the built environment is a major source of the environmental impacts caused by cities (The New climate economy, 2016; GABC, 2018)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Resilience at city level recognizes the urban area as a dynamic and complex system that can be understood across functional, organizational, physical and spatial dimensions (UN Habitat, 2016)
		13.2 Integrate climate change measures into national policies, strategies and planning	Spatial layout if a city determines per capita CO2 emissions, a compact urban form is a decisive factor for urban climate change mitigation. City form yields a wide range of positive co-benefits for adaptation, resilience and economic development (UN Habitat, 2016)
		13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Education programs related to the development of the built environment must focus its curricula on urban sustainability (Brandon & Lombardi, 2005; Haghighat & Kim, 2009)
		13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	Investments that developing countries will require to meet their needs on infrastructure and other elements of the built environment demand new and innovative approaches to financing and international cooperation (ILO, UNDP, UNECE, UNIDO, UNITAR and UNOPS, 2018)
		13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	Sectors related to the built environment are required to rise their capacity for change-related planning (UN Habitat, 2016)
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)
Housing and basic services	18. Urban infrastructure and basic services	6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Equitable access to sanitation involves infrastructure, which is an element of the built environment (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Cities contribute to water pollution via untreated sewage and urban runoff (UNEP, 2017)
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Water efficiency is a major goal to the sustainable built environment (One Planet Network, 2016)
		6.5 By 2030, implement integrated water resources management at all levels, including through trans boundary cooperation as appropriate	Water sensitive urban design is crucial to achieve integrated water resources management and restoring water-related ecosystems (UN Habitat, 2016)
		6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	
		7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Since cities are major energy consumers, a sustainable built environment would be an important contributor to increasing access to affordable, reliable, modern and renewable energy by means of distributed generation, energy efficiency and demand management (GABC, 2018
		7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	
		7.3 By 2030, double the global rate of improvement in energy efficiency	
		9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Reliable, sustainable and resilient infrastructure is a cornerstone for a sustainable built environment (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	An important challenge to the construction industry is to increase productivity in the same pace as other manufacturing industries (Whandal & Ussing, 2013)
		9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Infrastructure is a component of the built environment. In the other hand, construction supply chain includes industry. Hence, upgrading infrastructure and industry is directly related to the built environment
		9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	Scientific research and upgrading technological capabilities are required in order to set science-based targets that can be used to help transform the buildings and construction sector (GABC, 2018)
		9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	Sustainable infrastructure is a key element of the built environment, required to achieve the Sustainable Development Goals and reducing climate risk in line with the Paris Agreement (The New Climate Economy, 2016)
	19. Transport and mobility	3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	Urban form is a key determinant of transport systems and in turn is heavily influenced by transport systems (UN Habitat, 2016)
		11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	
	20. Housing	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	Adequate housing must provide availability of services, materials, facilities and infrastructure, physical safety, adequate space, access to disadvantaged and marginalized groups, access to employment opportunities, health-care services, schools, childcare centres and other social facilities. All of these are elements of the built environment

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Equal right to economic resources involves opportunities dependent on spatial planning (UN Habitat, 2016)
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	Access to economic resources, ownership, property, financial services and natural services means the access to specific elements of the built environment, such as housing, public space, infrastructure and basic services (UN Habitat, 2016)
		6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Equitable access to sanitation involves infrastructure, which is an element of the built environment (UN Habitat, 2016)
		6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Water efficiency is a major goal to the sustainable built environment (One Planet Network, 2016)
		7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Since cities are major energy consumers, a sustainable built environment would be an important contributor to increasing access to affordable, reliable, modern and renewable energy by means of distributed generation, energy efficiency and demand management (GABC, 2018
		7.3 By 2030, double the global rate of improvement in energy efficiency	

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Housing stands at the centre of the built environment. Sustainable housing will support the achievement of the Sustainable Development Goals of poverty alleviation, health, economic development, social cohesion, gender equality and environmental sustainability (UN Habitat, 2016)
		11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Urban form is a key determinant of transport systems and in turn is heavily influenced by transport systems (UN Habitat, 2016)
		11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Spatial planning covers a wide large of scales to the built environment. It aims at facilitating and articulating decisions and actions that will affect the distribution and flows of people, goods and activities (UN Habitat, 2016).
		11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Building the resilience of urban systems and the built environment to withstand adverse climate impacts and disaster risks (UN Habitat, 2016)
		11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	The life-cycle of the elements conforming the built environment is a major source of the environmental impacts caused by cities (The New climate economy, 2016; GABC, 2018)
		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Public space refers to all places publicly owned or of public use that are accessible and enjoyable by all for free and without profit motive. This includes streets, open spaces and public facilities. Public space is key element of the built environment
		11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Unplanned expansion of the built environment affects rural areas (UN Habitat, 2016)
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Urban policies related to spatial planning, housing and infrastructure must address sustainability and resilience(UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Buildings are central elements of the built environment and account for nearly 40 percent of total energy-related CO2 emissions and 36 percent of final energy use worldwide. At the same time, the building sector offers the largest cost-effective GHG mitigation potential, with net cost savings and economic gains (GABC, 2018)
		12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	One of the 10yfp areas, promoted by the One Planet Network is Sustainable Building and Construction
		12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Due to its intense use of energy, water and materials, the construction sector is crucial to achieve a global efficient use of natural resources (GABC, 2018)
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	The construction sector shows large opportunities for circular economy and waste reuse (GABC, 2018)
		12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	Public procurement practices should involve sustainability criteria for infrastructure, public buildings and social housing projects (Perera et.al, 2016; GABC, 2018)
		12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	Buildings worldwide are major users of fossil fuels (UNEP, OECD & IISD, 2019)
	22.Informal settlements	1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	Informal settlements are integral part of the built environment in the developing world. These areas usually lack, or are cut off from, basic services and city infrastructure, are often situated in geographically and environmentally hazardous areas and its housing may not comply with planning and building regulations (UN Habitat, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Equal right to economic resources involves opportunities dependent on spatial planning (UN Habitat, 2016)
		1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Resilience of the poor includes housing, neighbourhoods and access to infrastructure
		11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Housing stands at the centre of the built environment. Sustainable housing will support the achievement of the Sustainable Development Goals of poverty alleviation, health, economic development, social cohesion, gender equality and environmental sustainability (UN Habitat, 2016)
	21. Smart cities	3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	Early warning systems must be integrated into the built environment planning and management in order to enhance access to information to assist disaster risk management and promote adaptation decision making (UN Habitat, 2016)
		4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	Transformative learning is key to innovating sustainability education in the built environment (Usha Iyer-Raniga, Mary Myla Andamon, 2016)
		5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)
		7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	The buildings and construction sector accounts for nearly 40 percent of total energy-related CO_2 emissions and 36 percent of final energy use worldwide (GABC, 2018)
		8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	The building and construction sector is a major job provider worldwide. However, Increasing productivity, formalization, innovation and addressing labour rights concerns are major challenges to this sector worldwide (ILO, 2017; GABC, 2018). In the other hand, at city level, adequate patial planning is key to promote decent job creation (UN Habitat, 2016)
		9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)
		9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	Advanced use of information and communication technologies (ICT) are crucial to designing, building and operating sustainable and resilient urban environments by means of enhancing the efficiencies of urban systems, increasing the quality and effective delivery of services, empowering citizens, and addressing environmental challenges and disaster risks (Un habitat, 2016)
		12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	Companies taking part in the construction sector value chain are to be encouraged to report
		12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Information concerning sustainable lifestyles involves energy and water consumption, which is an aspect of the built environment
		12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	Sustainable patterns of consumption and production should involve the construction value chain
		13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Education programs related to the development of the built environment must focus its curricula on urban sustainability (Brandon & Lombardi, 2005; Highlight & Kim, 2009)

The New Urban Agenda. Thematic Areas and Issues		Sustainable Development Goals by Target	Potential contribution from the sustainable built environment
		17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism	Knowledge and expertise transference is required for better spatial planning, buildings and infrastructure (UN Habitat, 2016)
		17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)
		17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology	Increasing productivity, technological upgrading and innovation are major challenges to the construction sector (The new climate economy, 2016)
		17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	Knowledge and expertise transference is required for better spatial planning, buildings and infrastructure (UN Habitat, 2016)

C.2. Potential contribution of the sustainable built environment to the Sendai Framework for Risk Disaster Reduction

Senadi Framework priority	Specific criteria referring to elements and processes of the built environment
Priority 1: Understanding disaster risk	(c) To develop, periodically update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities
	(d) To systematically evaluate, record, share and publicly account for disaster losses and understand the economic, social, health, education, environmental and cultural heritage impacts, as appropriate
	(b) To encourage the use of and strengthening of baselines and periodically assess disaster risks, vulnerability, capacity, exposure, hazard characteristics and their possible sequential effects at the relevant social and spatial scale on ecosystems, in line with national circumstances
	(f) To promote real time access to reliable data, make use of space and in situ information, including geographic information systems (GIS),
Priority 2: Strengthening disaster risk governance to manage disaster risk	(a) To mainstream and integrate disaster risk reduction within and across all sectors and review and promote the coherence and further development, including publically owned, managed or regulated services and infrastructures
	(d) To encourage the establishment of necessary mechanisms and incentives to ensure high levels of compliance with the existing safety-enhancing provisions of sectorial laws and regulations, including those addressing land use and urban planning, building codes among others
	(k) To formulate public policies, where applicable, aimed at addressing the issues of prevention or relocation, where possible, of human settlements in disaster risk-prone zones
Priority 3: Investing in disaster risk reduction for resilience	(o) To increase business resilience and protection of livelihoods and productive assets
Priority 3: Investing in disaster risk reduction for resilience	(e) To promote the disaster risk resilience of workplaces through structural and non-structural measures
	(d) To protect or support the protection of cultural and collecting institutions and other sites of historical, cultural heritage and religious interest
	f) To promote the mainstreaming of disaster risk assessments into land-use policy development and implementation, including urban planning, land degradation assessments and informal and non-permanent housing
	g) To promote the mainstreaming of disaster risk assessment, mapping and management including through the identification of areas that are safe for human settlement, and at the same time preserving ecosystem functions that help to reduce risks
	(h) To encourage the revision of existing or the development of new building codes and standards and rehabilitation and reconstruction practices, particularly in informal and marginal human settlements, and reinforce the capacity to implement, survey and enforce such codes through an appropriate approach, with a view to fostering disaster-resistant structures
	j) To strengthen the design and implementation of inclusive policies, including through community involvement, integrated with livelihood enhancement programmes, including housing, among others
Priority 4: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction	(c) To promote the resilience of new and existing critical infrastructure, including water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities, to ensure that they remain safe, effective and operational during and after disasters in order to provide live-saving and essential services
	(d) To establish community centres for the promotion of public awareness and the stockpiling of necessary materials to implement rescue and relief activities
	(j) To promote the incorporation of disaster risk management into post-disaster recovery and rehabilitation processes, including through the development of measures such as land-use planning and structural standards improvement. This should also apply to temporary settlements for persons displaced by disasters;
	(k) To develop guidance for preparedness for disaster reconstruction, such as on land-use planning and structural standards improvement, including by learning from the recovery and reconstruction programmes
	(l) To consider the relocation of public facilities and infrastructures to areas outside the risk range

C.3. Potential contribution of the sustainable built environment to the Paris Agreement on Climate Change by using selected SDG targets (see Appendix C1)

Selected SDG target related to the Built Environment (see Appendix C1)	**Related dimension of Climate change action**
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Adaptation
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	Mitigation and adaptation
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Adaptation
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	Adaptation
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	Mitigation and adaptation
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Adaptation
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Adaptation
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	Mitigation and adaptation
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	Adaptation
6.5 By 2030, implement integrated water resources management at all levels, including through trans boundary cooperation as appropriate	Adaptation
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	Adaptation
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	Mitigation
7.3 By 2030, double the global rate of improvement in energy efficiency	Mitigation
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	Mitigation
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	Mitigation
8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	Mitigation and adaptation
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Mitigation and adaptation
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	Mitigation
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Mitigation and adaptation
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	Mitigation and adaptation
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Adaptation
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Mitigation

Selected SDG target related to the Built Environment (see Appendix C1)	**Related dimension of Climate change action**
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Mitigation and adaptation
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Adaptation
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Mitigation
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Mitigation and adaptation
11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	Mitigation and adaptation
11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Mitigation and adaptation
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	Mitigation and adaptation
12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	Mitigation
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Mitigation
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life-cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	Mitigation
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	Mitigation
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	Mitigation
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	Mitigation
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Mitigation and adaptation
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	Mitigation
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	Mitigation and adaptation
12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	Mitigation
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Adaptation
13.2 Integrate climate change measures into national policies, strategies and planning	Mitigation and adaptation
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Mitigation and adaptation
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	Mitigation and adaptation
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	Adaptation
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	Mitigation

Selected SDG target related to the Built Environment (see Appendix C1)	Related dimension of Climate change action
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	Adaptation
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements	Mitigation and adaptation
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	Mitigation and adaptation
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	Mitigation and adaptation
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	Mitigation and adaptation
17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	Mitigation and adaptation

APPENDIX D. Transcriptions from interviews and surveys concerning cognitive aspects of the socio-technical regime of buildings (Section 5.1)

Areas	Barriers	Opportunities
Institutional capacity	In the usual constructive practice there is a very low level of documentation about processes, procedures and even real quantities of materials, this makes it difficult to generate reliable and clear information concerning the feasibility of incorporating sustainability criteria The interest in the subject and the training in this regard is usually only at the technical level of the companies, generally it does not reach the managerial levels, nor the commercial areas and much less to the investors. The latter being, in fact, the least aware and least interested While there is a national code for sustainable construction. There is no monitoring or verification mechanism that obliges builders more clearly to incorporate these issues There is no evidence of implementation of sustainability criteria in public works. This demonstrates a lack of coherence between the regulatory framework and institutional will and capacity, reducing the strength of policies and norms	There is a growing interest in the subject, mainly at the technical level of organizations
Absence of regulation	There is incompatibility between the Colombian technical standards of architectural and engineering design, with respect to what is established by the code of sustainable construction or certification schemes	There is incompatibility between the Colombian technical standards of architectural and engineering design, with respect to what is established by the code of sustainable construction or certification schemes
Lack of technical knowledge	Although new design technologies have been incorporated, the medium is still far from achieving integrative processes such as those proposed by the BIM (Building Information Management) methodology Design offices and suppliers of materials, equipment, systems and devices frequently ignore the issue. In many cases, they don't even know about the existence of a norm Training courses are usually very conceptual and theoretical. More practical approaches are required	Certification schemes can simplify the process, provided the certification scheme is likewise simple The existence of training courses have allowed greater access to the subject
Lack of market demand	The largest proportion of area built annually in the country is for housing use, however, it is there that the market has created less demand for sustainable projects	In institutional and commercial projects it is easier to incorporate sustainability criteria, mainly in offices, hotels and shopping centres. More and more it becomes a requirement on the part of the client
Lack of incentives	There are exemptions and tax reductions at the national level for investments that demonstrate a decrease in environmental impacts in any economic activity, including the development of construction projects. However, these incentives are not very attractive because	Recently the financial sector has begun offering preferential interest rates for sustainable projects.

Areas	Barriers	Opportunities
	they are very difficult to access and, in addition, can only be obtained the following year of making the investment. Therefore, incentives applicable to initial investment costs, such as urbanization and construction taxes, are required. The obstacle is that these taxes are of a municipal nature and can significantly affect the finances of these entities. It is necessary to design other types of incentives, such as greater land use for sustainable projects. This type of stimulus would be attractive to investors and developers	This may be an important boost for the issue, but it requires a certification process.
Implementation costs	Design offices charge a higher value for designs that include sustainability criteria The criteria of easiest implementation in the design phase (efficient equipment and systems) are the most expensive to include in the construction. Similarly, the lowest cost measures in construction (bioclimatic design) are the most complex to incorporate in the design phase since they require a greater degree of knowledge. Hence the general perception that a project with sustainability criteria is more expensive	
Diversity of approaches	The most recognized approach in the medium is that provided by the LEED certification EDGE certification is taking hold. For companies the first is more complex and more expensive, the second is more understandable and attainable Some companies are focusing on achieving compliance with the national code for sustainable construction (Act 0549 of 2015 of the Ministry of Housing), but the standard does not clarify quantitative results. On the other hand, the standard is only aimed at saving water and energy consumption in the operational phase of new buildings, leaving out many other relevant aspects Some companies have been applying their own criteria and the same company may have applied a different approach in each project. Finally, the introduction of sustainability criteria is still in an exploratory state and no company implements them in all its projects Concerning some measures with a high positive environmental impact, such as the use of alternative sources of water supply and energy, the investment costs remain very high and the back payment periods remain very long. Rarely, customers are willing to make these investments	The existence of a standard allows the processes to be oriented towards clearly defined objectives
Business models	The times and commercial priorities (promoter), many times are not compatible with the times and technical priorities (builder) Design offices, both architecture and engineering, do not apply sustainability criteria. Generally, they don't even know the norm. At the same time, there are few local suppliers of materials, systems, equipment or devices that meet criteria. Without designs and without products that meet criteria, it is difficult for construction companies to develop sustainable projects. However, existing instruments are mainly aimed at builders. On the other hand, the responsibility of the builder regarding the performance of the projects in the operational phase is limited. The role of users in achieving sustainability objectives is not yet clear.	In new business models, where promoter, builder and administrator are the same person (company), the implementation is very simple. Decisions are not discussed at length. The perspective of saving in operating costs is usually sufficient argument