



Ain Shams University
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University of Stuttgart
Germany

Sustainable Construction Agenda, Between National Policies and Local Actions

***Implementation of related regulations in the case of Bucaramanga,
Colombia: Deficiencies, rationality, and recommendations***

**A Thesis submitted in the Partial Fulfillment for the Requirement of the Degree
of Master of Science in Integrated Urbanism and Sustainable Design**

by

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Supervised by

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July, 2022

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The work included in this thesis was carried out by the author during the period from February – to July 2022.

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Eliana Paola Gomez Acevedo

Sustainable Construction Agenda, Between National Policies and Local Actions

Implementation of related regulations in the case of Bucaramanga, Colombia: Deficiencies, rationality, and recommendations

Abstract

The main objective of this research is to analyze how sustainable building codes and similar regulations are being implemented in the city of Bucaramanga, Colombia identifying what aspects are left behind in this process. This research will comprehensively consider the needs and issues identified by different stakeholders, considering their diverse perspectives and agendas. Then, it will suggest strategies to integrate sustainable construction practices with local-level governance processes to create a more sustainable city. The research methodology consisted of a qualitative and quantitative analysis of the three main stakeholder groups: using in-depth and semi-structured interviews and online surveys. The research found various implementation gaps in the city's application of sustainable codes. One of the main obstacles is the regulation's proposed methodology that does not suit the city's socio-economical, climatic, and architectural conditions. This research concludes with a series of suggestions considering more suitable solutions that can be taken.

Keywords: Colombia, Energy code, regulation, methodology.

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List of abbreviations

CONPES - Consejo Nacional de Política Económica y Social - National Council for Economic and Social Policy

POT - Plan de Ordenamiento Territorial - Territorial Management Plan

NTC - Norma Técnica Colombiana - Colombian Technical Standard

UVT - Unidad de Valor Tributario - Unidad de Valor Tributario

AMB - Área Metropolitana de Bucaramanga - Bucaramanga Metropolitan Area

DNP - Departamento Nacional de Planeación - National Planning Department

MADS - Ministerio de Ambiente y Desarrollo Sostenible - Ministry of Environment and Sustainable Development

PNUD - Programa De Las Naciones Unidas Para El Desarrollo - United Nations Development Program

DANE - Departamento Administrativo Nacional de Estadística - National Administrative Department of Statistics

IDEAM - Instituto de Hidrología, Meteorología y Estudios Ambientales - Institute of Hydrology, Meteorology and Environmental Studies

CCCS - Consejo Colombiano de Construcción Sostenible - Colombian Council for Sustainable Construction

CAMACOL - Cámara Colombiana de la Construcción - Colombian Chamber of Construction

IFC - International Finance Corporation

LCA - Life Cycle Assessment

HVAC - Heating, ventilation, and air conditioning

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

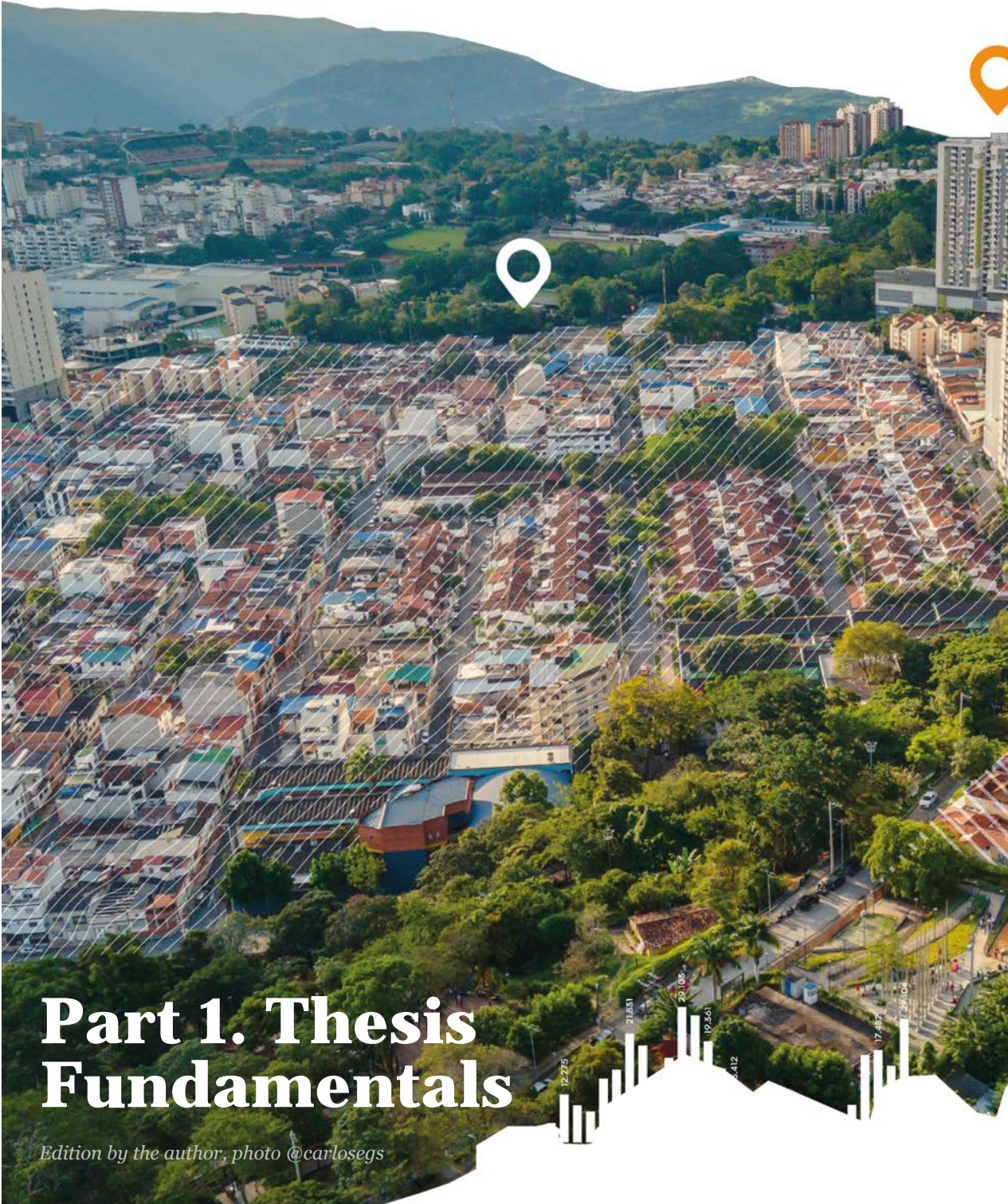
LEED - Leadership in Energy and Environmental Design

BREEAM - Building Research Establishment Environmental Assessment Method

EDGE - Excellence in Design for Greater Efficiencies

HQE - High Quality Environmental standard)

DGNB - Deutsche Gesellschaft für Nachhaltiges Bauen - German Society for Sustainable Building



Part 1. Thesis Fundamentals

Edition by the author, photo @carlosegs



5,831

29,005

19,361

13,412

17,897

12,275

21,831

29,103

19,361

4,112

17,482

27,104

1. Research Structure

1.1 Introduction

Colombia has compromised to reduce carbon emissions by a 51% by 2030 (Gobierno de Colombia, 2021). In strategy E2050, a Colombian document was created to integrate efforts and take the country toward cutting its carbon emission to comply with the Paris agreement. This plan contemplates 30 actions that emphasize the multisectoral approach of the proposal.

E2050 has a goal in action number 6 to have net-zero carbon buildings in the urban edifications, contemplating both new and existing stock. This strategic plan also seeks to incorporate vulnerability to climate change studies in city planning regulations. It is the first document to introduce the goal that for 2050 is expected that Colombian construction regulation contemplates the whole building life cycle and reuses at least 75% of the construction waste. In this way, the strategy sees the need for sustainable urban development, integrating buildings into the equation. After all, the construction sector in Colombia compromise approximately 20% of the carbon emissions (IDEAM, PNUD, MADS, DNP, CANCELERÍA, 2018), a percentage that can very likely go higher due to the continuous growth of metropolitan cities in the global south, as an estimated 68% of the population will be living in urban areas by 2050 (UN Habitat, 2020).

In Colombian legislation, one of the first policies to directly address climate change was introduced in 2017 in the climate change national policy (Ministerio de Ambiente y Desarrollo Sostenible, 2017). The policy reflected the compromises of the country with the Paris Agreement in 2015 and the inter-institutional commission that the government created in the same year to incorporate the Sustainable Development Goals SDG in their National Development Plan. Until that point, no policy integrated a multilevel framework concept of sustainability, climate change, and reduction of carbon emissions. The elaboration of a policy

is the big umbrella of creating different strategies and laws. There has not been a new law that comes as a result of a comprehensive sustainable construction strategy. In 2015, Colombian resolution 549 was the last legislation piece with some sustainable construction components.

Building performance codes then regulate how buildings are designed, made, and managed. In the case of Colombia, there is not yet an obligation to comply with these codes. This obligation remains open to the builder. Nevertheless, some incentives are in place to incentive developers to build more sustainably or at least to limit the building water and energy consumption. However, these incentives often do not provide enough support, and other behavioral, economic, technical, and legislative barriers make it also a difficult task. The primary law in Colombia that regulates some energy efficiency parameters in the building sector is resolution 549 of 2015. Nevertheless, this law is limited to controlling water and energy consumption and does not contemplate the influences of the construction sector in a multiscale and multisectoral ecosystem.

The elaboration of building codes alone requires extensive knowledge of architecture and the socio-economic context, land vocation, and demographics, among others. In the case of building performance codes, this requires a second level of understanding of how architecture, climate, and available materials, among other factors, will ensure that these codes positively impact the people and environment. People/users are one of the focuses of this research, which seeks to highlight the vital role they play in the construction of sustainable policies. After all, these regulations should ensure that it improves people's life quality.

After understanding the national context, the research went to its next phase. Where the question of how can the governments create sustainable construction policies that come from local actions and pay attention to people's well-being, context, architecture, and legislation? Became the basis of this research.

1.2 **Research Objectives**

The main objective of this research is to analyze how sustainable construction and related regulations are being implemented in the city of Bucaramanga, Colombia, to identify its deficiencies. To reach this objective, the research will comprehensively reflect on the needs and issues identified by different stakeholders, considering their diverse perspectives and agendas. After that, it will suggest strategies to integrate sustainable construction practices with local-level governance processes to create a more sustainable city.

1.3 **Research Questions**

The research will answer these two main questions, the first regarding the status quo of the sustainable construction regulations, and the second more related to how sustainable construction regulations can better integrated.

- What is the degree of applicability of the sustainable construction regulations in Bucaramanga, and which are its deficiency factors?
- What can be suggested to improve the deficiencies factors of the sustainable construction regulations in the case of study and/or similar contexts?

1.4 **Research Methodology**

The research methodology is structured in two parts, the theoretical framework, and the empirical research. The empirical research was based on the collected primary data in the study area. The analysis was carried out using a mixed method of both qualitative and quantitative analysis. The data was collected using surveys, in-depth interviews, and semi-structured interviews. The chosen study case was Bucaramanga, Colombia, representing an intermedium city that can act as an example of replicability. The used data collection method varied depending on the stakeholder. First, semi-structured interviews were carried out for ecopolitical stakeholders and those involved in the technical application of construction codes (like construction companies), allowing in-depth conversations. The

second part of the data collection was based on surveys; these surveys were sent online and by doing the survey in person with the users in printed form to surpass barriers like the lack of access to technological tools to answer the surveys.

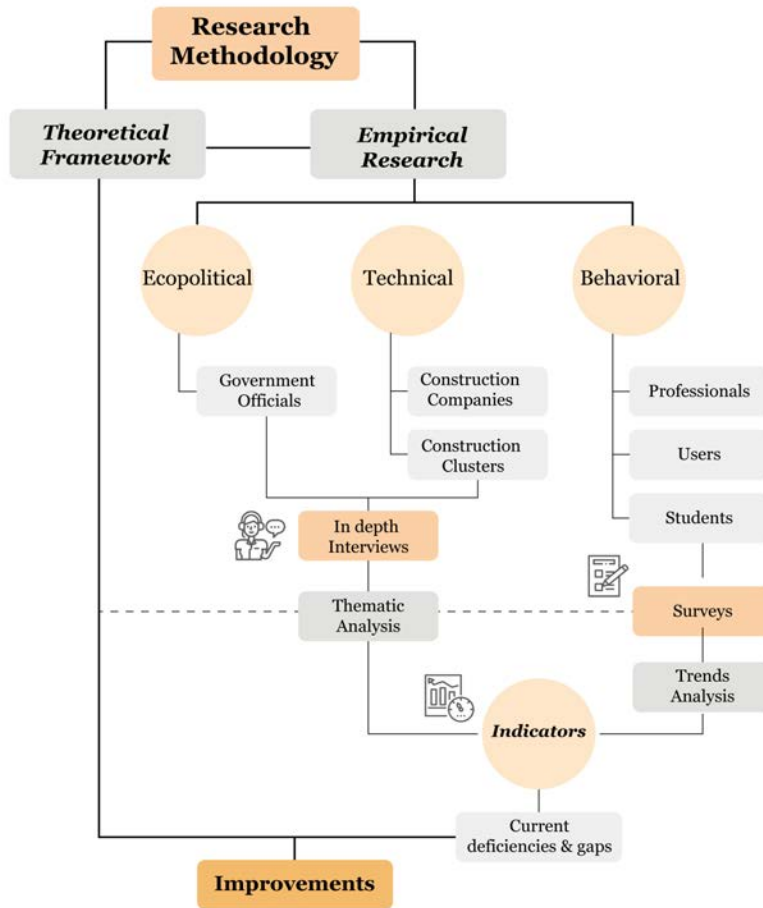


Figure 1. Proposed research methodology, Source: the author.

1.4.1 **Categorization creation**

To start with the research, the author defined a set of categories. These classifications aligned with the main obstacles to the implementation of building performance codes and related regulations. The main barriers are ecopolitical (compromising regulations, incentives, economic constraints, implementation, and control between others), technological (technologies, tools, and materials), and

behavioral (knowledge, education, capacity, interest). The research then, focused on the stakeholders that are directly interconnected with such barriers.

1.5 Research Scope and Limitations

This research will focus entirely on the local level scale and propose the improvements for the case of study, not trying to go towards all scales of governance, which will suppose more extensive research. One cause for this limitation is how energy building codes are enforced in Colombia; each municipality must oversee the application of the regulation (like resolution 549 of 2015). Because of that, this application level can vary a lot from city to city. It is then up to local governments to first place the law into effect and second to create the mechanisms to give incentives and the organisms to monitor and control them.

Colombia has a plurality of climatic, economic, and social contexts, because of that it was necessary to focus on one city considering the time limitations. Of course, this does not mean that the research and suggestion cannot be replicable in similar context, but the purposes of this research will be used as an example. In addition, this thesis will generally refer to building construction in general but will specifically focus on housing.

2. Theoretical Framework

2.1 Building performance codes in the Latin American context, issues, and possibilities

2.1.1 Definitions and concepts

Energy code: specifies how buildings must be constructed or how they should perform. These codes are written in mandatory, enforceable language. States or local governments adopt and enforce energy codes for their jurisdictions. (Bartlett, et al., 2003)

Energy Standard: describe how buildings should be constructed to save energy cost-effectively. They are published by national organizations such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). (Bartlett, et al., 2003). These standards are a recommendation which makes them of non-obligatory compliance. Most of the time, energy standards are a base for elaborating energy codes. For example, in Colombia, the ASHRAE 90.1 is the standard used as the base of the energy code from Bogota and Cali. (Alcaldia de Bogota , 2019), (Alcaldia de Cali, 2019).

Energy Performance Certificate: Certification showing the actual energy consumption of a building or apartment. With this consumption performance, buildings get a category that usually goes from A to H. In the case of Germany, issuing this certificate is mandatory when the owner wants to rent or sell as stipulated in the German Energy Act for Buildings (GEG) (German Federal Government , 2020). Green Building Certification Systems: a set of rating systems that aims to assess the building performance from a sustainability and environmental perspective (Hildebrand, et al., 2018). This work is done by introducing the building data in a software or application where the certification will be produced at the end. Auditors are accredited for a specific certification system (LEED, BREEAM, DGNB, EDGE, among others).

Energy performance method: by following this method, the issuing body assures that the building complies with at least the minimum values established in the energy standard by following the different charts and other considerations presented in the norm.

Prescriptive method: This method achieves compliance with the energy codes by simulating the building and then comparing it to a defined “baseline building.” This process is developed in an energy simulation software by introducing all the building relevant data (3d model and materials, localization) and then adding the weather file. After this, the model is checked and simulated commonly on a typical year basis. For a correct use of this method, designers need to have the specific U-values of the materials they will use in the specific projects. The U-Value shows a construction element’s ability to transmit heat by considering the surface thermal resistance of the faces of the element. U-values can differ considerably even for the same material (for example, a masonry brick) depending on its location.

2.1.2 The issue of applying international energy efficiency standards in Colombia

In Colombia, resolution 549 of 2015 (Ministerio de Vivienda, 2015) was issued to regulate the water and energy consumption in new edifications for non-social housing, large shopping malls (more than 5000m²), offices, hotels, universities, and hospitals. The resolution divides the consumption reductions by climate zone (cold, mild weather, hot, humid, and hot dry), creating a baseline of water and energy consumption and then determining how much the reduction should be for each type of building and climate.

One of the resolution’s first issues is the implementation guidelines (Ministerio de Vivienda, Ciudad y Territorio, 2014). These guidelines define the thermal comfort goal that the simulations should achieve. What is comfortable in a tropical country like Colombia can differ significantly from what can be found in the north part of the hemisphere. The law mentions that as a “general rule,” the comfort will be taken from 21 °C to 25 °C but does not give the reference from which

this measurement is taken. The goal of using the prescriptive method based on simulations will be to achieve that comfort level. However, that limit of comfort is relatively short when consulting related studies. A study in Bogota found that indoor temperatures between 20°C and 27°C have an 80% of acceptability. The authors conclude that applying the adaptative model made by ASHRAE could increase energy consumption, especially where satisfactory thermal comfort levels could be attained through natural ventilation. (García, Olivieria, Larrumbidea, & Ávila, 2019)

Different strategies can be applied to achieve a good comfort level. Still, when the comfort level is so low, it will tend to conclude that there is a need to incorporate active strategies like air conditioners or other types of HVAC systems. This situation is aggravated by the fact that a large portion of the energy consumption of a building comes from achieving a good thermal comfort level (Liu Yang, 2014). Multiple scholars have discussed the problem of applying international standards in the tropics (Rodriguez, 2019). Here, the authors point out how these methods have been widely criticized for not performing well outside the context where they were created, which leads to an overestimation of cooling needs in the case of warm-humid weather.

Typically, prescriptive methods have a table that stipulates the U-Value of the different materials for different building types; following the table and comparing to the material specified by the fabricant users can guarantee that the building complies with this. In Colombia, resolution 549 has the prescriptive method as a possibility. Still, it is just a table with strategies that the builder can mark if they have, without having to be verified.

The second way to prove compliance with the norm is using performance-based methods. For this requirement, builders must model the building using energy simulation software. In the case of Colombia, one of the main barriers to comply using a performance-based method is the educational barrier to using advanced energy simulation software and adding the economic barrier of having to buy the license for the software. These barriers could be overcome by creating a govern-

ment-based software and giving capacitation to the use of the tool; countries like Spain and Germany are examples of this.

2.1.2.1 Green building certifications in Colombia

After reviewing the route of application developed by other municipalities like Bogota and Cali (Alcaldia de Cali, 2019) (Alcaldia de Bogota, 2019), the standard that they use for applying the law is the ASHRAE 90.1. The ASHRAE is an American standard for high-rise buildings (more than three floors). Both application routes say that the candidate should check appendix G of this law for the resolution application for compliance. This standard is created for buildings with HVAC systems; for this reason, the Bogota law, for example, says that if the building is also using passive ventilation, one should still get the same results that appendix G. Often, international standards are just transported to a tropical context without an accurate reflection on the technicalities of it. As expressed by Rodriguez, one can think that these laws merely apply standards for regulating HVAC systems but do not address the causes of their demand. (Rodriguez, 2019).

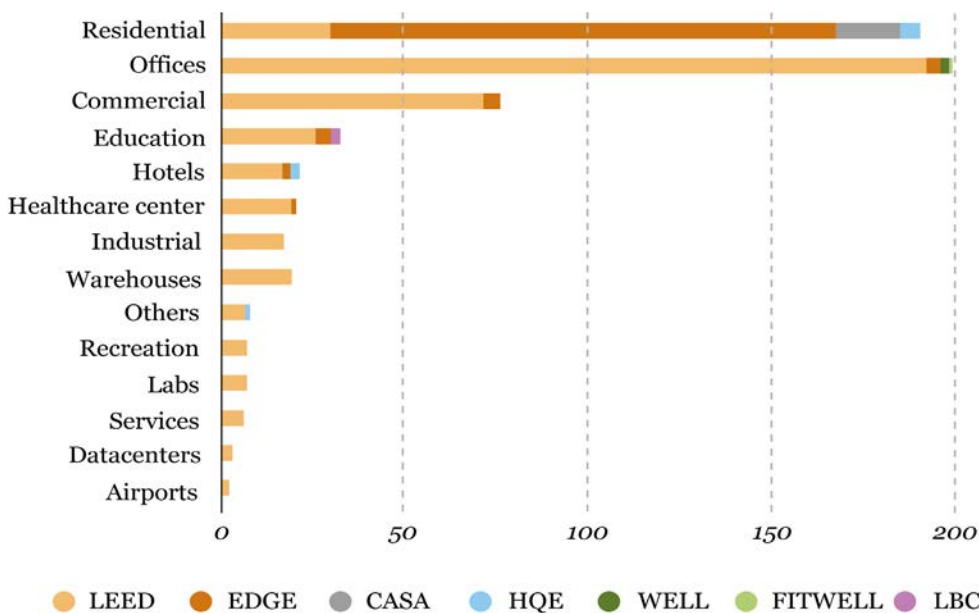


Figure 2. Numbers of projects by typologies of the certification codes in Colombia. Source: CCCS based on data for each certification company. Modified and translated by the author.

The certifications implemented the most in Colombia are LEED, EDGE, and

CASA Colombia. Most certificates are obtained for offices, comprising 32% of the certified buildings. On the other hand, residential units represent 21% of the market (CCCS, 2021). LEED entered the Colombian market in 2012 and was, until recently, one of the only certifications applied; today, other certifications have entered the market. However, LEED still has a significant market share. Codes like EDGE became a more predominant part of the certified buildings, especially after 2018. This situation is probably due to the partnership between CAMACOL (Colombian Construction Chamber) and the IFC (International Financial Corporation) to implement them. The EDGE certification in Colombia is based on the national law (resolution 549), which is outdated (no actualization since 2015), becoming an issue when adopting this certification. Nevertheless, most buildings that want an EDGE certification will get it without having to change much substantially. In Colombia, EDGE regulates mainly water and energy savings, requesting reductions in lighting and sanitary appliances already on the market. However, one of the tool's main advantages is its ease of use, having its own on-line applicative.

2.1.3 Research in energy code creation in the Latin context

Often, developing countries face a research gap. Multiples are the barriers, which more commonly are financial, lack of experienced personnel, lack of access to funds for publication, and lack of research infrastructure. In the case of sustainable construction, when compared with other nations, Latin America places low on the scale of publications (see fig.3).

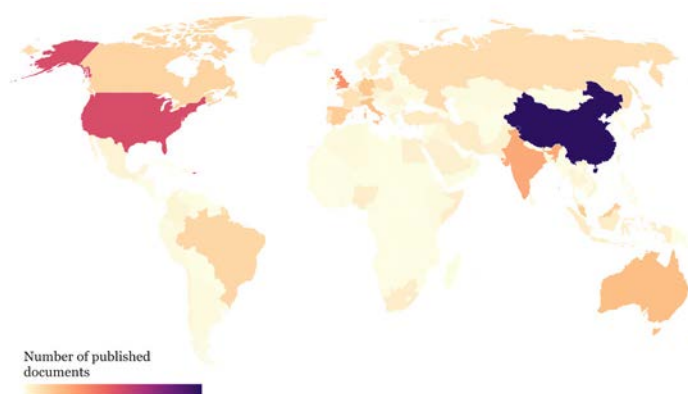


Figure 3. Published documents about sustainable construction in the world since 1970. Source: The author using Scopus Analytics, the filtered term “sustainable construction”.

Totals can portray a different reality, that is why when calculated the production of research in sustainable construction per capita, one can see where most of these products are made (see fig.4). It is interesting to see the amount of research produced in countries like Malaysia where results are similar that the ones in Norway and Sweden, being Malaysia a developing country.

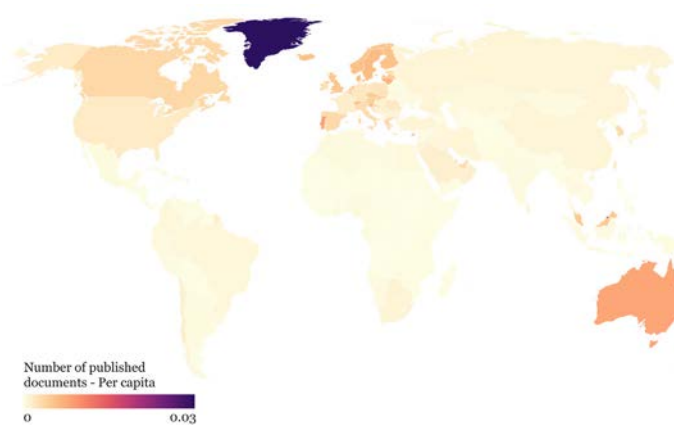


Figure 4 Published documents about sustainable construction in the world since 1970. Source: The author using Scopus Analytics, the filtered term “sustainable construction”. Adjusted per capita.

In applied research done in Latin contexts, researchers faced limitations in acquiring measurement instruments and issues applying accepted international methods due to the language difference (Rodriguez, 2019).

There is a lack of methodologies and available information resources in tropical Latin contexts. No country in Latin America has a material database with carbon emission values (De Wolf, 2017). Material databases are necessary for creating detailed energy code regulations and giving the constructors and designers the possibility of measuring their projects’ real carbon emissions impact. However, it also allows the consultation, research, and improvement of the sustainability of the construction sector, allowing to perform Life Cycle Assessments (LCA). The creation of materials databases is also encouraged by the United Nations CEPAL (Economic Commission for Latin America and the Caribbean *in Spanish*) in the report made in 2013. They thoroughly support the implementation of LCA in Latin America to analyze elements of policies for sustainable development. (Ruiz-Tagle, Samaniego, Jordán Fuchs, & Desarrollo, 2013).

However, there are good examples in the region of strategies to apply. In Peru, the government created a sustainable construction code (Gobierno de Perú, 2014), that is mandatory for construction licensing. The code contains the maximal values of thermal transmittance depending on the climate zone where the project will be located, also the list of the hygrometric characteristics of the Peruvian construction materials—a more extensive classification of each climate zone and the main cities that belong to each of them. Having a code made specifically for its location will allow a more straightforward implementation

2.1.4 Alternatives to traditional Energy codes

Traditional energy codes utilize one or both prescriptive and performance-based methods. Both methods are based on the calculation of virtual energy. One follows a table of rules with the hygrometric construction characteristics and other determinations, and the other uses simulations to prove a virtual energy performance given the morphologic features of the building and its components. However, both are based on estimates that do not guarantee that the results portrayed, for example, in the simulation, will be the actual total energy/water consumption. For this reason, we explore a different methodology, the outcome-based method.

As noted by (Evans, Halverson, Delgado, & Yu, 2014), traditional codes do not include other energy consumption means for the elaboration of the regulation. Energy consumption derived from plug loads like computers and small appliances is often left behind, same as occupancy patterns, users' behavior, and building maintenance. Resulting then in very different outcomes between reality and the simulation. The incorporation of an outcome-based certification could be a better alternative as it would regulate the building against itself, proposing an uncomplicated set of rules (Evans, Halverson, Delgado, & Yu, 2014), (Yudelson, 2016)

One of the most positive aspects of using the outcome-based method is that it addresses the regulation of the consumption of existing buildings, as this method can be applied to all existing and new buildings. Nevertheless, of course, there should exist different parameters for new and old. One cannot forget that the

issue of regulating the energy consumption of existing buildings is not minor since 70% of the buildings that will exist in 2050 are already built (Sustainable Development Commission, 2006).

2.1.5 The role of Local Knowledge

With the proliferation of Green Building Certification Systems and their implementation outside their original country, certifications ended up applied in vast climates, architectures, and socio-economic contexts. Often the codes are seen as a sign of progress and development. However, these certifications frequently impulse the dependence on specific materials and technologies, leaving behind local knowledge (Boschmann & Gabriel, 2013).

Local knowledge has proven to be a great resource in urban planning, especially for those at environmental and health risk (Corburn, 2003). Creating policies with locals' help would benefit the development of a more customized product. For example, understanding an area's climate conditions would require extensive study and data collection. Nevertheless, using local knowledge of the site will help to make this process faster and engage locals in creating their policies. Unfortunately, local knowledge is often left at the back. Frequently, community members are treated as ignorant of the technical hazards they endure. (Corburn, 2003). Nevertheless, in a study by Corburn where the team analyses multiple cases where local knowledge is or could have been used, Corburn concludes that community members can contribute with technical and political expertise.

Corburn also mentions the three ways local knowledge contributes to environmental policy (i) epistemology by making a cognitive contribution, (ii) procedural democracy by bringing excluded voices, (iii) effectiveness by identifying low-cost implementation options, (iiii) distributive justice by enlightening unknowledge residents. Integrating local knowledge with diverse forms of data collection will allow a heterogenic information tool to analyze the area comprehensively. Different approaches have been used to incorporate this knowledge using participatory GIS (Reichel & Fromming, 2014). (Pauli et al., 2021) used a combination of local and technical expertise to determine which areas were more propended to floods

and prioritize better resources. Another example is the study by (J. Jacobi et al., 2022) about the knowledge generated in sustainable development research derived from the analysis of the results of 54 studies. They investigated how and by whom the knowledge was used, what changes the study work achieved, and how non-academic actors were engaged. After assessing the stages of utilizing research knowledge, it was found that local community actors play a significant role in multiple stages, especially in social learning, empowerment, building trust, and application and replication.

One can find good examples of applied local knowledge with traditional architecture construction methods in Santander's towns. The houses were traditionally built by assembling big soil walls called "Tapia" these were the enclosing and structural walls. Then, the house was terminated by installing wooden ceilings with clay tiles. The houses are very extroverted, open to the exterior, and with high heights, allowing cross ventilation and performing well in the warm-humid weather of the region. They were also painted white using a lime mix to keep the house out of humidity and insects. What also helps to have more reflective surfaces, meaning it absorbs less energy and heat from the sun. They are being built even today but now switching to high-income households.



Figure 5. Workers of "tapia pisada" in Colombia. Source: Escala Urbana Arquitectura, Casa Mila project

Tapia construction is becoming a rare art slowly. That is why some organizations

in the area are working on teaching this construction tradition. These organizations empower local workers and allow them to technically develop their work and engage with people with little knowledge of construction. Nevertheless, they see this as an opportunity to connect with traditional knowledge.

To conclude this part, the author wants to reflect on the importance of bringing local knowledge into the policy creation, based on all the positive aspects that were exposed before, which can contribute to filling the information gaps in applying normative. Creating a framework that involves people will be necessary for elaborating a holistic, sustainable policy. Unfortunately, no experiences in the study area were found where communities get the opportunity to be involved in these laws' creation. This possibility is often limited to a few companies and public sector officials.

2.2 Deficiencies aspects

As was exposed in the research methodology, the categories for analyzing the different stakeholders come from their direct relation with the principal barriers to implementing sustainable policies and related initiatives. This part of the theoretical framework will expose the general aspects of these terms that constitute the basis of the research. It will, however, always reflect on the context of Colombia as a developing country.

2.2.1 Ecopolitical

2.2.1.1 Reaching the SDGs in developing countries

The SDGs are a set of global development targets adopted by the member countries of the United Nations (UN) in September 2015, aiming to set the global agenda for 2030. In its launching, the 193 UN members unanimously approved its adoption. In the case of Colombia, it was one of the first countries to incorporate it into the National Development Plan in 2016 (World Business Council, 2022). The SDG comprehends 17 objectives, touching thematic like education,

equality, clean access to water resources, sustainable communities and cities, and climate protection, among others.

Nevertheless, reaching sustainability in developing countries is still a notorious task due to the lack of economic resources. This situation is aggravated by the COVID 19 pandemic, where 73.9 million in 2020 have been pushed into poverty (Moyer, 2022). The world after the pandemic, combined with the exacerbated effects of climate change, purposes an uncertain future for all, but especially for communities at higher risk. For this reason, governments in developing countries need to act soon and strategically. Knowing the constraints of developing countries, a study from the IMF discusses the need to prioritize the areas where investments would significantly impact reaching the SDGs by 2030. They found that in the countries of study is necessary to increase funding by 14% of the GDP to achieve the 2030 goal. The new strategy is then to pursue a highly ambitious reform agenda that prioritizes fostering growth, Strengthening the capacity to collect taxes, Enhancing the efficiency of spending, and catalyzing private investment (IMF, 2021).

Colombia places 75 in the SDGs ranking being the weakness points its performance for decrease poverty and reduce inequalities. The country then, is Stagnating in areas like hunger, gender equality, sustainable cities, life on land and pace among others. The two only areas where the country is on track or maintaining the SDG goals is in climate action and responsible consumption and production (The Sustainable Development Report, 2022).

2.2.1.2 Colombian political system

Colombia has a hybrid organizational system and political centralization, and decentralized administration. The branches of public power are three, an executive with the president as a supreme administrative authority in the national order, and then governors at the state level and city majors at the local level. The legislative is composed of two chambers: the Senate and the House of Representatives. The job of the legislative branch is to create the laws, exercise control over the

national government (executive power) and do reforms to the constitution if necessary. Finally, the judiciary power is composed of the Supreme Court of Justice. The judiciary oversees dispensing justice, settling disputes and controversies between citizens and the government, and making decisions on contentious legal matters with the force of definite truth. It is then a faculty of the national government to create the laws that will affect each state, but the state must administrate these laws and guarantee compliance.

2.2.2 Technical

2.2.2.1 Technical development and materials

The technological development of Latin America's housing construction sector is still underdeveloped. Self-made constructions are a significant part of how housing units are built. It is estimated that 75% of housing built annually in the region is informal (The World Bank, 2017). The socio-economic inequalities manifest on how new developers are being generated, with the urban low-income residents relegated to the sprawls of the city, lacking access to public infrastructure, and placing their homes often in risk areas.

Considering the urban growth of Latin American cities, where is estimated than 75 percent of the population will live in urban areas by 2050 (The World Bank, 2017). It is the labor of the government to provide housing options. Nevertheless, most countries in Latin America have qualitative and quantitative deficits. To surpass this issue, people often create their own houses to supply that demand. In the case of Colombia, is consider that at least 50% of the new construction is built informally (Contreras Ortiz, 2017).

The construction methods then to be very artisanal, with the employment of little to no technology and with unqualified working force. Nevertheless, in Colombia, different initiatives have impulse the qualification of the construction workers "maestros de obra," which gives them more technician knowledge and access to a formal training degree that helps them find jobs and move more into

the regulated and formal workforce. These initiatives are done by the Colombia National Learning Service *in Spanish* SENA and other ONGs like Swisscontact, an international organization that also has done similar jobs in Peru with the initiative *Promotion of safe, healthy, and sustainable construction practices in vulnerable urban areas* (Swisscontact , 2022)

This informality in the construction sector affects the quality of the housing produced. A study made by the BID found that the housing deficit in Latin America is just 6%, but the quality deficit is 94% (Rossel, 2018). The main challenge pointed out by the author is the high percentage of informality in the economy and employment sector. The informality of the land makes it harder to obtain ownership over the property. This condition is very negative when other procedures like registering property, transferring titles, and obtaining loans and credits for housing.

2.2.3 Behavior

2.2.3.1 Socio-cultural aspects addressed in the housing sector

The UN defines that for the housing sector to be socio-cultural sustainable, it requires to be affordable, inclusive, secure, and have good quality producing healthy residential areas and communities. They emphasize the importance of considering cultural worldviews, values, norms, traditions, lifestyles, and behaviors of the communities where a particular policy wants to be implemented. The social dimension must be considered and counterbalance other economic, environmental, and cultural aspects. (UN Habitat, 2012). According to some, the cultural dimension not only plays a significant role in achieving development but also serves as the foundation for the growth of local communities (Shehayeb, Borham, & Abdel-Hadi, 2013).

Housing can be affordable and sustainable. Initiatives like this have been done in the past; a good example is Mexico's strategy for sustainable, affordable housing. The National Housing Commission created in 2007 a massive housing project which meant that a lot of carbon emissions would be generated from it if con-

structured with traditional methods. In contrast, the Mexican government launched “Hipoteca Verde” green mortgage, which gives subsidies and credit incentives to the dwellers developed with energy efficiency design and technology, lowering the burden of the initial application costs of these technologies.

Sustainable housing should also consider all inhabitants from all backgrounds in the city dynamics. New developments should not send the most unprivileged people to the periphery but care for providing suitable quality social spaces, giving all city residents (even those from low-income neighborhoods, traditionally excluded) the right to the city. Incorporating cultural aspects into the creation of assessment tools and policies is necessary to reach sustainability. The authors (Qtaishat, Adeyeye, & Emmitt, 2020) proposed a systematic framework to incorporate this since most building sustainability evaluation methodologies typically do not consider non-tangible non-environmental or socio-cultural indicators of sustainable human living.

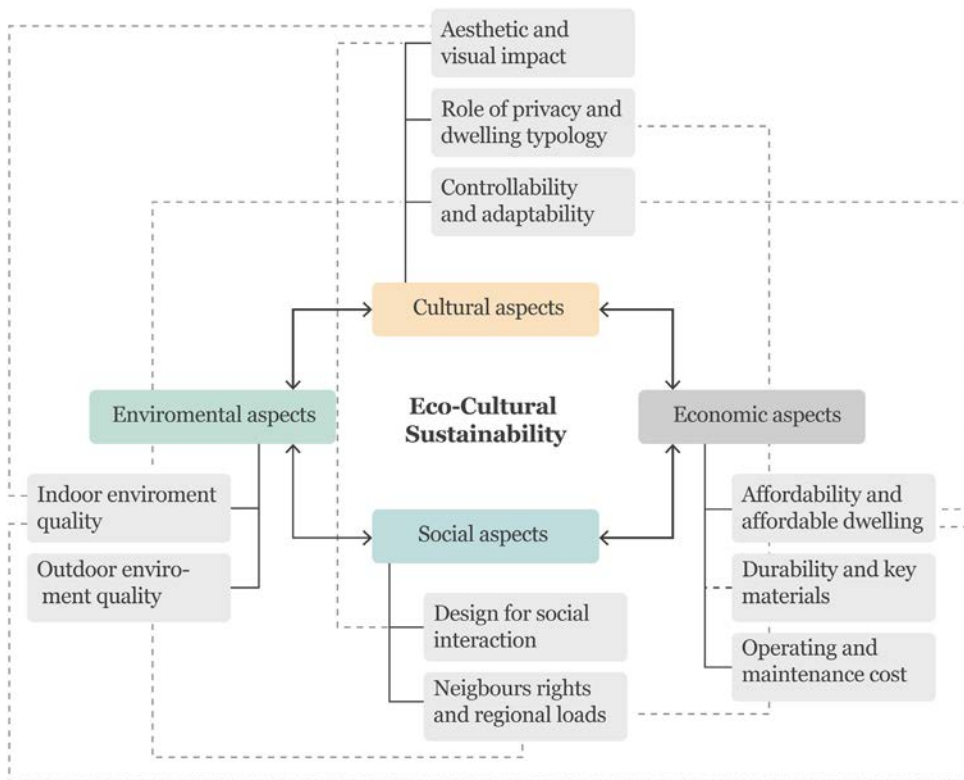


Figure 6. Eco-cultural sustainability. Source: (Qtaishat, et al., 2020), edited by the author.

The authors proposed incorporating cultural aspects like the aesthetic, visual impact, privacy preference, controllability, and adaptability alongside the social elements to assess social interaction and enhance neighbors' rights. In this way, the research explores the need to add more abstract and qualitative indicators to existing measuring tools, like in the case of green building certifications. It is necessary to find a way to include trade-offs that help decision-makers to compromise when all factors cannot be reached to their full extent.

2.2.3.2 Poverty and inequality

a. Access to water and basic services

Access to public services varies greatly depending on where one lives. Interior states like Antioquia, Santander, and Valle del Cauca have consistent access to energy, clean water, and gas services. Sewage coverage is deficient in several states. Only a few of them have more than 80% of the range. This situation is exacerbated by being highly populated states. There is a relationship between poverty, education access, and the percentage of university professionals per State. Analphabetism is very high in the country's periphery, compromised by the Caribbean and Pacific coast, and the area called "Llanos Orientales", Eastern plains next to the border with Venezuela. However, this is more evident on the Caribbean and Pacific coast (see fig. 8). Putting it together with the population density, one can see that a considerable percentage of inhabitants live there, which means that there is no equal access to education to an significant part of the country. Of course, this is due multiple reasons. One of the most influential is the multidimensional poverty in those areas.

The results show a similarity if one match both illiteracy (see fig. 8 left) with poverty (fig.9 right). Adding to that, the percentage of illiteracy and the percentage

of people with professional degrees are inversely proportional.

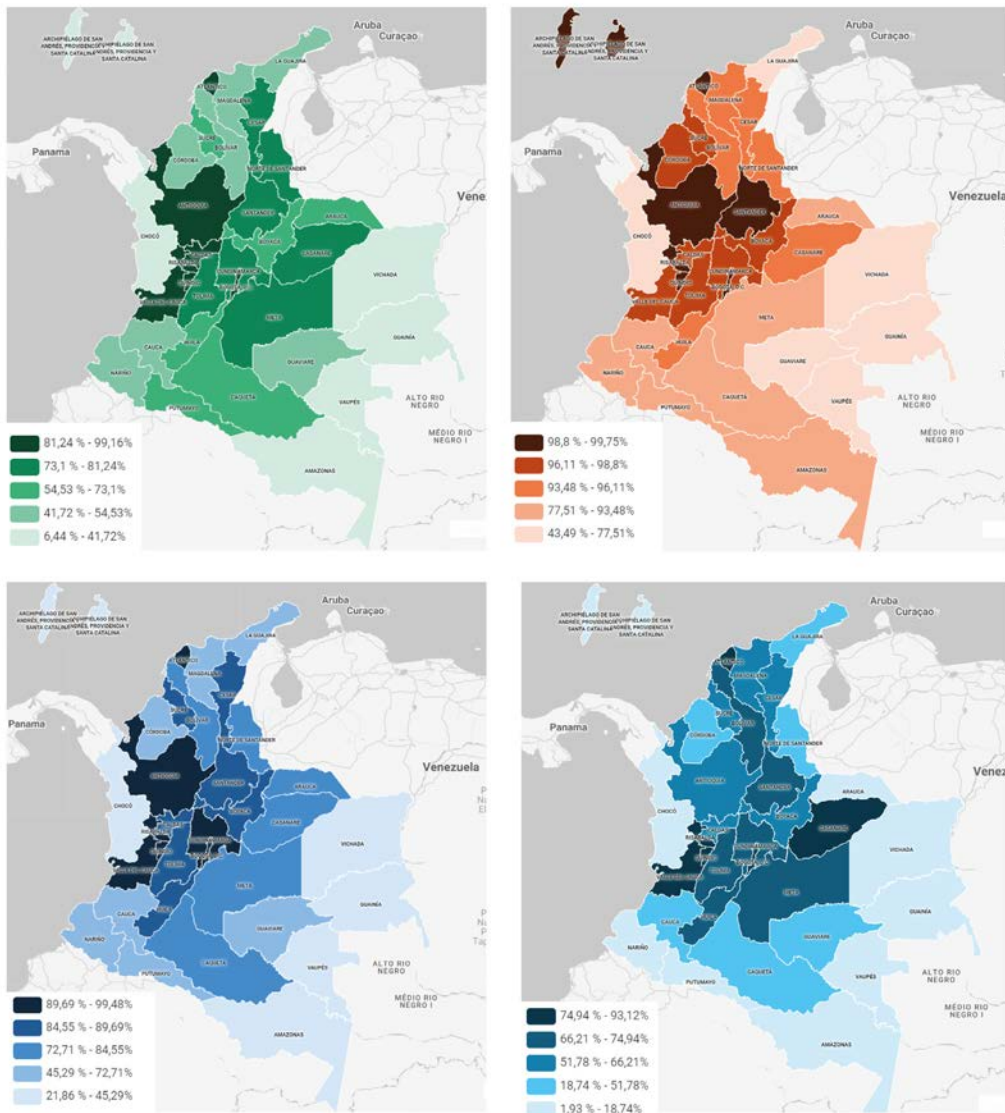


Figure 7. Do you have access to... sewage system (top left), energy (top right), clean water (bottom left), gas? (Bottom right). Source: DANE 2018.

The country's south has a huge lack of services with states with sewage coverage between 6,44% to 41,72%; water access from 21,86% to 45,29%; gas from 1,93% to 18,74% (see fig,7). When crossing all the data from average to public services with the population density, the most affected states are Nariño, Cauca, Boli-

var, Cordoba, and Magdalena, all located on the Pacific and Caribbean coasts. However, till today, the problem of the lack of sewage coverage in these parts of the country seems not to find a solution. Local papers have highly reported the lack of coverage on the Caribbean coast (El Herald, 2021). There are multiple reasons why this continues to happen, like the limited restraints on mining and infrastructure mega-projects, the absence of planning, the systematic disregard for the needs of the poorest, and the lack of an environmental culture. Also, the distribution of aqueduct and sewage operators across the region—4 in Atlántico, 41 in Bolivar (nearly one for each municipality), 15 in Córdoba, and 6 in La Guajira—must be added to these criteria (El Herald, 2019).

One of the most significant reasons for the underdevelopment of public services is poverty. According to Dane, among the ten departments in the nation with the largest percentage of people living in poverty—well above the national average of 39.3 percent—are La Guajira, Magdalena, Córdoba, Cesar, Sucre, and Bolivar. To improve this problem, the local governments have asked the incoming administration to advance the energy transition, sustainable transportation, and ongoing or completed coastal preservation projects (Caracol, 2022).

b. Inequal distribution of knowledge

There is a relationship between poverty, education access, and the percentage of university professionals per State. Analphabetism is very high in the country's periphery, compromised by the Caribbean and Pacific coast, and the area called "Llanos Orientales", Eastern plains next to the border with Venezuela. However, this is more evident on the Caribbean and Pacific coast (see fig. 8). Putting it together with the population density, one can see that a considerable percentage of inhabitants live there, which means that there is no equal access to education to an significant part of the country. Of course, this is due multiple reasons. One of the most influential is the multidimensional poverty in those areas. The results show a similarity if one match both illiteracy (see fig. 8 left) with poverty (fig.9 right). Adding to that, the percentage of illiteracy and the percentage of people with professional degrees are inversely proportional.

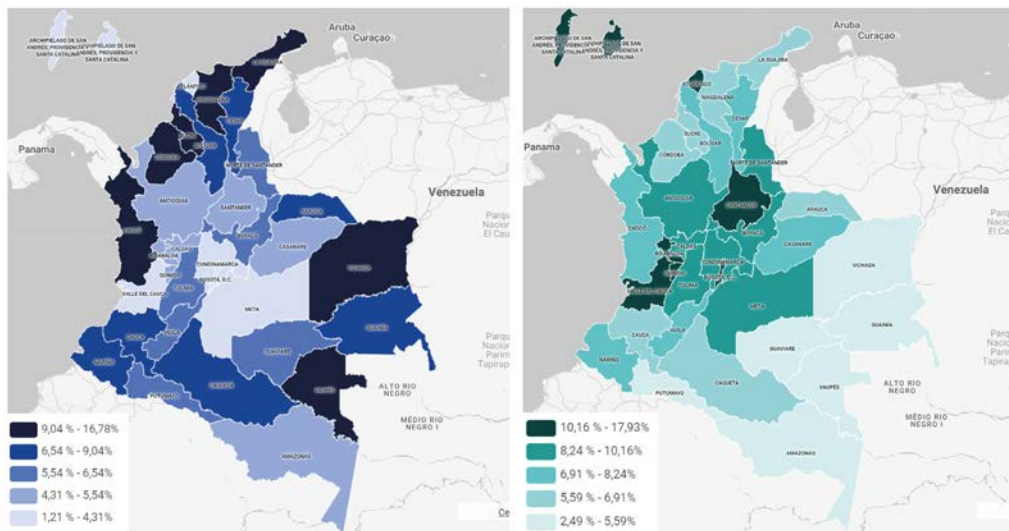


Figure 8. *Analphabetism (left), and percentage of professionals (right). Source: DANE, 2018*

It is worth mentioning that the four states (see fig.9) with the most considerable percentage of people with professional titles all have high-ranked public universities (Universidad Industrial de Santander, Universidad del Valle, Universidad Nacional-San Andres, and Universidad del Atlántico). This case does not consider Bogota DC, which concentrates most of the country’s universities. Being also highly populated states, the impact on the total of available professionals shows the importance of having available, affordable public education.

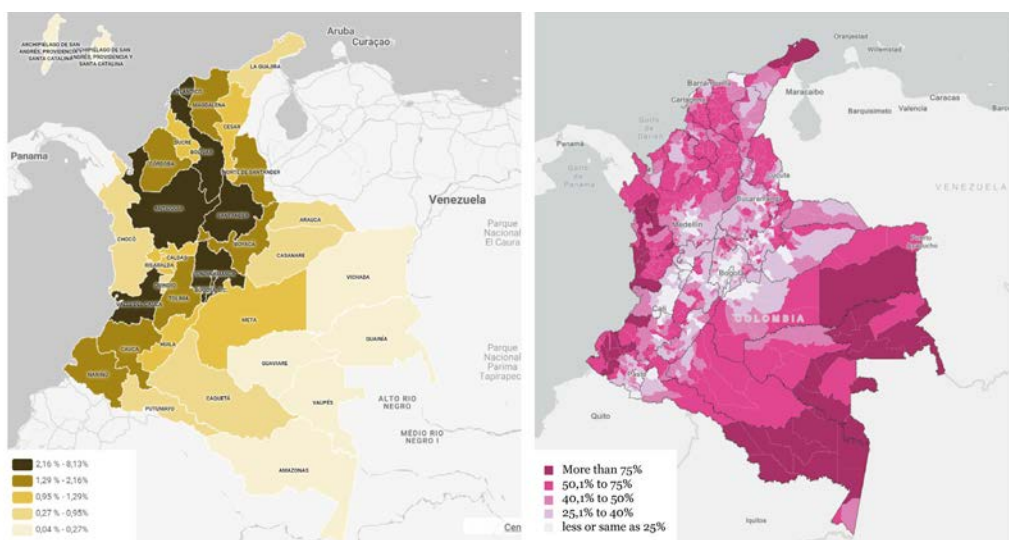
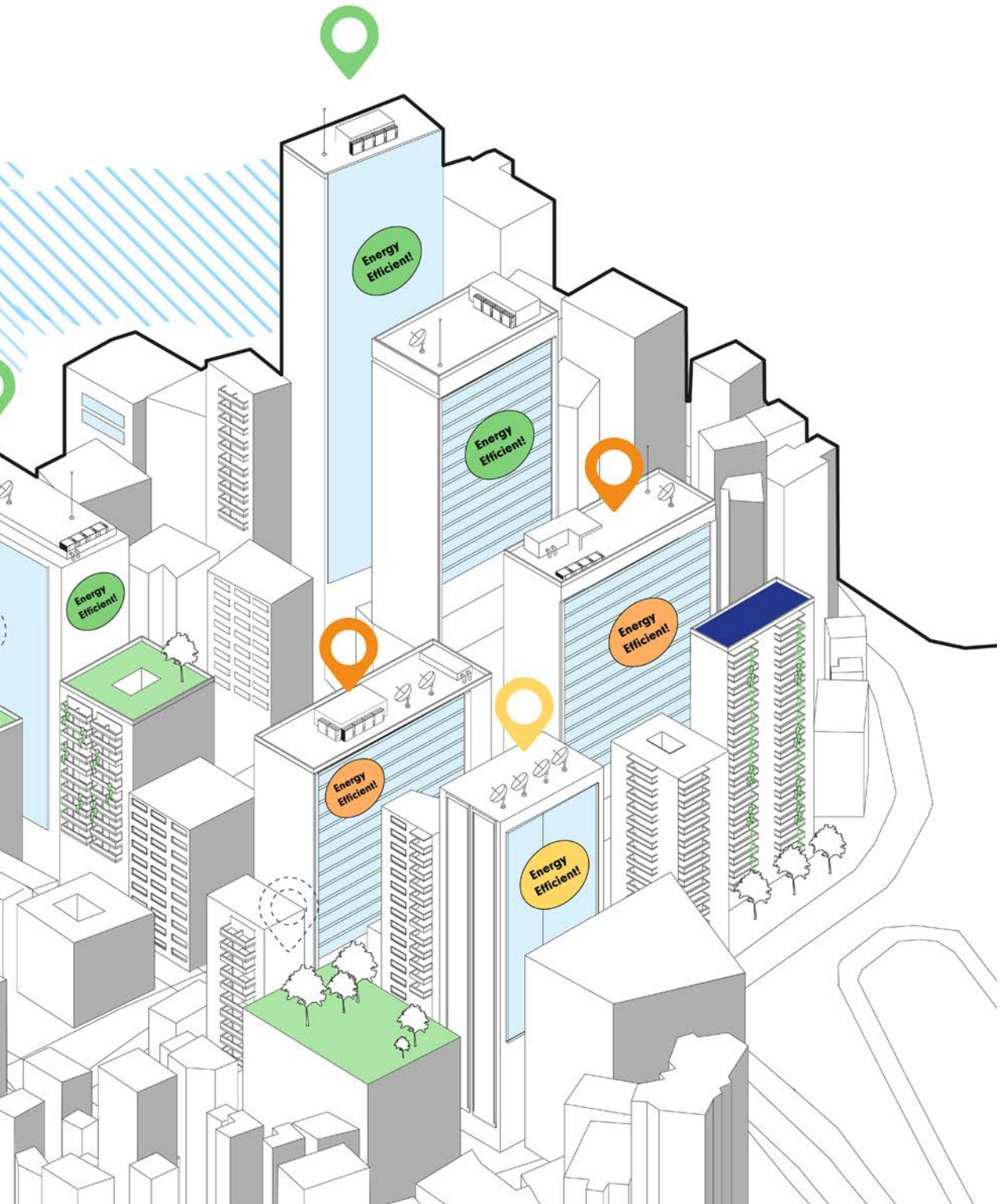


Figure 9. *Percentage of the country population living in that state (left), multidimensional poverty (right). Source: DANE 2018.*



Part 2. Empirical Research

Fig. 10 Illustration by the author



3. Context

3.1 Election of the study case

To start the election of the study case, this research investigated if there has been some data from the government over the implementation level of resolution 549 of 2015, which limits water and energy consumption. For this reason, the National Planning Department produced the CONPES 3919, one of Colombia’s main planning instruments (Departamento Nacional de Planeación, 2018) stating the state of sustainable construction in the country in that moment. The government found in regard of the resolution, as is shown in table 1, the bigger cities in the county have a better knowledge of resolution 549. This situation was one of the reasons why this research had an intermedium city (Bucaramanga, Colombia) as the study area. Since knowledge, implementation, and control issues are more pronounced than in the larger cities. Nevertheless, in general, all of them fail to control the law and have a medium level of implementation, meaning that they have the documents and instruments. Nevertheless, no organism control or implement it fully. One can conclude that the resolution is not being applied in most countries. Only 11 municipalities have adopted it (Bogota and the ten towns from Valle de Aburrá). As can be seen in Tab.1 The level of implementation and control of the different municipalities varies greatly.

Recognition System	Bogota D.C	Medellín	Cali	Barranquilla	Villavicencio
Knowledge	●	●	●	●	●
Implementation	●	●	●	●	●
Control	●	●	●	●	●

Level	Knowledge	Implementation	Control
High ●	Knows and understands the resolution	Has documents and instruments aligned with the resolution	There is a mechanism of control adopted
Medium ●	Has heard about the resolution	Has documents and instruments but not aligned with the resolution	There is a plan for adopting control mechanisms
Low ●	Does Not know about the resolution	Has no documents not instruments aligned with the resolution	There are no control mechanisms

Table 1. Source: CONPES 3919 (2018), National policy of sustainable edifications modified by the author.

Nevertheless, this research will not be limited to suggesting better strategies to implement this law (resolution 549 of 2015). But it will look into the sustainable construction certification system holistically, finding the issues of the existing laws and suggesting more suitable alternatives.

3.2 Location



This research takes place in South America, in the country of Colombia. To be exact, in the state of Santander, located in the northeast part of the country, close to the border with Venezuela. The chosen city was Bucaramanga (Santander's capital) and its metropolitan area, as the research wants to focus on a local case study.

Figure 11. Santander, AMB location. Source: the author.

Santander is the sixth state by population size in the country. The metropolitan area of Bucaramanga houses more than 60% of the state's population. The topography of the state is divided between mountainous areas and plain areas. Separated from the body of the mountain range, there is a set of medium-elevation mountains in the center of the department, the "Serranía de Los Yariguíes." The rest of the state has a flat topography, part of the "Magdalena Medio," a region rich in swamps and grazing areas. Santander has a diverse economy. The composition of its PIB is divided by the services sector as the one that contributes the most to the PIB with 32.9%, then followed by Industry at 17.1%, commerce at 12.3%, construction at 6.9%, agriculture at 8.7%, mines at 3.6% (DANE, March, 2020).

3.3 Background

This research takes place in Bucaramanga, Colombia. However, as the city is situated in a metropolitan area that is deeply interconnected, the four municipalities of the metropolitan area (Bucaramanga, Floridablanca, Piedecuesta, and Giron) are being considered for the surveys. One person can live in Bucaramanga but work in Floridablanca, for example. Furthermore, as the state's capital, Bucaramanga is the municipality with most of the power in the local policies creation and application. Because of this, the local entities that participated in this research at the local level belong to Bucaramanga's City Hall.

Bucaramanga is in the northeast part of the country over 959 MSL. It is located over one of the three mountain ranges, a bifurcation of the Andes mountains, influencing its warm-humid climate. The city has 1.160.694 inhabitants in its metropolitan area, making it fifth in the ranking of metropolitan areas in the country. One of the particularities of this part of the country is its location in a zone of high seismic activity (Portal Servicio Geologico, 2018). Three seismic faults passed over the city, Santa Marta, Río Suárez, and Bucaramanga. Additionally, another issue that puts the city at risk is its high proximity to rivers due to the construction of dwellers overtaking the rivers' buffer areas which makes the city vulnerable to natural disasters.

3.4 Economy and emissions – State level

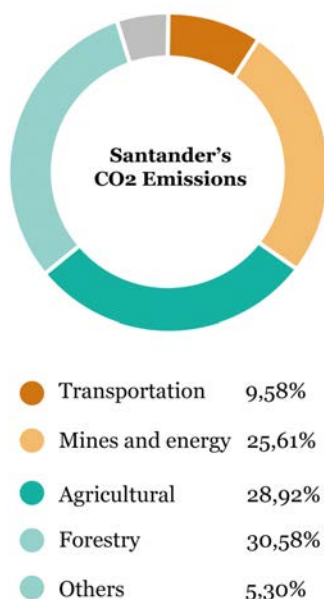


Figure 12. Santander's emissions by economic sectors, (IDEAM 2016) Edited and translated by the Author.

The state of Santander is ranked four in the PIB per state in Colombia (DANE, 2021), and the sixth for the total of inhabitants. Santander's economy and emissions do not seem to go hand in hand. The state refines 73% of the country's oil, and the refinery processes of fossil fuels like gas and petroleum occupy 20% of the state's carbon emissions (IDEAM, PNUD, MADS, DNP, CANCELLERIA, 2016). Still, mines (oil extraction included) only generate 3,6% of the PIB, same with agriculture producing 28.92% of emissions (see fig.7) but only gives 8,7% of the PIB. The changes in the natural land cover from native forest to grassland for beef cattle or other agricultural uses are the next in the account for generating 30,58% of the state's carbon emissions. Transportation and the emissions derived by enteric fermentation of the bovine species are last on the list with 9,58% and 5,30%, respectively.

Barrancabermeja's refinery located two hours from the capital, Bucaramanga, attracts many workers from all over the country. The map (fig.8) shows that the areas with the most significant net emissions are the whole region of the Magdalena Medio, where the refinery is located, along with most of the beef cattle areas. The next red areas are the metropolitan area of Bucaramanga AMB, where most of the state's services are located. Bucaramanga for being the capital of the states attracts a lot of workers, that come from the nearby towns to have access to university education, higher level hospitals, entertainment among other services.

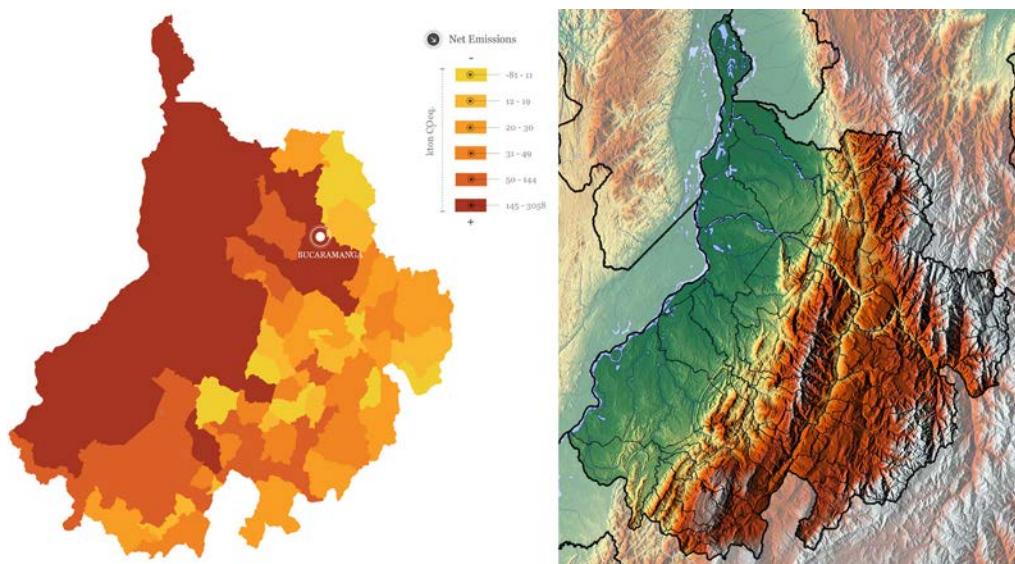


Figure 13. Santander Net Emissions (IDEAM 2016) Edited and translated by the author.

3.5 Competitiveness index – Metropolitan Level

In the competitiveness index created by The Private Competitiveness Council and the University of Rosario, an exercise that was made as an input for the follow-up and monitoring of the management of territorial competitiveness (Consejo Privado de Competitividad, 2021). In this list, the Metropolitan Area of Bucaramanga AMB places fifth. The city carries almost half of the added value of the state, all concentrated in 3,6% of the state’s area. This places the AMB as a significant place for both the country’s economy and the creation of laws that can influence the future of sustainable construction development.

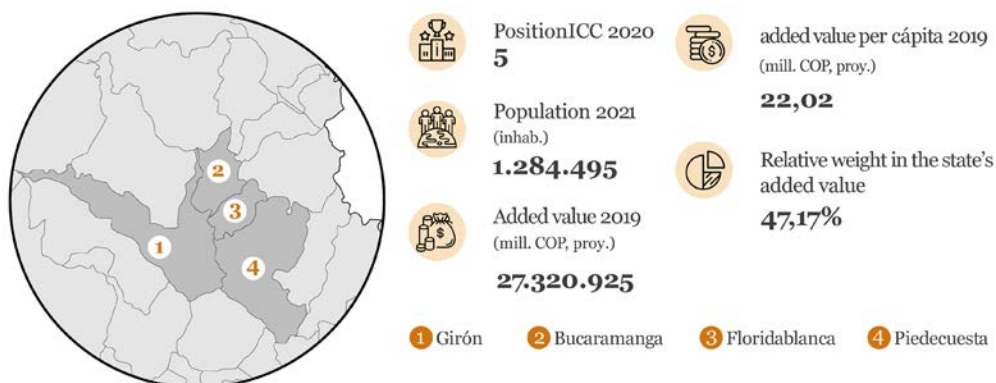


Figure 14. Position of the Metropolitan Area of Bucaramanga AMB in the competitiveness index by the Private Competitiveness Council. Edited and translated by the author

The competitive index is divided into four areas, enabling conditions, human value, market efficiency, and Innovation ecosystem (see fig.10). In the list, each element has a classification based on a disaggregate list. The index gives the result per category and which city was the best in that classification. The cities that place at the top are Bogota, Tunja, Arauca, Pasto, Manizales, Cali, and Medellin. Most of these cities are intermedium cities.

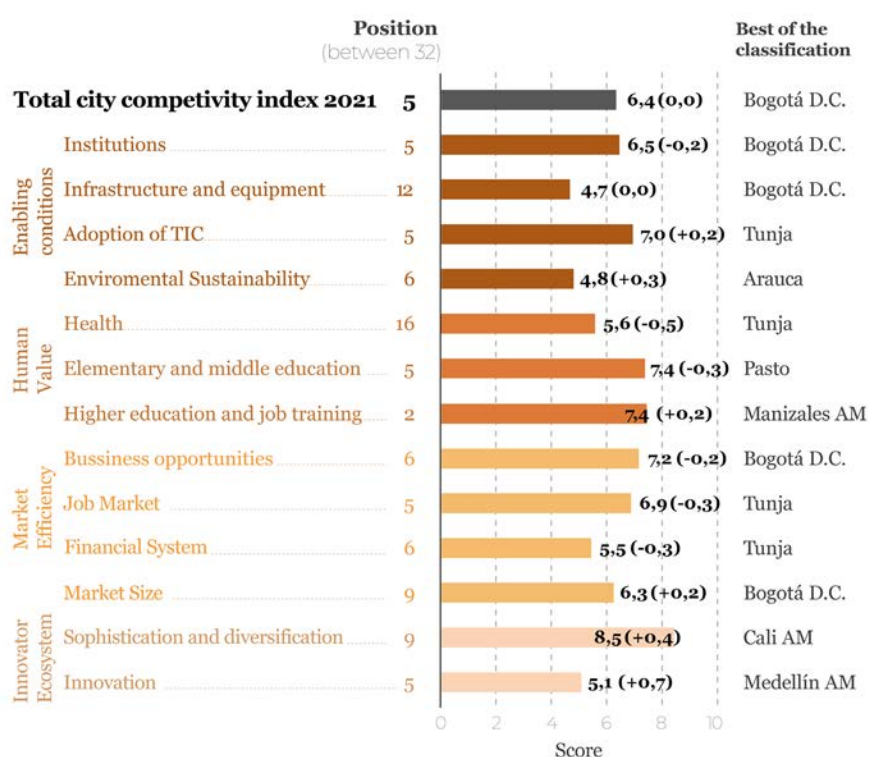


Figure 15. Competitive level of the Metropolitan Area of Bucaramanga compared nationally. Source: ICC 2021, edited and translated by the author

The report places the AMB in a good position regarding education and lowers on health, infrastructure, and equipment. It also puts it sixth on environmental sustainability, but when checking the breakdown of this classification, the AMB places 26 in CO2 emissions and 19 on deforested forest areas (see tab.2).

PILLAR 4: ENVIRONMENTAL SUSTAINABILITY	4,8	6
AMB-1 natural assets	6,43	10
AMB-1-1 Protected areas	7,73	4
AMB-1-2 CO2 emissions from fixed sources	2,23	26
AMB-1-3 Deforested Forest area	9,35	19
AMB-2 Environmental and risk management	3,17	8
AMB-2-1 ISO14001 certified companies	2,9	6
AMB-2-2 Investment in environmental services	3,45	8

Table 2. breakdown of the environmental sustainability calification

Although then, the city only reached this sixth place because it has a good portion of protected areas and ISO14001 certified companies. However, one can wonder if this is truly important when the principal reason to have these accredited companies and protected areas is to deforest less and reduce the city's carbon emissions. Therefore, this shows the importance of disaggregating these rankings to comprehend the issue entirely.

3.6 The housing sector in Bucaramanga and its metropolitan area

Most of the typology of the housing units in the AMB are apartment buildings (see fig. 16) Floridablanca is the city with the highest percentage of them. On the other hand, Giron is the only one that has more houses than buildings. This case can be explained due to the Spanish architectonic heritage of the town, where one and two-floor houses are the most common type.

Figure 17 gives a perspective on the materiality of the housing units in the metropolitan area of Bucaramanga. The primary construction system is masonry construction with concrete columns and wood roofs. Poured concrete in the form of structural walls traditionally used for high-rise buildings takes a more significant margin of the construction typology in Bucaramanga compared with the other municipalities. Homes made with materials like wooden planks and recy-

clad-mixed materials account for approx.—2% of the housing units in the metropolitan area. (DANE, 2018). Then, one can infer that approx. 2% of the city has informal settlements with low to precarious conditions.

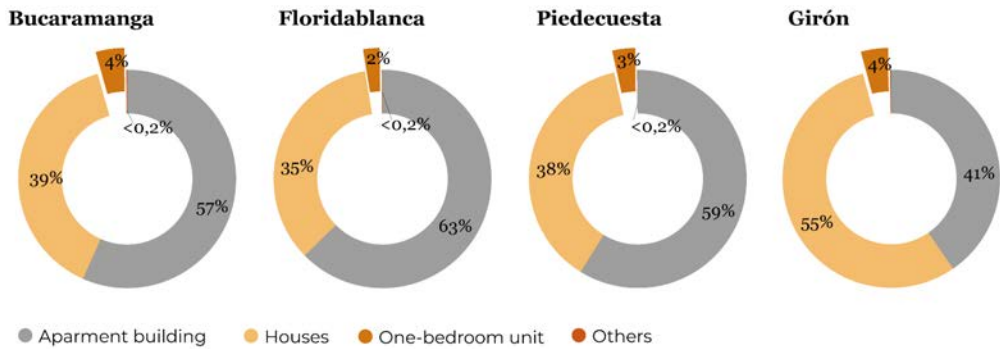


Figure 16. Construction typologies in the AMB, source: the author based of National Population and Housing Census 2018, DANE.

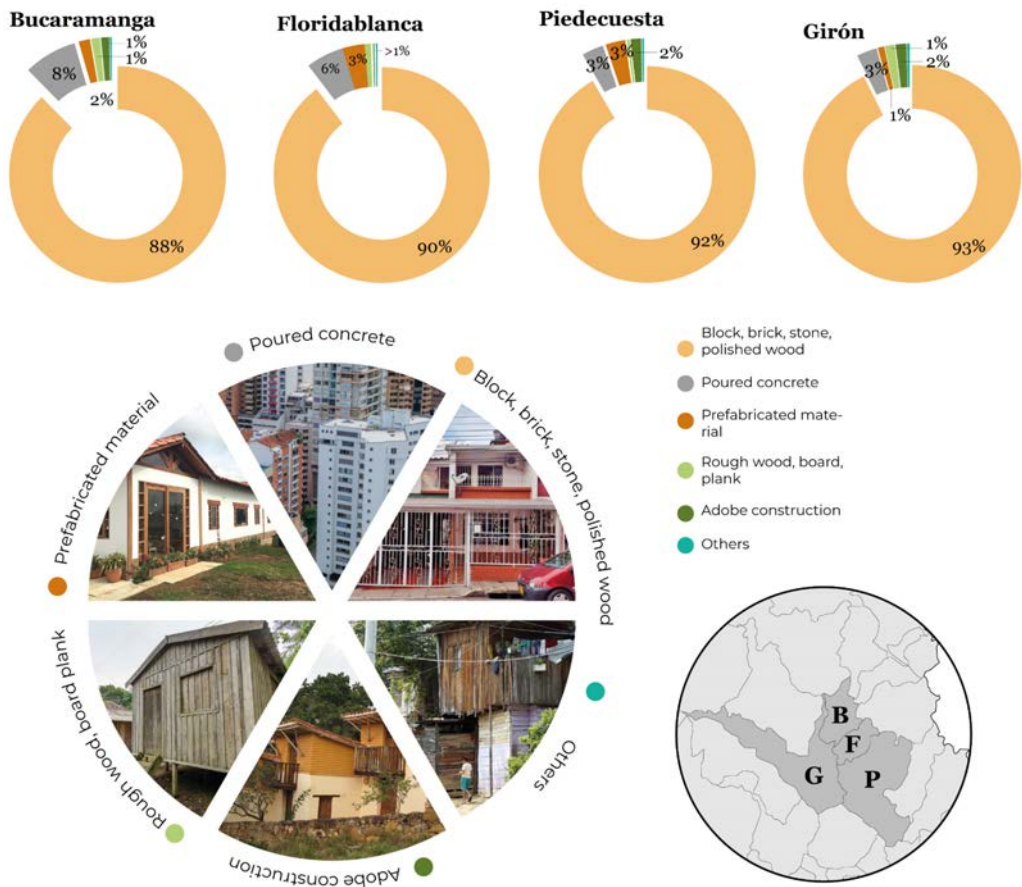


Figure 17. The author based on the National Population and Housing Census 2018, DANE, the source of housing materials in the AMB.

Colombia is a country of high contrasts. Inhabitants of the urban areas can access

education and services, but for their counterparts in rural areas, access to education is no guaranteed. That is why many travel to middle or capital cities to access education. As the research explored in the theoretical framework, there is a lack of vital public services like water, electricity, or gas in rural areas, a condition that differs significantly from state to state. In the case of Santander, there is a significant difference between each municipality, some of them having significant qualitative deficits and others quantitative. In the case of the eight most populated cities in the state, the qualitative deficit is the main issue, going as higher as 42,58% in Puerto Wilches (see Fig.18). In the AMB, the average qualitative deficit is 19,06% of the housing units and 4,46% for the quantitative deficit.

Defeating this deficit is one of the main priorities of both state-level and local-level officials. Therefore, they carried out projects such as “Casa Digna Vida Digna” (Decent house, decent life). Fortunately, Santander is not one of the states with the highest margin as it has a 12,9% poverty indicator compared with states on top of the list like Guainía and Vichada, which have more than 55% of the population in poverty (DANE, 2018). Yet, it is still a critical subject that must be addressed when creating sustainable housing policy in the metropolitan area.

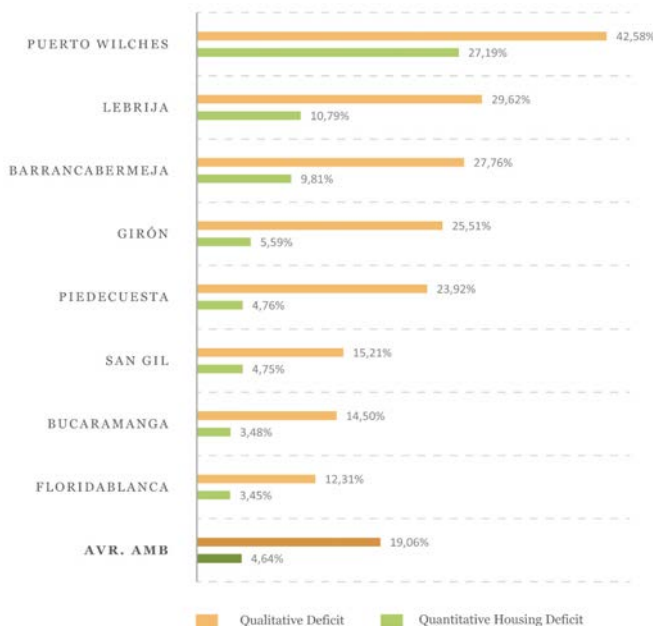


Figure 18. Qualitative and quantitative deficit of the main eight cities in the state of Santander. Source: The author, based on Terridata 2018, with data from DANE

Most of the developments in the city are made “plot by plot,” which gives the city a heterogeneous architecture typology image. This situation happens since most of the construction companies in the city are micro-companies, often offices of one architect that singularity develops plots owned by the clients. Supporting data from the Construction Chamber of Colombia (CAMACOL) shows that these micro-companies comprise 80,1% of the number of offices in the city; the category given for firms that receive less than 32.988 UVT yearly (a UVT in Colombia for 2022 is 38.004 COP) meaning then approx. 300.000 USD per year.

Nowadays, only large companies are invited to any sustainable talks, and they are only less than 2% of the construction companies in the city (Camara Comercio Bucaramanga, 2021). This case is even less in architecture design offices, where big companies account for less than 1% of the offer (see fig. 19).

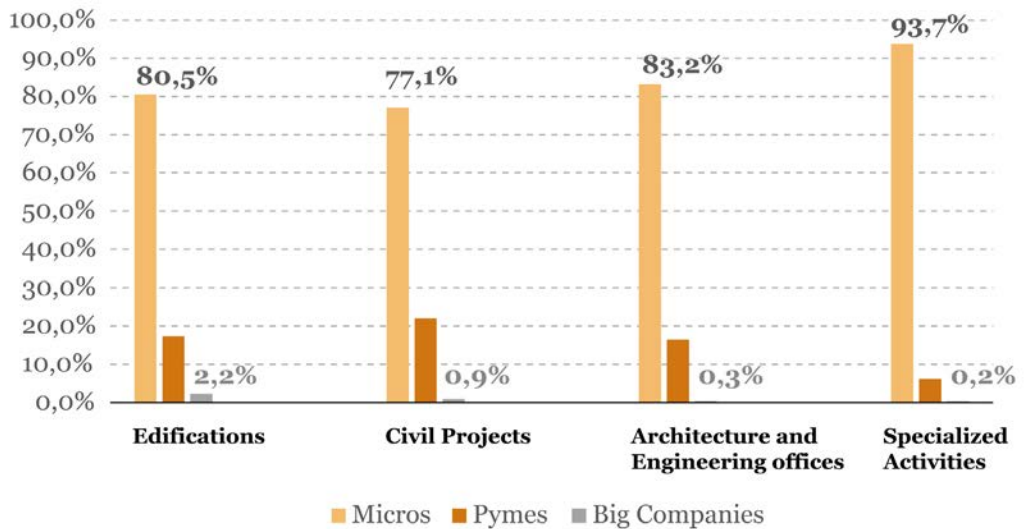


Figure 19. Companies' composition in Santander, Source: The Author based on Camara de comercio, 2021.

4. Empirical Research

This research has recollected data from different study groups to understand how the various stakeholders see sustainable construction and where the main implementation gaps are. This process is done to see each group’s most determinative aspects, differences, and similarities. In the end, the proposed suggestions will specifically tackle each group’s needs.

4.1 Preparation for the interviews and surveys

Before starting the process was essential to know what to ask and why. As shown in fig.20, the author prepared different sets of questions depending on each group.

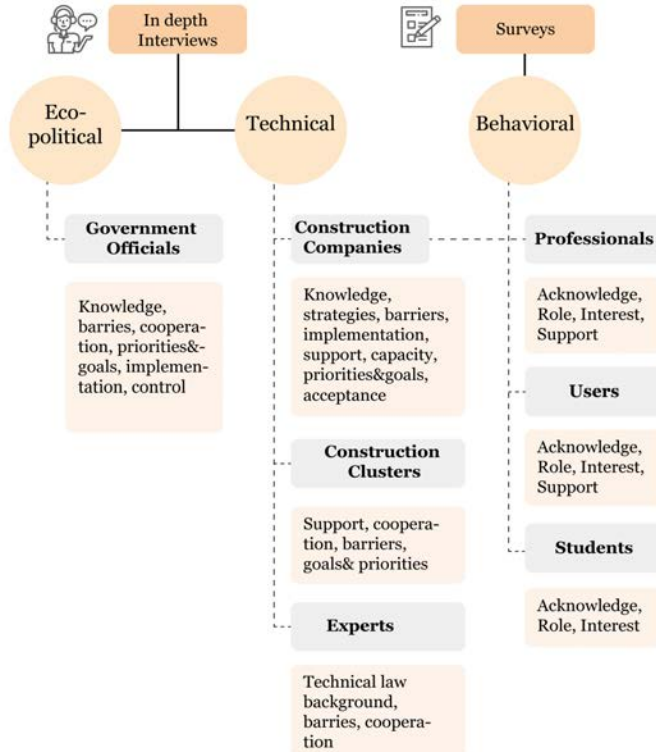


Figure 20. Main themes of the surveys and interviews. Source: the author

4.2 Survey and Interviews presentation

A small introduction was prepared for the survey to present the interview context; this text was similarly explained to the interviewed subjects when performing the in-deep interviews in person.

This investigation is carried out for academic purposes and financed by the German Exchange Service (DAAD). The research seeks to establish the challenges faced by the different actors involved in formulating and implementing energy efficiency codes in the construction sector of Bucaramanga and its metropolitan area. Here academics, entrepreneurs, professionals, and citizens, can give their opinions and consideration to the matter. We want to know your point of view on the subject; your opinion is important to us.

Online Invitation to participate in the questionnaire

4.3 In-depth Interviews

4.3.1 Method

The in-depth interviews were performed in-person prior appointment. All the interviews were recorded, and the author elaborated on a conversation transcript. The questions asked to each participant were similar from person to person. They were only different depending on the group that was interviewed, government officials (ecopolitical), construction companies (technical), and experts (behavioral). After having the transcript of the interviews organized by the groups, thematic analysis (Braun & Clarke, 2006) was used to analyze the data.

4.3.2 Sample characterization

A list of all possible stakeholders in the different implementation scales was developed for choosing the interview actors. In the case of government entities, the author could interview government officials from all scales in the local government, from city to state-level administration.

In the technical stakeholders, even when the sample size is not very large, it involves all the levels, from the curatorship that approves the licensing of new projects to the experts that had often worked with multiple companies as consultants in the city and also on projects from the national government.

4.3.2.1 Government entities

In the case of the government entities, the study interviewed secretaries and directives directly involved in the execution of infrastructure and housing projects for the municipality. In this order, they have an active role in the possible application of the sustainable construction codes.

No.	Professional body	Charge in the organization	code	Interview duration	Scale
1	Metropolitan Area of Bucaramanga	Director	GVN1	30 min	Metropolitan
2	Metropolitan Area of Bucaramanga	Coordinator	GVN1	30 min	Metropolitan
3	Santander State Government	State Housing and sustainable development Secretariat	GVN2	25 min	State
4	Santander State Government	Director of projects from the infrastructure secretariat	GVN3	25 min	State
5	Housing Institute and Urban Reform	Director	GVN4	25 min	City -Local
6	Bucaramanga's City Hall	Members of the construction studio from the infrastructure secretariat	GVN5	30 min	City -Local
7	Bucaramanga's City Hall	Member of the Planning secretariat – Control	GVN6	15 min	City -Local

Table 3. Interviewed government entities. Source: the author

4.3.2.2 Technical stakeholders

The technical group represents the local and metropolitan level, as they work on projects located in different parts of the Metropolitan Area of Bucaramanga AMB.

No.	Professional body	Charge in the organization	code	Interview duration	Scale
1	Bucaramanga Urban Curatorship	Director	TECH1	40 min	Local
2	Construction company	Director of architecture design	TECH2	60 min	Metropolitan
3	Construction Cluster	Director of the construction cluster	TECH3	30 min	Metropolitan
4	Energy Efficiency expert -Architect	Expert – Project Director	TECH4	60 min	Metropolitan
5	Energy Efficiency expert -Engineer	Expert – Project Director	TECH5	60 min	Metropolitan

Table 4. Interviewed technical stakeholders. Source: the author.

4.3.2.3 Stakeholder analysis

Figure 21 shows the stakeholder constellation. It portrays how implementing sustainable codes nowadays works; it does not try to show how the local government functions but the current relations of the different stakeholders' in applying sustainable construction regulations. The diagram comprises three parts the public and private sector and the civil society stakeholders. The position in the rings shows the level of importance of each stakeholder. The center is for the key, the next for primary, and the last for secondary actors. Continuous lines represent close relations while dotted lines weak ties, lines pointed lines represent a cooperation agreement.

One can notice how detached architects and residents are from creating and implementing policies and strategies in the city. Bucaramanga's city hall plays vital importance in the political dynamic in the metropolitan region and also at the

state level, as the capital is considered an influential figure at the same level as the governor. This detail is crucial to understand how introducing a sustainable policy by the Bucaramanga's city hall can take be an excellent example for other municipalities.

In the private sector, to this day, the construction cluster has been identified as one of the protagonists of the development of sustainable initiatives in the construction sector. This organization operates as a private company. It is funded mainly by the Colombian national government. Since national funds finance their projects by applying to specific project initiatives, they have a concise time frame. Most of the projects that were founded lasted less than a year. There is no clear continuity objective, most of the projects are temporary, yet they have a straightforward line of work.

The author found that there is a conflict of interest affecting the policy implementation dynamics in the case study. Since the public sector had taken a step down, acting more as a secondary player, primarily as an economic funding source. The situation has made the private sector the primary player in creating programs or initiatives to apply sustainable construction policies. Nevertheless, in the end, the private sector push for implementing a specific green certification code, the one that favors them the most (per example, because there is a partnership with a certification company, or is the easiest one, is the one that they know the most, among others). Their interest and agenda are not fully divulged or contemplated by the public sector. The construction cluster manifested haven found any barrier to implementing their initiatives, which was a bit surprising because the other actors have expressed the opposite. It is true that they are not responsible for implementing, monitoring, or controlling any sustainable code. Still, they are launching projects to provide companies with knowledge about specific energy-efficiency tools. They also gave multiple workshops to implement the Colombian energy efficiency resolution (549 of 2015), which means that they indeed must have to overcome specific issues. Because they are a private company, there is no possibility of reflecting on the difficulties they must have to have surpassed;

exposing their issues is not something that companies want others to know.

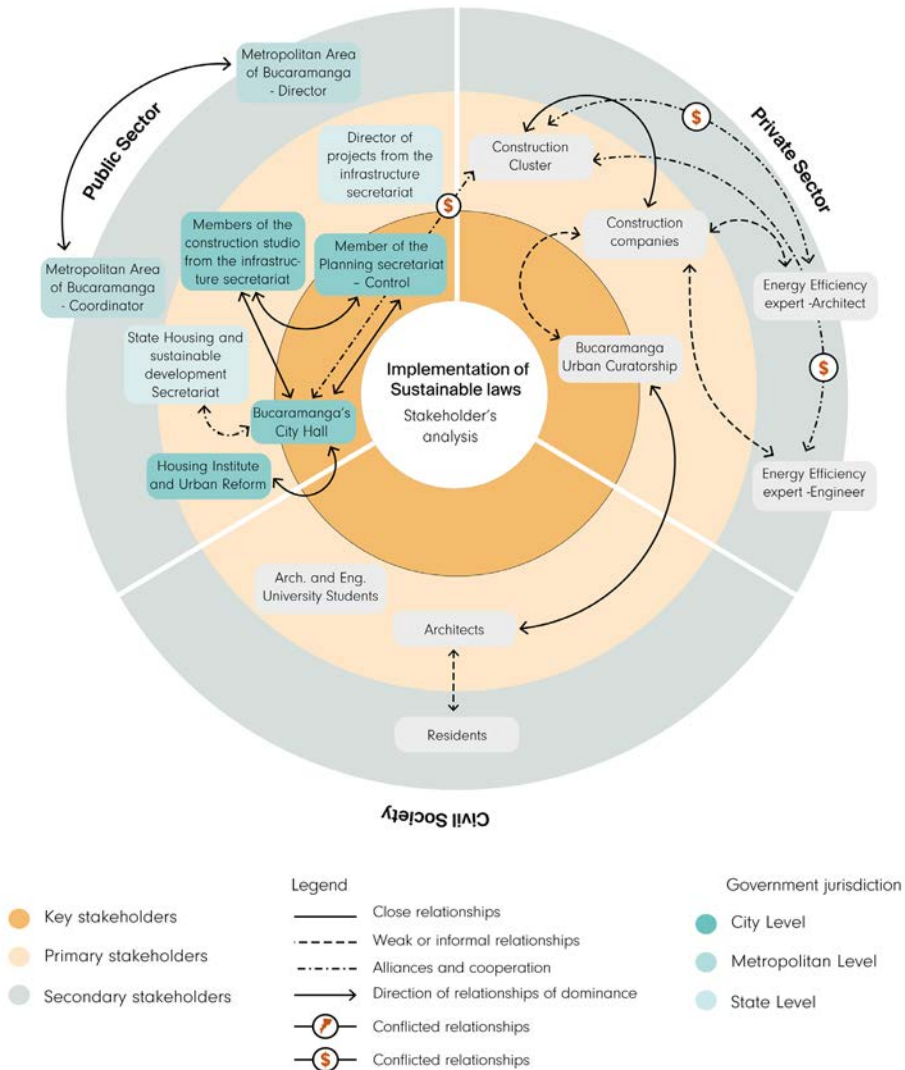


Figure 21. Stakeholder's Analysis. Source: the author

Nevertheless, one cannot ignore that private companies and organizations have done a significant job bringing different groups to create conversations around sustainability. They even had done some experiments and tests around energy efficiency in the region. Stepping the functions of the local government as they have not come up with initiatives but just contributing through funding that, of course, is still not a minor task.

4.3.3 Results

The analyses of the in-depth interviews started by creating a direct transcript of all the interviews. Then, the author used the thematic analysis method (Braun & Clarke, 2006). The process used for the thematic analysis was the theoretical approach applied to resolve a specific research question. After familiarizing themselves with the data, the author coded the principal findings of the interviews for posteriorly grouped them into themes. To finalize it linking it with the concepts that are going to be the basis for the suggestions.

Figure 22 shows the main thematic groups that resulted from the analysis of the interviews. To comprehensively understand, the author combined the directly related themes (like barriers and criticism of the current method). For the diagnostic that was discussed by the technical stakeholders, the analysis correlated the city characteristics and knowledge about sustainability from the government group. Another category created was strategies that combined: the government priorities, future, and positive aspects of sustainable construction. In this way, the resulting categories were diagnostic, strategies and opportunities, barriers and gaps, and criticism of the current system.

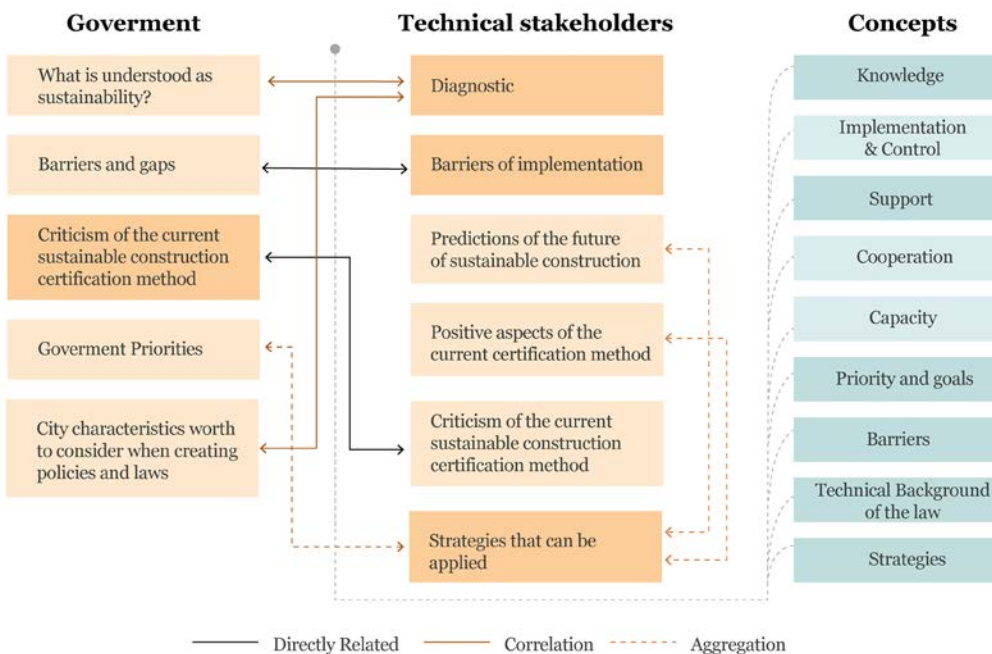


Figure 22. Themes from the government and technical groups. Source: the author

4.3.3.1 Knowledge

In the interviews, all government officials did not know any law regulation like resolution 549 of 2015 regulating energy and water consumption. Nevertheless, some acknowledge that there is now a credit subsidy when buying “sustainable housing.” Without being asked directly, government officials gave their definitions of what sustainable means for them. These answers were primarily focused on the material aspects of sustainable construction. They thought sustainable construction uses construction systems that reuse plastic and perhaps Guadua (a traditional construction method from the coffee region). One official said sustainability was to generate housing conditions such as having constant access to primary public services.

In the technical group, the level of knowledge about the resolution, credits incentives, and sustainable construction practices varied, all of them knew about its existence, but little had read it. For them, the subject of tax and credits subsidies was more important. They manifested that by applying for one of the green certifications, they were complying with the Colombian law.

Experts and companies think there has been progress made in knowledge about sustainable construction in the region. They highlight that now there are subsidies for users too, and that water and electricity saving appliances are now standard.

4.3.3.2 Implementation and control

There is no implementation of the Colombian resolution 549 of 2015 in the metropolitan area of Bucaramanga. No municipality is controlling it. There is no program from the local government to implement it or workshops for learning about it. The only found example is the construction cluster, as they sometimes give workshops about the resolution to some architectonic companies in the area.

There is no control over the law. When the author asked about it to the urban curatorship, he acknowledged its existence and knew the law's role; he also said that there is a paragraph in the national licensing registry that directly asks if the project complies with this resolution to get licensed. Nevertheless, he manifested that this is never reviewed and has no repercussions on the licensing if the project complies with the water and energy consumption regulation.

The author identified significant gaps in the formulation of the resolution. For example, the law does not analyze institutionality processes (who does what, how the monitoring will be done). The situation created loopholes in the law and constraints on the application and, ultimately, the appropriation of it by the authorities since nobody knows who is responsible for it.

4.3.3.3 Support

This section of the analysis showed conflicted answers. For one part, all government officials said there was no strong support from the national government, not directly related to their jobs but the application of sustainable construction methods by the final users. They consider that most of the advantages are made for the builder but not for the users that are left behind without economic support. Some officials argue that they do not see that there is support for micro-companies and small architecture start-ups. On the contrary, the construction cluster was pleased and optimistic that the support from the government is quite good as all the projects they develop come from national initiatives.

Researchers on sustainable construction practices manifested the need to have support from the national government to finance their research. They have applied to multiple initiatives and are constantly trying to get funded. However, if their project does not get selected, then there is no possibility for them to continue with the research.

4.3.3.4 Cooperation

At the local level, there have been past initiatives in the city that look to develop the construction industry towards sustainable practices increasing the knowledge about sustainable construction in the region. The most recognizable project was done in a partnership with the Commerce Chamber (Camara de Comercio Bucaramanga), Swiss cooperation, and local universities. In this project, experts tested the thermal comfort conditions in different locations and projects in the city. There, experts found that low-income households have many thermal comfort problems compared to high-income houses that already incorporated sustainable and comfort design strategies, without them realizing it. The experts and the construction chamber made a simulation guideline from these experiments.

At the national level, cooperation between cities for creating the codes or implementing routes that cities like Bogota or Cali had made does not exist. Even as an experiences-sharing opportunity, there is not much possibility to know about regional projects but to look for already published articles. If there is an ongoing process, there will not be a way to know it.

4.3.3.5 Capacity

Local government officials manifested problems with their economic and human resources capacities, particularly in the case of the social housing institute INVISBU (in Spanish) adjacent to the city hall. One of the issues that the INVISBU manifested was that the housing improvement projects require a prominent investment and, in their view, have a small impact. They observed that low-income houses have significant problems regarding their thermal comfort. Furthermore, in general, they have poor habitability conditions. Other dependencies in the city hall and the metropolitan office manifested similar problems: a small number of workers, tight budgets, and overall pressure to finish their projects.

On the contrary, construction companies consider they have enough availability of human resources to implement sustainable construction laws. Nevertheless,

there is a need for economic support in form of incentives to reduce the possible extra costs of the implementation of energy-efficiency and alternative energy technologies.

4.3.3.6 Priorities and goals

Priorities from the government officials and the technical groups differ significantly. When they were asked about the following priorities to have more sustainable ways of building, they manifested that their priorities were to improve road communication between small and middle cities and to attack the qualitative and quantitative housing deficit. Sustainability is not one of the targets but rather to improve the living conditions of the more, in their view, pressing issues.

When asked the same question in the technical group, construction companies said that they want to have more projects accredited with the EDGE certification in the future. The construction cluster has a similar goal to continue boosting the certification of buildings with green certification seals in the region.

4.3.3.7 Barriers

Implementing policies suppose the existence of different barriers that can vary from group to group. The technical and eco-political groups were asked which barriers they considered the ones that have more significant negative repercussions on enforcing sustainable policies in Bucaramanga. Their answers were grouped into categories and then framed into specific components of each barrier. Even when both groups named barriers bellowing to the theme “politics and regulation,” differences can be found. Nevertheless, in general, they complement each other.

Economic and socio-cultural barriers are similar yet focused on the particularities of each expertise. The technical group did not consider technical development an issue at all.

Technical		Answer	Component
In politics and regulation		It is not mandatory	Regulatory framework
		Formulation: no monitoring and verification	Monitoring and control
		Workshops sponsored by the government are private and require invitation	Technical background
Economic		It is more expensive to build sustainable	Cost
		There is a lack of incentives	Incentives and financial resources
Socio-cultural		There is a lack of knowledge about the standard or possible sustainability strategies to apply	Knowledge and education
		Little capacity to do research due to budget availability. The extensive times of the academy do not go with the fast industry needs.	Education

Table 5. Technical group barriers based on the interviews. Source: the author

Government officials' barriers are summarized in Table 6. In politics and regulation, they consider the main barrier the lack of support they receive from the national government. Also, how extensive their contractual processes are, making it more challenging to introduce new regulations as they fear it would make their work harder, as they already have a lack of personnel and high time constraints. In the socio-cultural barriers, the lack of social consciousness was often named; government officials think that, in general, there is much work to be done with professionals and communities to achieve sustainable development. They think a good piece of legislation is not enough but instead attack the issue from different fronts, involving users in the process of producing and enforcing sustainable policies.

...also, there must be economic benefits for the end user, if the user applies that technology, they are given a series of benefits that have a positive impact in their pockets. In this way that person will see that applying this law is good, not to achieve to this from a prohibition. also, pedagogy, because if you buy an apartment that is designed to be efficient, but at the same time you have four cars, well that doesn't make sense. -

Interviewee from government entities

Government		Answer	Component
In politics and regulation		Lack of knowledge of the regulation even as public officials	Monitoring and control
		Loophole and little support from the national government	Regulatory framework
		Extensive contractual processes	Regulatory framework
Economic barriers		Time constraints	Lengthy processes
		Limited budgets	Costs
Socio-cultural barrier		Educational and research barriers	Education
		Emptiness in consciousness – environmental sensitivity	Conscience
		Lack of human resources	Capacity
Technical development		Little technical development and logistical complexity when projects are developed outside municipal capitals. The application of renewable energies is complex due to high tariff rates.	Technology

Table 6. Government entities barriers based on the interviews. Source: the author

4.3.3.8 Technical background of the law

a. Creation

The resolution 549 of 2015 was created from a cooperation agreement between the IFC, Swiss cooperation, and CAMACOL. One of the first pilots was done in Bogota by World Resources, and their goal was to accelerate processes that generate energy efficiency. Later CAMACOL collaborated with the IFC to implement EDGE, a private certification. In this way, the same actors that created the Colombian law were the developers of a different certification, which made, from the beginning, more challenging for the Colombian law to be implemented as the focus of CAMACOL, and even local governments were to implement EDGE instead.

When it comes to the writing of the resolution 549 of 2015, interviewees of the technical group pointed out that the government made a single-company consulting for its technical design. The hired company is the one in charge of pro-

ducing the technical background of the resolution. However, the government did not make public the base document on which the requirements contained in the resolution were made. There was no possibility of a later peer-reviewed process. Researchers call the attention on the notable level of confidentiality behind this process. In the end, experts consider that the fundamentals done for the resolution were substantial, but this base document is not reflected in the result of the policy itself.

It seems that the Colombian government will push for the implementation of certifications like LEED, EDGE, Casa Colombia, and HQE rather than their own law as they found the monitoring process a hard work to do (Vanguardia Liberal, 2022). After all, the subsidy incentives from the banks are made for the projects that use these certifications (banks like Bancolombia, BBVA, Davivienda, Banco Caja Social among others) (CCCS, 2021). The implementation of EDGE is not the problem but using local resources and funding to promote a private certification is highly problematic. In the interviews with the experts, they expressed their concerns as EDGE shows difficulties for being a static tool, generating doubts about its benefits when implemented. Also, in another interview with a leading construction company in the region, the author found that the company did not change anything regarding what was initially proposed in the project to be certified with EDGE. This project was the first social housing to be certified in the city. The certification was achieved by implementing appliances, light bulbs, and saving taps appliances already on the market.

b. Technical background

In this part, the author will reflect on the comments of the technical experts. For the Colombian resolution 549 of 2015, there is no static baseline, meaning that every time the government wants to actualize it, they will need to create new baseline, which becomes a lengthy process. Other countries had resolved this issue by introducing a reference building, as Germany did in the Energy Savings regulation of 2009 (posteriorly amendment in 2014) (German Federal Government, 2014). Creating a baseline means that every new regulation will propose

reduction of certain percentage based in that baseline building. Introducing this was a significant contribution as it quickly tracked the reduction targets on time, making comparable results over time.

The experts also consider that the choice of the evaluation methodology for the regulation is not the most adequate. Due to the fact, that international methodologies are not adapted to the tropical climates and their architecture. In the case of the Colombian resolution the standard used is ASHRAE 90.1, made for buildings that have an HVAC system. Hence even applied to the best extent, it cannot guarantee accurate results, leading to overestimating energy consumption due to the installation of air conditioner systems. To this day there has not been a project by the government to create a national standard. Most standards used in the law are translated directly from the ASHRAE 90.1.

In the end, interviewees found the Colombian resolution very superficial, as its objective only limits the consumption of water and energy and does not consider other aspects necessary when talking about sustainability. Another significant issue that limits the creation of standards and regulations from the technical perspective is that there are no standardized laboratories where the thermal properties of the local materials can be tested. Nevertheless, some technical interviews consider that most people know about the Colombian regulation (resolution 549/2015). Yet, they see it more advantageous to apply the EDGE certification as it is achieved by using simple concepts. Adding to this, they consider EDGE an excellent business strategy and a promising way to access tax benefits and, lastly, be friendly to the environment. Another point about the certification brought by the construction companies is that by using it, clients manifest pleased with the idea of living in a building with a seal.

The technical group predicts that EDGE and LEED will be the standard required for the certification of “green edifications.”. Although, this is already the case, as the author has exposed before, banks and the government are working to push the implementation of these seals. They also think there will be more projects to certify architects in these certifications done by the Chamber of Commerce of

Bucaramanga (Camara de comercio de Bucaramanga). The Construction Cluster also expressed that they would continue working to promote sustainable construction in the region by introducing new technologies, thus creating new business models. The experts want to continue their long-term goal of creating a Colombian software, but they need funding from the Colombian government. With this, they hope to remove implementation barriers, as is the lack of software, by creating a simple tool that construction companies can use. The researchers also hope that the government launches soon the energy labeling for buildings where they participated.

c. Other considerations, holistic approach

Interviews from both groups brought over the problem of socio-economic inequality that Bucaramanga, like multiple cities in the country, has. They are standing the question of how to create a policy that considers this context. Another big concern was, as they call the “excessive technicality” that certifications have. They fear this would lead to a loss of architectural sensitivity, where passive strategies are not considered but rather the predilection for active measurements to achieve indoor thermal comfort. Considering Bucaramanga’s climate, passive design strategies perform very well in the city.

.... most architects and designers see these solutions only from the materiality and the implementation of mechanical-type strategies. However, they are not exploring and rediscovering the passive-type solutions, which work very well in these climates. Parallel to the mechanical solution, we must begin to develop some rediscover of passive solutions that have worked for thousands of years –

Interviewee from government entities

Experts consider that the current Colombian resolution does not achieve the incorporation of other indoor environment aspects very much necessary to include. Like natural ventilation, visual, thermal, and acoustic comfort (see fig.23). Not including all these in-

door environment components makes the indoor space propensity to risks like air pollution, high noise exposure, and non-adequate light levels. Nowadays people stay at home most of the day. Hence, indoor environmental quality plays a significant role in people’s health. The hazards found in households with poor indoor environmental quality (IEQ) can deteriorate human health, producing diseases from asthma to cancer (Wu, Jacobs, Mitchell, Miller, & Karol, 2007). Wu et. proposes creating economic and informative solutions to overcome the issue of poor IEQ involving policymakers and a broader level of stakeholders. They recommend being assertive in showing how health benefits can be translated into economic terms. Researchers analyzed the interlinkage between policy, human health, and IEQ to cross it with data about all the costs. The result of this study provided a very straightforward representation that can be a way of motivating policy-makers into action. (Wu, Jacobs, Mitchell, Miller, & Karol, 2007).

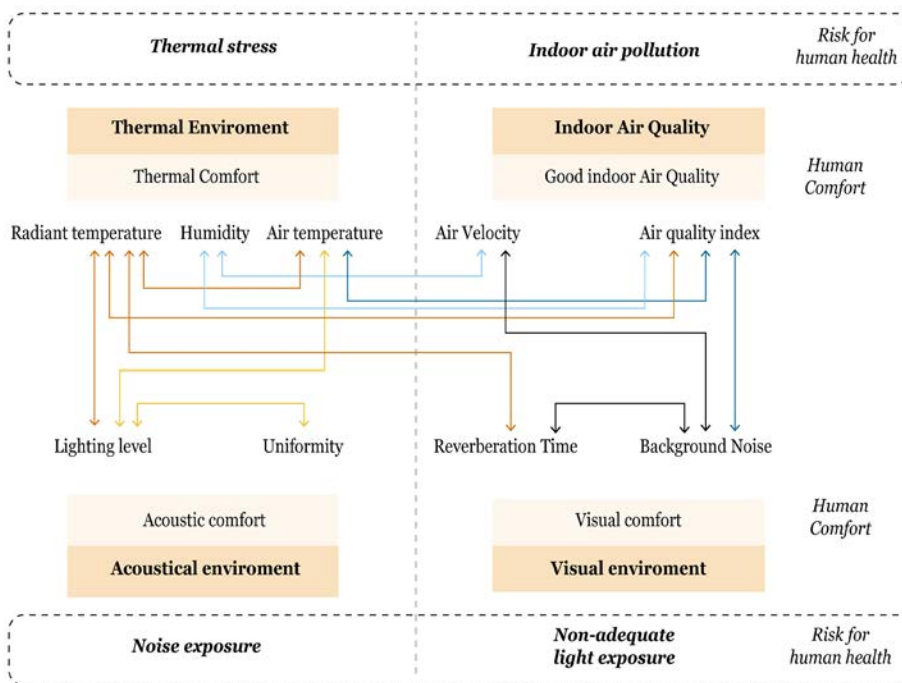


Figure 23. Indoor environment, human comfort aspects and their relationships. Source: The author based on (Karyono, et al., 2020), (Fantozzi & Rocca, 2020)

As the law concentrates on just one of the multiple comfort needs, technical stakeholders ask themselves how the Colombian legislation on sustainable con-

struction could push for examining critical urban issues like water quality, sewerage, water supply, and energy? In the past, the government has made laws to regulate the use of water, energy, and construction waste. However, sustainable construction legislation lacks a conglomerate of these actions. For this reason, interviewees said there is a significant opportunity to include in these laws other clever solutions, like enforcing the incorporation of a rain management system in each project. Considering that Colombia is a tropical country with significant levels of rain, moving the adoption of sustainable concepts beyond just the buildings but their surroundings.

Another missing parameter brought by the eco-political group was the incorporation of sustainable concepts in urban planning. No part of the Colombian resolution incorporates sustainability criteria for urban development. Although this could be contained in each city's POT (Territorial Management Plan *in Spanish*), the law could make incorporating these criteria mandatory with a clear set of goals or parameters. Integrating sustainable development and climate change actions should not be dependent on political willingness but be a must. In the end, professionals conclude by saying that a possible new law must be easy to apply, easy to understand, and not put a lot of economic constraints on them.

4.3.3.9 Strategies

Members of the technical group named different strategies that can be used to improve the sustainability of the construction sector in the city. Nonetheless, also strategies to improve Colombian law as it is.

1. Create a differential approach free of preconceptions about what sustainable construction is
2. The national government must get involved and make the standard mandatory.
3. Use GIS to review water and energy consumption in the country.
4. Make it mandatory for the government to use renewable energy in the facilities that they build.

- Incorporate other water-saving systems such as gray water collectio
- 5. Generate relations between the academy and the industry so that strategic alliances are formed, and the technology is taken to the companies; the academy must seek applied research. More focused research
- 6. Take advantage of national and international cooperation.
- 7. Pedagogy with users

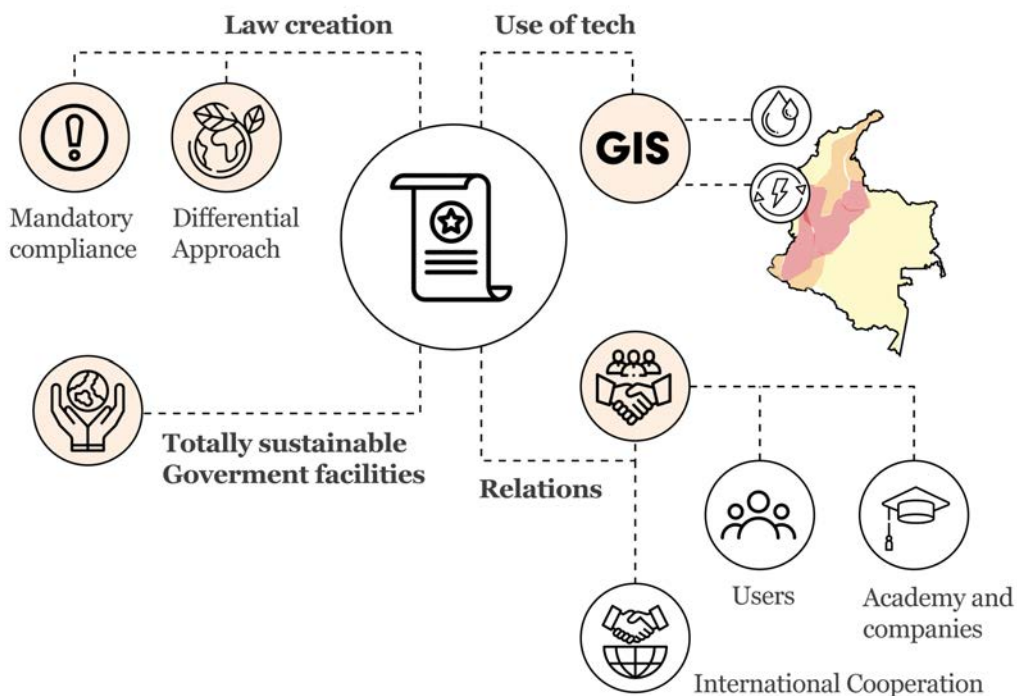


Figure 24. Strategies suggested by the technical group. Source: the author

These strategies proposed by the interviewees will be later integrated into the framework of suggestions that the author will present in chapter five.

4.4 Surveys

Surveys were sent by email to the professionals and companies. Student’s surveys were collected using both printed and digital forms, all the students received an in-person presentation by the author explaining to them the main theme of the thesis and its objectives. Allowing them to have a more informed decision; the

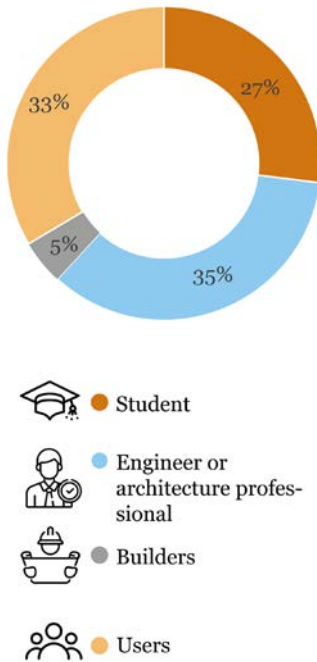


Figure 25. Sample percentages. Source: the author

students filled it using cellphones after scanning the QR code with the survey link. This process was then repeated in three classrooms from the eight semester students (from ten in the career) in an Architecture university in the Metropolitan area, where most of the architects in Bucaramanga graduate from.

For the residents, interviews were sent to each by social media, but also filled with them directly in person. The second option gave the possibility to have some feedback about their motivations to give specific answers.

4.4.1 Sample size

The surveys had a sample size of 152 participants and were recorded using the platform SoGoSurvey. The survey platform was open for a month. Most responders were open to answering the survey; companies showed less openness to it. Most of the company owners that received the survey ignored it or directly manifesting not wanting to discuss their construction/management processes.

4.4.2 Characteristics of the study sample

4.4.2.1 Residents



Figure 25. Sample percentages. Source: the author

Buildings codes and regulations focus almost entirely on the design and construction of the buildings, but one cannot forget that residents play a significant role; as most of the carbon emissions of a building are related to operative energy, research shows this can be around 77% of its carbon emissions (Mehrddad

Rabani, 2021). Consequently, this considerable percentage can directly be affected by residents' behavioral patterns. In that case, creating a mechanism where users can learn how to live more sustainably is a must to reach any environmental policy goals.

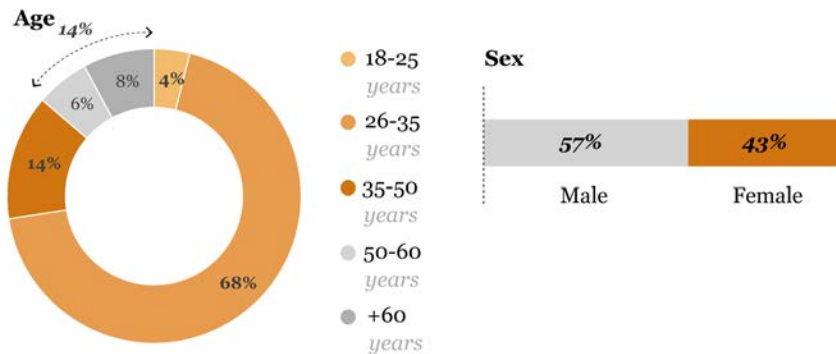
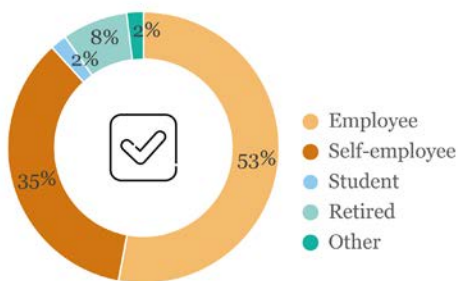
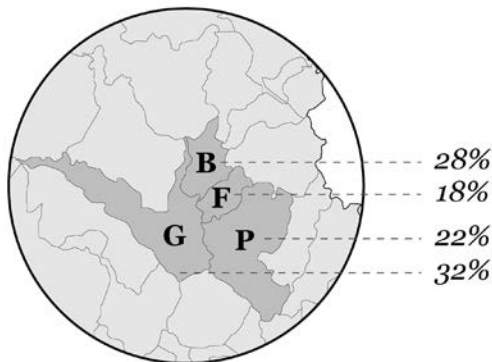


Figure 26. Resident's profile. Source: the author

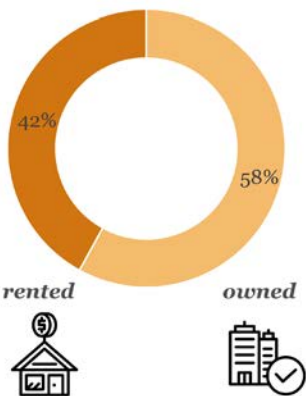
What is your condition?



Your residence is located in?



Is your house?



What is the socioeconomic status of your place of residence?

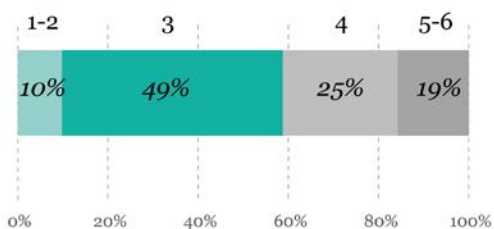


Figure 27. Sample of residents. Source: the author

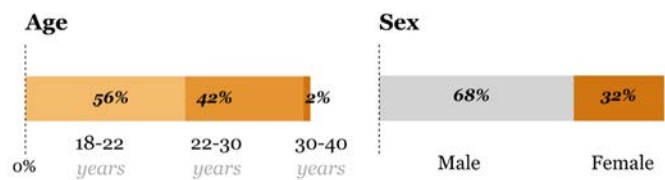
This research is not a probabilistic survey, but the author tried to get a representative sample size equilibrated regarding age, gender, and socio-economic background. Most interviewees were young adults, followed by adults and senior citizens with 14%. The sample has people that reside in the four cities of the AMB; most were employed house owners with low and middle income. In the socio-economic part, users were asked which socio-economic stratification they belong to. In Colombia there is a figure called “Estratos Sociales,” social stratification, a classification of neighborhoods created in 1994 by the Colombian government. Households in brackets 5 and 6 subsidize those in 1,2 and 3. Bracket four does not pay extra or receive subsidies.



Figure 28. Student's profile. Source: the author

4.4.2.2 Students

The majority of the students were male and less than 30 years old. All of them were architecture students from a private university in the area; 63% of the students said that they do not work, and the rest have part-time or full-time jobs.



4.4.2.3 Engineer or architecture professional

The sample of architects and engineers' that answered the survey was nicely distributed between self-employed, employees, and workers from the public sector. This distribution gives a valuable re-

sult to the research as their opinions do not reach the public often, especially for self-employed and public sector workers—most of the talks and programs led by the Construction Cluster target big office owners. A tiny part of the sample had a Ph.D. Nevertheless, most of the interviewees had a professional title.

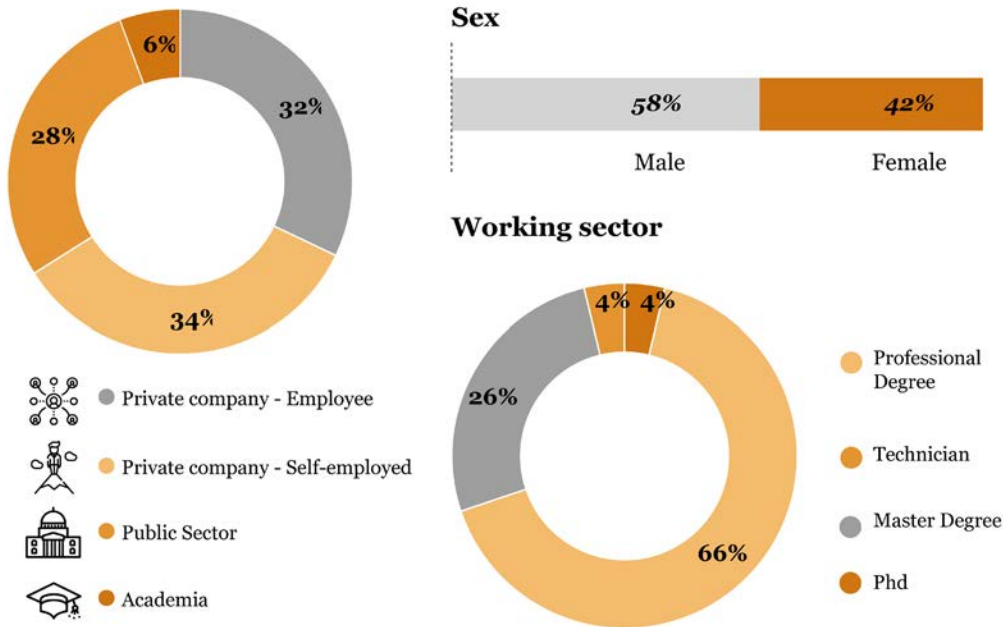


Figure 29-30. Professional's profile, and Academic degree Source: the author

This distribution gives a valuable result to the research as their opinions do not reach the public often, especially for self-employed and public sector workers—most of the talks and programs led by the Construction Cluster target big office owners. A tiny part of the sample had a Ph.D. Nevertheless, most of the interviewees had a professional title.

4.4.2.4 Builders

In the results for the builders is easy to recognize how male-dominated the industry is in the region. Most of the people who took the survey were company owners. Commercial and residential projects are the focus of their operations.

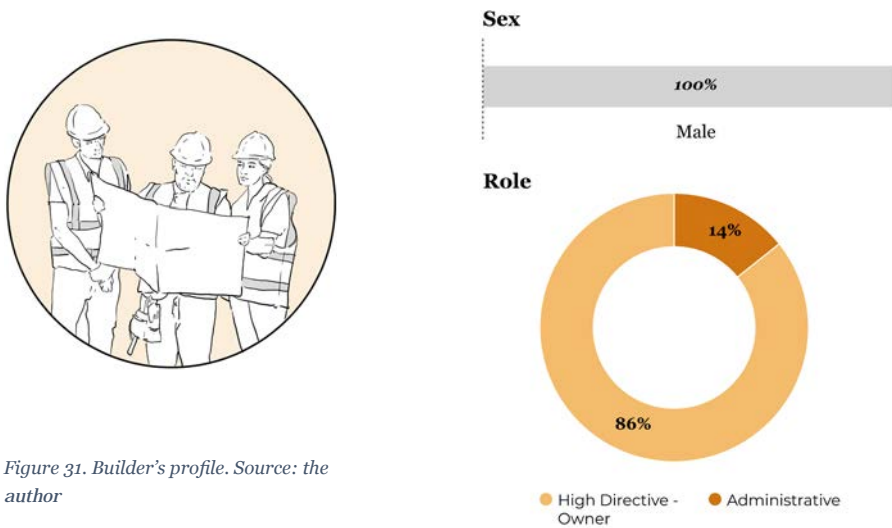


Figure 31. Builder's profile. Source: the author

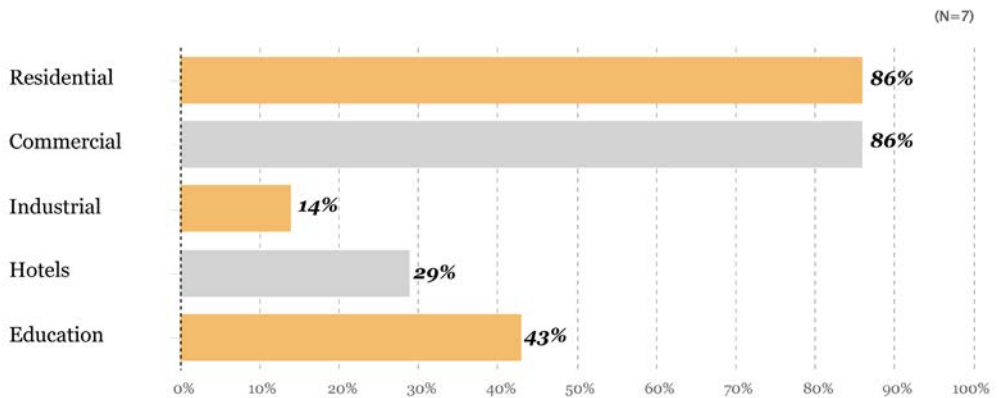


Figure 32. Type of projects that the builders do. Source: the author

4.4.3 Results

The survey's questions addressed different issues like knowledge, role, interest, and support that the stakeholders perceived they had. After this, the answers were cross-examined to find the aggregations and correlations between the groups to elaborate on the authors' interpretation. Based on these questions, a holistic policy framework for the city of Bucaramanga can be suggested, which will comprehend the next chapter. Therefore, following these parameters, the results will be exposed following the same structure (knowledge, role, interest, and support) (see fig.33) rather than divided into the original interviewed groups

(users, students, architects, and companies).

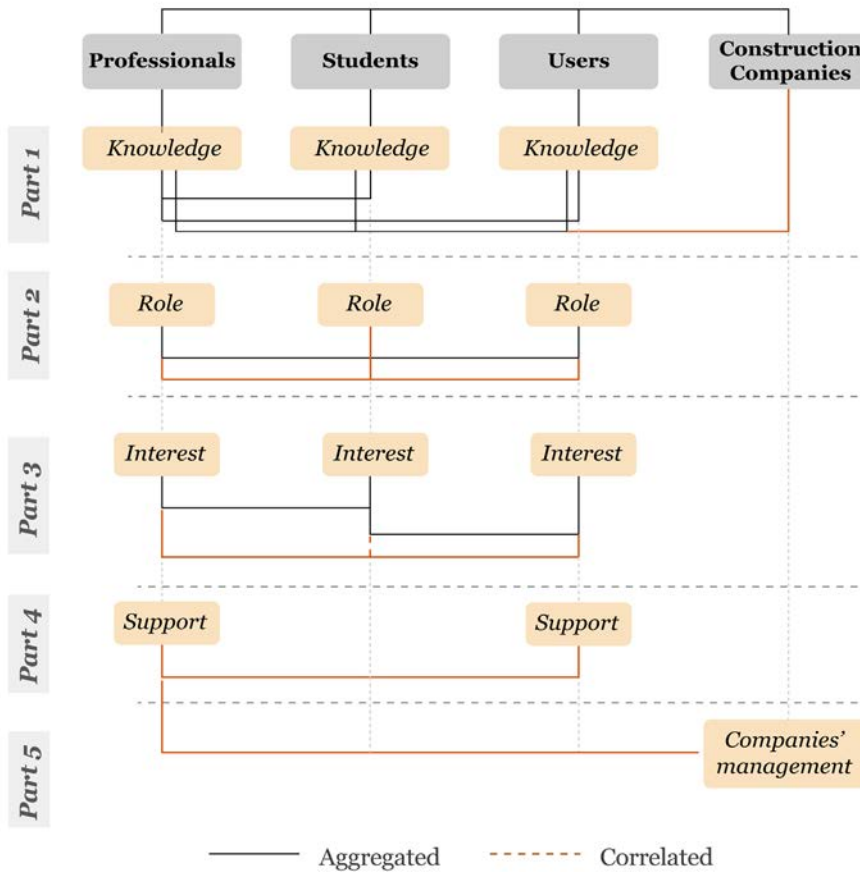


Figure 33. cross-cutting issues. Source: the author

4.4.3.1 knowledge

The lack of knowledge is one of the main issues identified as barriers to the implementation of sustainable construction policies by different studies done in Colombia (Swisscontact, 2017), (Murcia, 2021), (Republica de Colombia, Departamento Nacional de planeacion, 2018). For this reason, this part will start by testing the knowledge of the interviews by intersecting different questions and focus groups. For example, regarding knowledge of the Colombian law, professionals, and students, two groups potentially in closer contact, have similar negative answers regarding the knowledge of the law with 71% and 73%, respectively.

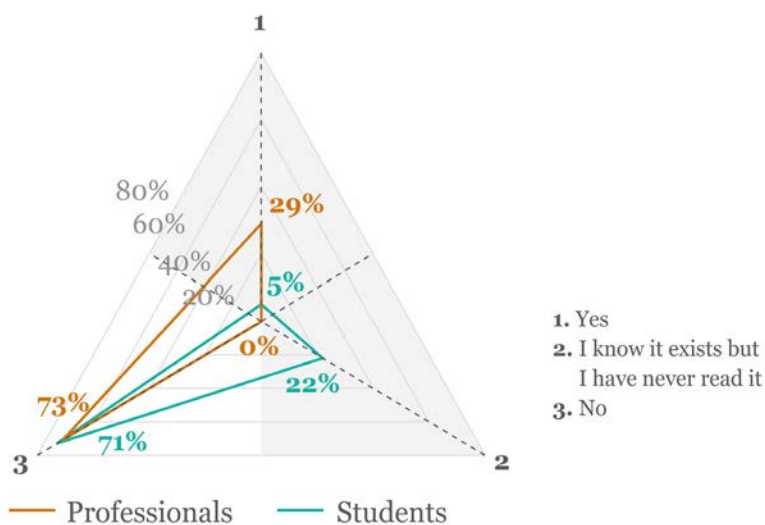


Figure 53. knowledge of initiatives. Source: the author

When laws for the implementation of certain efficiency targets are created, they usually come with a straightforward incentive program that could include tax breaks, better credit opportunities, funding, and subsidies. In the case of Colombia, the main incentive for residents is to have a more minor credit interest (half of a point) when accessing credit banks. The government also has a new program launched at the end of 2021 and issued in January 2022 (Ministerio de Vivienda, Ciudad y Territorio, 2022) called “ecobertura,” a subsidy program created for non-social housing, where people can apply, but there is no guarantee of getting the subsidy.

Subsidies for buying non-social housing already exist. These can be an option for people from 18 to 85 years old. They are given 42 minimal salaries monthly for seven years. Nevertheless, when applying for subsidies with a house with a certification (like LEED, EDGE, CASA Colombia, HQE), they have a plus 10 minimal salaries in the same seven years. It is worth notice that these subsidies cannot cover the capital. In other words, they do not cover the house itself but the bank interest, which is very high. Using the calculator of one of the leading banks in Colombia, the interest paid in 15 years is almost the whole value of the first amount asked. In other words, in 15 years, users would have paid the dou-

ble (BBVA Bank , 2022). Additionally, if a new homeowner were to buy a house without using the bank but with direct payment, there would be no advantage or subsidy for it, even when purchasing new certified homes. Therefore, one can ask if these subsidies are for the people or the banks?

Before ecobertura was launched in 2021, banks like Bancolombia, already had a program of better credit coverage in 2017 for those users that were to buy new green-certified homes (CCCS, 2021). Nevertheless, when asking both users and professionals if they knew about these programs the answers were a similar 80% no. (see fig.35)

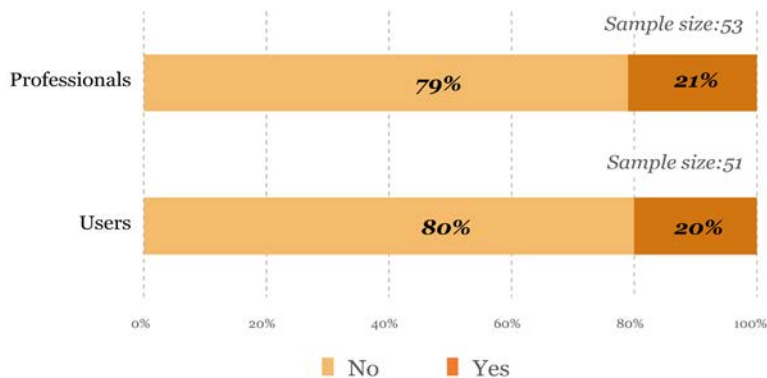


Figure 35. Credits programs knowledge. Source: the author

There are strategies to include this information in the formulary of credit assessment to inform users that they could access a government subsidy for “sustainable housing.” That could incentive them or just, in general, inform more people about these credits. Still, there should be other economic incentives that people could apply to instead, not just in terms of better credits or subsidies for credits, but direct incentives to build ‘green-houses’. In the case of Germany, with the program ‘KfW Efficiency House,’ the government provides financial support to homeowners that modernized their homes with the objective of making them more energy-efficient. The higher the performance level, the highest the funding they receive. This funding consists of a payback for the direct cost and not just a credit allowance. Applying this to Colombia could be perhaps too expensive. However, similar direct economic measurements can be applied like a higher

construction index on heights among other economic directly-translated benefits.

Certifications are commonly used as a measure of sustainability levels. However, certifications alone can sometimes be used surreptitiously as a commercial tactic, not effectively guaranteeing that the certified buildings consume considerably less energy than others (Scofield, 2009). Nevertheless, this is still one of the few measurement possibilities; today, Colombia does not track the implementation of its energy efficiency law. The research showed that the difference in knowledge between users and professionals is high. Yet, the majority of the professionals also mostly know three certifications programs which are also the ones leading the market in the Colombian case (see fig.2). The perceived knowledge by students and residents is very similar; too little to no knowledge of certifications. However, LEED is still the recognized market leader. Measured by the certification's knowledge the public does not seem to have a good understanding of the existence of green certifications in buildings. (See fig.36)

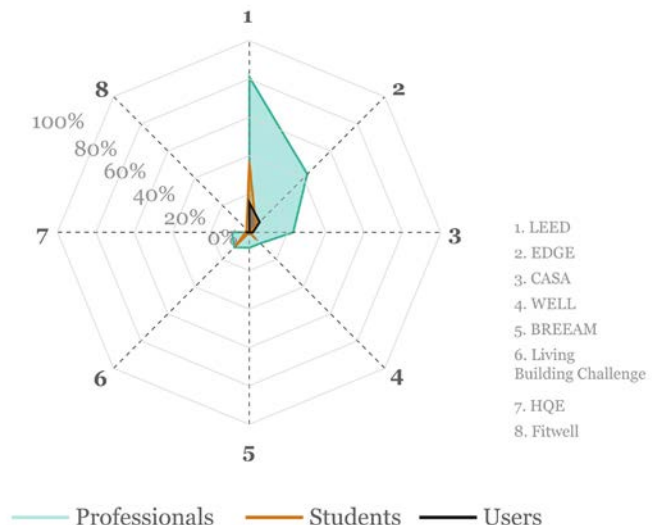


Figure 36. Students, users, and Professional's knowledge of green certifications. Source: the author

The lack of knowledge and other reasons makes existing green building certifications not very appealing for construction companies. A study from Norway (Ryghaug & Sørensen, 2020) based on the author's decades of study into the incorporation of energy efficiency into the construction sector found that the main

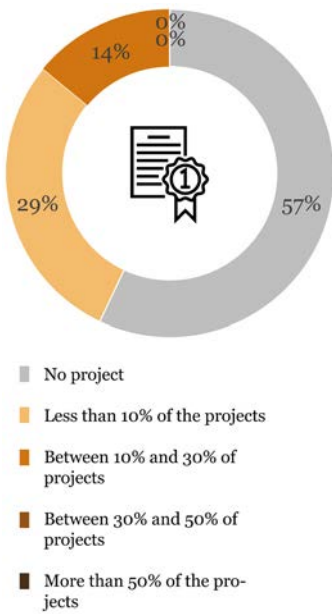


Figure 37. Companies number of certified projects with green certifications. Source: the author

reasons why construction companies do not apply energy standards and certifications are

1. Insufficient government attempts to regulate the building business.
2. insufficient public policy initiatives to promote energy efficiency
3. a conservative building sector.

In the study area, most companies have no project certified with these energy certifications or other energy standards seals and a 43% between less than 10% of their projects to 30%.

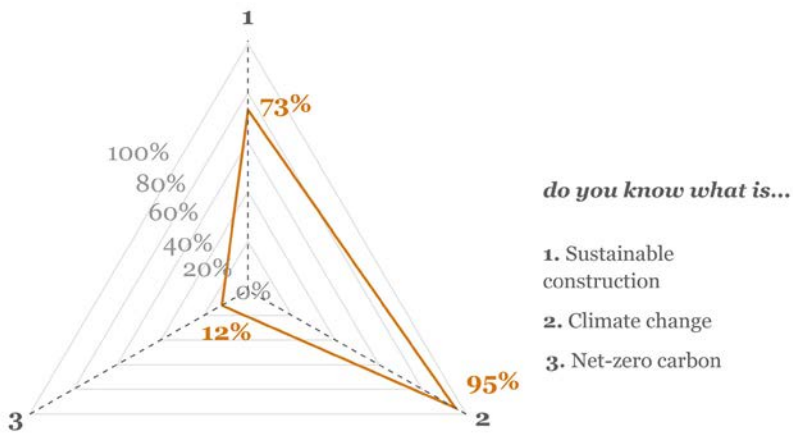


Figure 38. Students' knowledge of concepts. Source: the author

When the subject of knowledge is reviewed from the perspective of company owners, the results are similar to the architecture students' ones. Companies know what sustainable construction and climate change mean but do not know about Colombia's compromise to reduce its carbon emissions or the concept

of decarbonization itself. This situation is particularly troubling in their case as they have a direct responsibility in reaching the Paris Agreement goal for being in the construction sector that produces 20% of the country's carbon emissions. (IDEAM, PNUD, MADS, DNP, CANCELLERÍA, 2018)

In a study by the Camara de Comercio de Bogota (Bogota Chamber of Commerce), they surveyed different city companies about decarbonization in the construction industry, having companies from the whole construction cycle (commerce, services, and manufacturing). Found that of the 1513 responders, 72.9% did not know what decarbonization meant (CCB, 2022). Those results are similar to the one this research got, as 71% of the surveyed construction companies do not know the term. Also, in the research, the author found that 86,2% of the responders do not know carbon neutrality, as shown in fig.39.

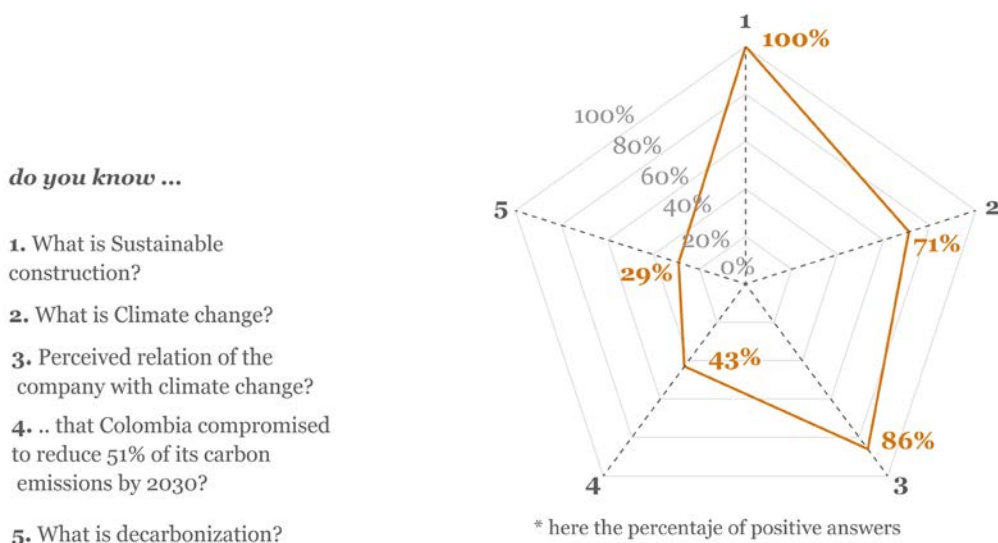


Figure 39. Companies' knowledge of concepts. Source: the author

4.4.3.2 Role

The second topic of the survey was the role. Professionals and users were asked who they think has the leading role in correctly applying energy efficiency codes.

Both groups answered similarly that the government has the primary responsibility, which also alienates with the response of the technical group in the interviews. This answer calls for more robust accountability from the government in creating sustainable policies, and especially in its monitoring and control processes.

However, also the role of the architects cannot be left behind. Almost 40% of the responders think they have the most significant role in applying the codes. Architects are the piece that connects both users and government, hence their importance in the dynamization of the construction sector. If architects get more vocal about the people’s (clients) needs and create unions for climate and sustainability initiatives, they could influence policy-makers into action. Examples of this in the world can be found with Architects Declare, a collective group of architects from the UK that seek to bring attention to the climate and biodiversity emergency that we as a society are in, proposing ways to raise awareness about climate change, advocate for a transition into net-zero in the industry among other initiatives (Architects Declare, 2022).

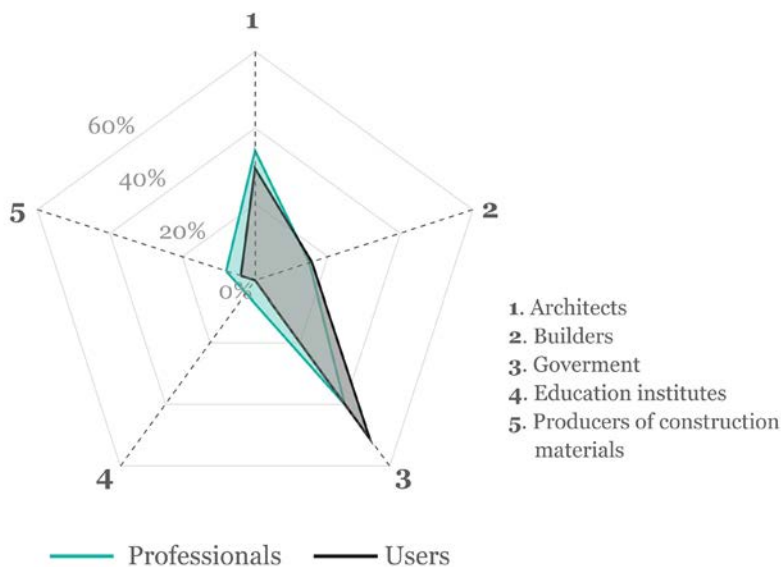


Figure 40. Who has the leading role in the application of energy codes? answers from architecture professionals vs. users. Source: the author

Inside their companies’ architects also feel they have an influential role, with 75%

of the responders saying they could influence. However, only 19% of them feel that they are doing it. In research done by Alozie et., authors discuss how architects: “are citizens to their environments and owe an obligation to bringing sustainability into them” (Alozie, O.O, & Odim & I.B., 2018). Here the researchers suggest ways on which architects can improve and dignify their role in sustainable development by, for example, doing personal self-improvement, switching their practices into more sustainable methods, being vocal in their role as citizens, and finally by collaborating between people and other organizations.

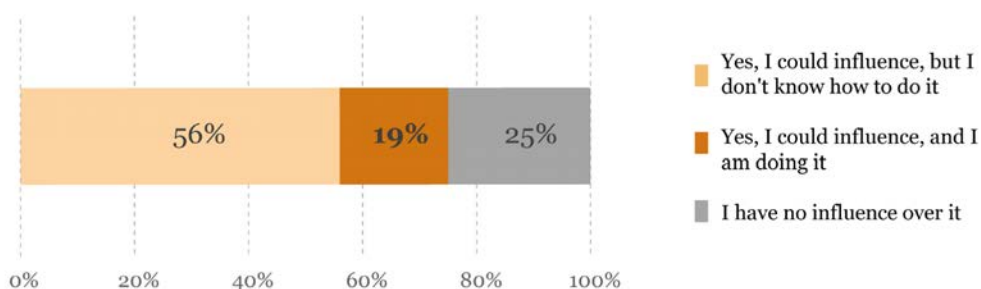


Figure 41. Do you think that as a professional, you could influence the company you work for so that it incorporates sustainability and energy efficiency criteria more fully? Source: the author

In the case of study, even when students believe that there are university groups where they can learn about sustainability and climate change, most consider these options incomplete and need improvement. These responses account for 88% of the total (see fig. 42). As future practitioners, providing students with tools to incorporate sustainable construction practices into their projects or being an agent of change is a good investment in the future. Studies show that correct planning can significantly impact the reduction of carbon emissions. Early stages of design can contribute positively or negatively to the carbon emission footprint of a project. Osmani et al. (2008) determined that 33% of site waste comes from the design (Osmani M. & A, 2008). Though construction waste is often not considered when planning a project, a study done in Hong Kong (Poon, Yu, & Jaillon, 2004) shows that practitioners pay very little attention to the election of materials and their emissions as well as its control of the construction site which leads to high material waste.

Nevertheless, in the design stage architects can do significantly advances to reduce the carbon footprint of a project, in a study made within the scope of the Ecological Architecture course conducted by the Department of Architecture at Ataturk University in Turkey. Researchers found that applying the principles under the guidance of eco-design strategies, using the LCA method, led to reduce of 60-86% of the carbon emission footprint of the mini-houses they were testing (Sipahi & KulözüUzunboy, 2021).

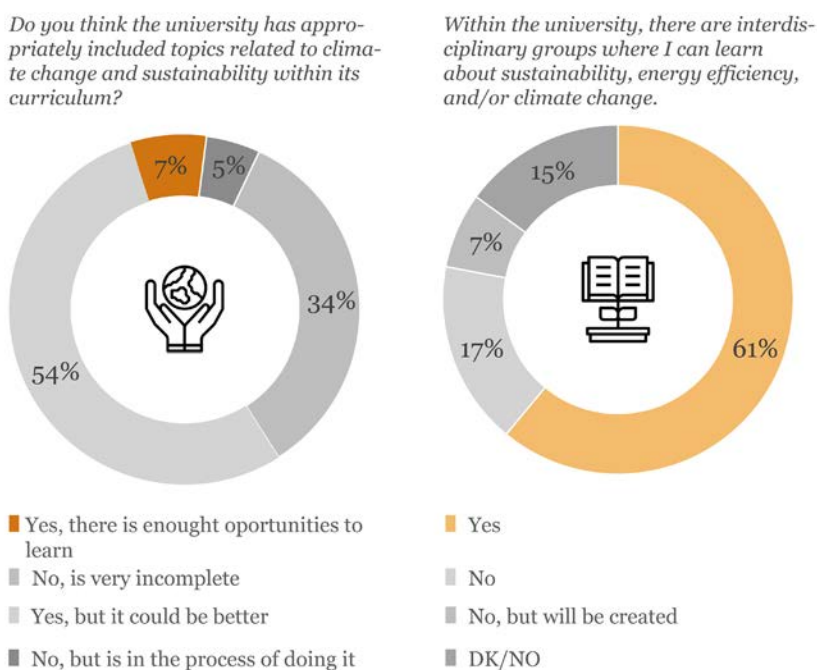


Figure 42. University Role in students' education. Source: the author

What can universities do then to have a better offer of programs? Teaching concepts and pure knowledge is a part of it but having more open and flexible methods of studying architecture allows students to be openly critical in the classrooms. This shows to be an effective learning method (Donovan & Holder, 2016). The academy plays the biggest role in educating professionals about energy efficiency matters. When the author asked professionals, “What is your primary source of information on energy efficiency? I mean, a source in this sense, where did you get the information?” Most of the responders said that in the University.

It is very interesting to see that many responders said they also learned about it under their initiative. This compliments the answer about the interest of professionals to learn more about sustainability (see fig.45).

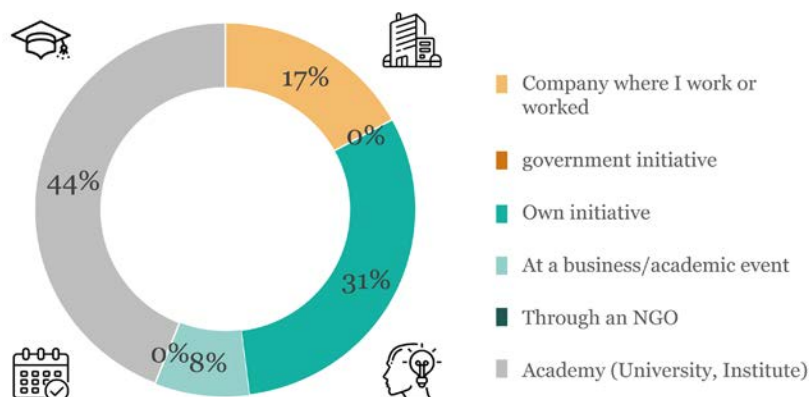


Figure 43. Where did professionals learn about sustainability and energy efficiency? Source: the author

General recommendations mentioned by Ibrahim, 2008 comprehend thinking in architecture beyond buildings, but holistically considering different issues and user types, and then transporting that to the classrooms, integrating sustainability in all the areas as a cross-cutting issue, not encapsulating it in a class (Ibrahim, 2008).

This last is the case in the University of the study case. Sustainability is taught in a class called “bioclimatic” as an emphasis. Students can then choose between sustainable-oriented classes or patrimony buildings studies. A student may graduate after studying for ten semesters without having any touch with sustainable notions. Because of this, students recommend a curriculum change as their main suggestion (see fig. 44). They find that having more research groups could be highly beneficial. More classes, personnel, and practical workshop had similar responses between 66% and 55%. One suggestion, backed up by the research, is to have sustainability as a cross-cutting issue between all the classes and have some multidisciplinary workshops, integrating sustainability beyond architecture. Since the University has environmental and civil engineering careers, this could very well be the case.

1. change of curriculum
2. more offers of investigation in energy efficiency and sustainability
3. more classes and programs on energy efficiency and sustainability
4. more university personnel with knowledge in the area
5. more practical and theoretical workshops with specialized personnel

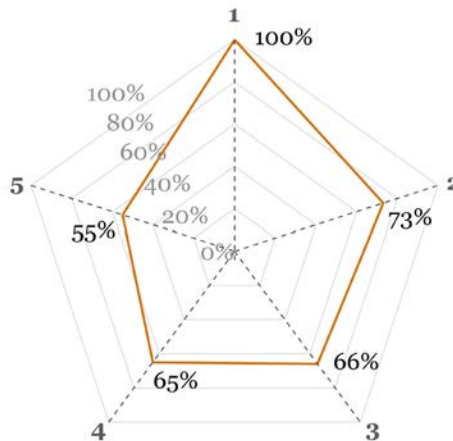


Figure 44. Students focus strategy to improve their learning about sustainable architecture design. Source: the author

4.4.3.3 Interest

The third part of the survey topics concerns the respondents' interest in sustainability and sustainable construction. First, the author started by reviewing the interest of students and professionals and the correlation between their answers, then the motivation between users and students to participate in initiatives that are related to climate change. Students and users were asked this question as they have stronger connections with communities and organizations (aka. Neighbors' associations or students' bodies).

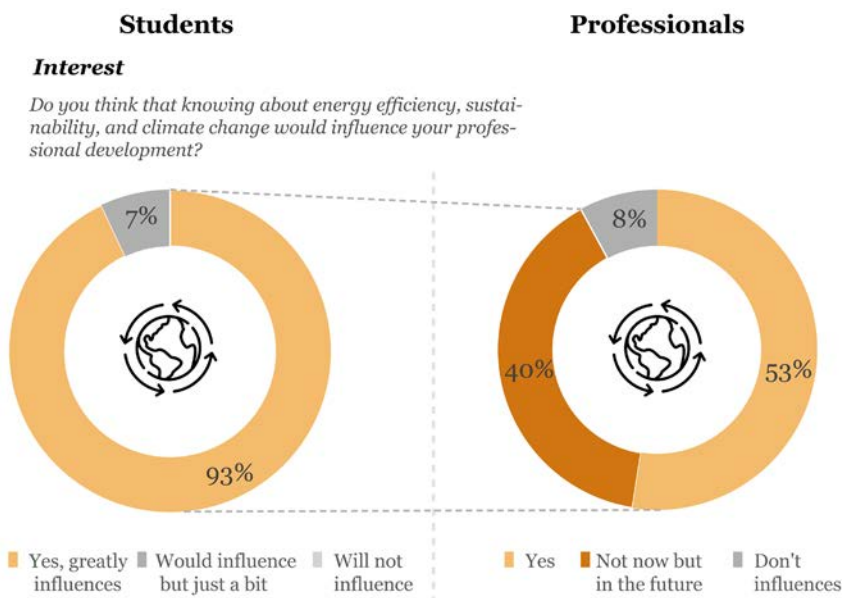


Figure 45. Interest of students' vs professionals in sustainability measurements. Source: the author

It is interesting to see (Fig.45) how connected the answers between the two groups are. One sees that students consider that knowing about energy efficiency, sustainability, and climate change will significantly influence their future as professionals being 93% of them answering yes. Parallely this same 93% of professionals think, in general, that having notions about sustainability influences professional development. However, still today, 40% of the answers think that knowing these concepts is not influential, meaning they perceive there is not a strong need to build and design more sustainably. One of the questions for the suggestions will be to then try to answer the 'How to bring all these professionals into thinking that sustainable design is not *just* a pure technical knowledge but that it can be integrated with the traditional and vernaculars way of construction that they already know?'

If fig.46 and 47 get cross-examined, the straightforward takeaway is that all groups: students, professionals, and users, are motivated to do actions towards climate change. Furthermore, users are already doing actions for the mitigation of climate change. One can conclude that there is an interest in it, but still, there is much work to do. As seen in fig.47, only 20% of the students are seen to be directly involved in climate change initiatives.

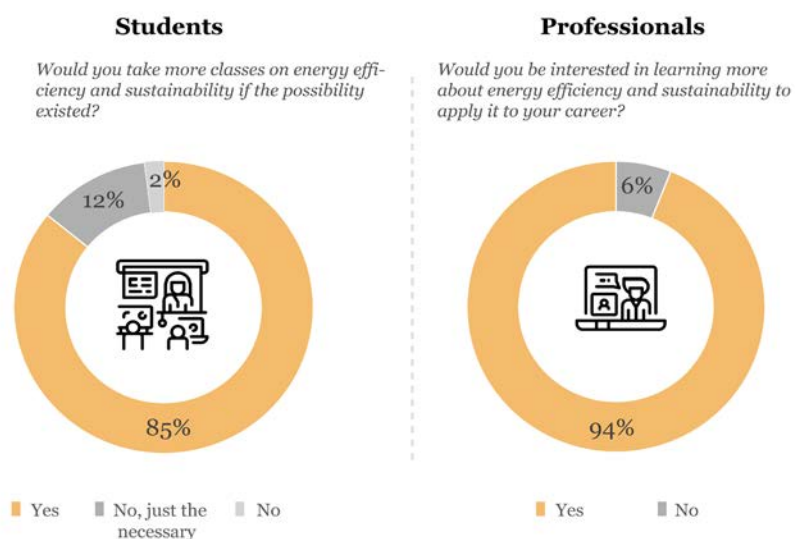


Figure 46. Interest of students and professionals to learn more about energy efficiency and sustainability. Source: the author

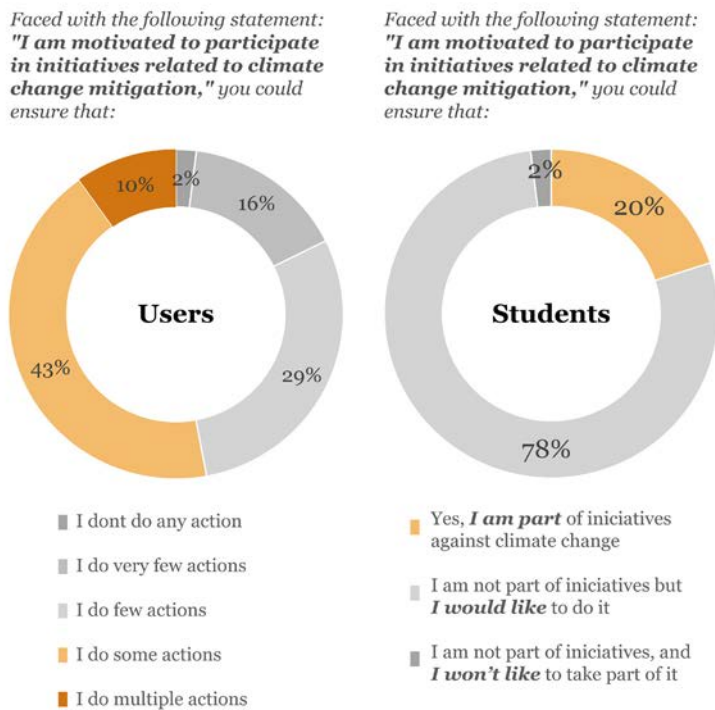


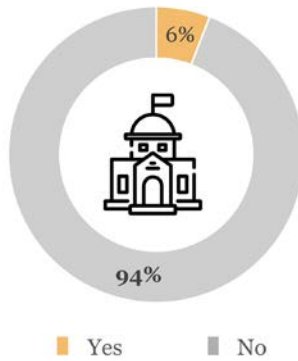
Figure 47. Motivation towards sustainable actions, user's vs students. Source: the author

4.4.3.4 Support

One of the most significant gaps found in this research is how little users know about the credit advantages offered by the national government when buying sustainable housing (see fig.48). 94% of the people do not know them. Still, almost 60% of the users think that if the house they were about to rent or buy would have an energy certification, it would influence their decision. Users were asked to organize the factors for choosing a home in order of importance. The localization and price come up first, followed by area and materials; they placed last the house energy demand. Still, even when users have other preferences at first *now*, that does not mean this cannot be changed with pedagogy. There is a potential intention of users to choose a sustainable home now, which is then a task of the government to make users aware of the benefits of sustainable architecture. Since, as it has been seen, if this energy certificate existed, this parameter could be used as a tie-breaker and in the future it could have a more significant

role.

Do you think the national government sufficiently discloses the credit benefits for purchasing sustainable housing?



Would it influence that the house you are considering buying or renting would have an energy certification?

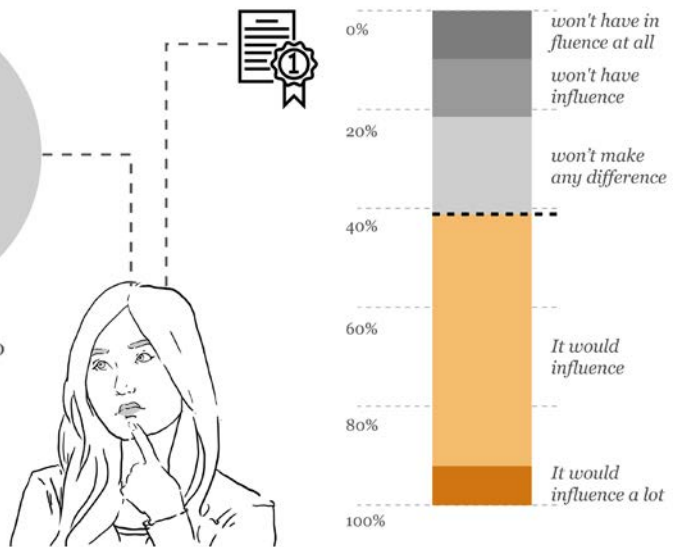


Figure 48. Reflection of user's intentions to buy sustainable housing. Source: the author

Direct economic stimulus is the preferred incentive strategy by users (see fig.49). Especially having a better credit margin which is what the government is doing now by giving an almost 25% plus on top of the already existing subsidies to pay the bank credits when choosing sustainable housing. However, as we have seen before, these subsidies are not a total guarantee and only cover non-social housing that represented a 50% of the market in the first trimester of 2022 (DANE, 2022).

Understandably, the national government wants to subsidize high-income homes that traditionally consume more water and energy, but sustainability is more than reducing operative energy. Lower-income residential areas tend to be on the city's outskirts, often in risk areas. The construction of these neighborhoods results in a big carbon footprint due to the transportation of services, the change of land use, and the long daily commuting of people to these areas. Nevertheless,

the issue goes back from the beginning to what the law measures and how the incentives are created around it where different strategies are needed for the different social sectors.

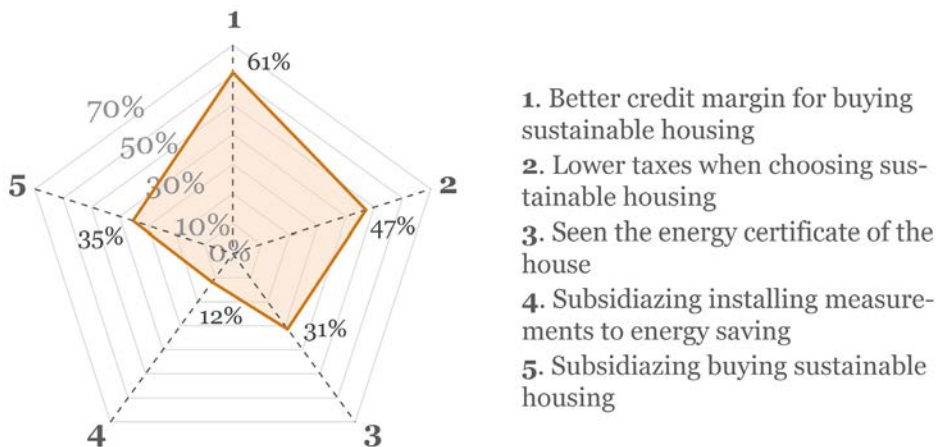


Figure 49. Preferred incentives by users. Source: the author

The knowledge barrier is one of the issues professionals consider affects the most the implementation of sustainable construction policies since it was selected 66% of the time by the surveyors. Nevertheless, other barriers like the lack economic support from the government, combine with the high prices of energy-saving technologies makes also play an important role (see fig. 50). But one can wonder if for the Colombian contexts is really necessary to have these very expensive technology for reach sustainability. Maybe if one needs to have a building certified in a specific energy building certification, that sometimes can push to implement international developed technology as Lizarralde debates: *“critics also argue that these certifications encourage the use of imported construction components and foreign technology, increasing project costs, carbon emissions, and dependency on industrialized solutions coming from the “North.”* (Lizarralde, 2018)

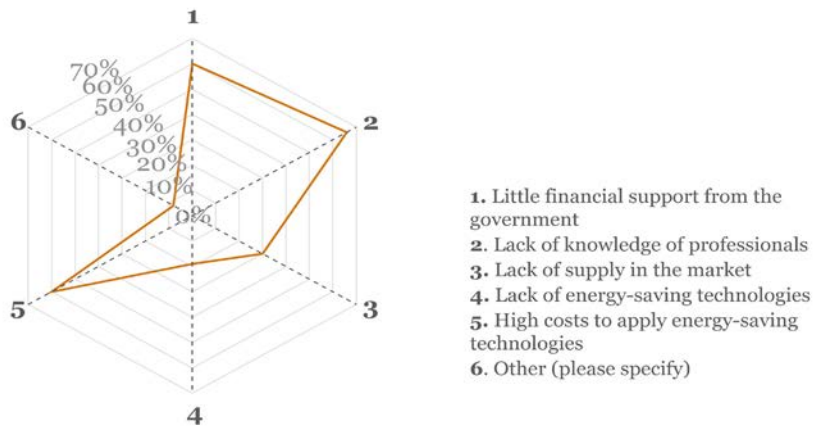
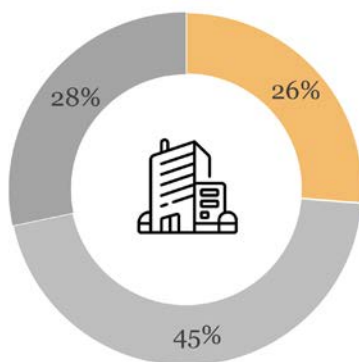


Figure 50. Professionals' perceived barriers for the implementation of sustainable policies. Source: the author

On the other hand, the lack of support that professionals receive is evident. Inside their offices, there are not many opportunities to learn. Only 26% of them said to have support from their employer to learn more about building energy efficiency. This situation should not be the case, as training opportunities have proven to be an effective measure to increase productivity, motivate employees, and attract them into the company. In the end is beneficial for both employees and employers (Pedrini & Cappiello, 2022). This scenario is also the case for the support professionals expressed to have from the government to learn about energy efficiency. Only 9% of the answers were positive (see fig.51).

Do you think you have the necessary support **from the company** you work for to learn more about building energy efficiency?



Do you consider that you have the necessary support from the **National Government** to learn more about energy efficiency in buildings?

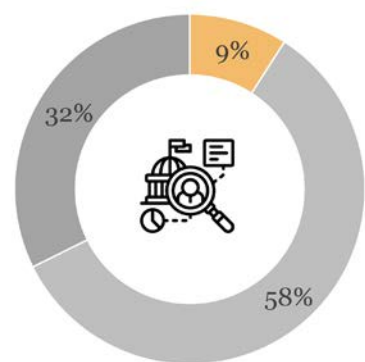


Figure 51. Support received by professionals from companies and the government. Source: the author

4.4.3.5 Companies' management

Company owners and directives see knowledge as one of the principal barriers to implementing sustainable policies. Answers given by the companies show there is a lack of knowledge about Colombian energy and water regulation, the initiatives the company can participate in, and technical knowledge. Furthermore, they also do not have the tools to make decisions. This issue means that even if they knew about how directly related their job is to climate change and how urgent it is to build more sustainable, they do not have the decision tools to deal with this.

The areas in fig.52 related to knowledge are highlighted in orange, that is the ones that companies selected the most as barrier to implement sustainable construction policies. Nevertheless, there are other barriers like the non-priority sustainable measurements have for the company, barrier number seven. Could be there a way to bring companies to see sustainability as a good investment and move this issue into their priorities?

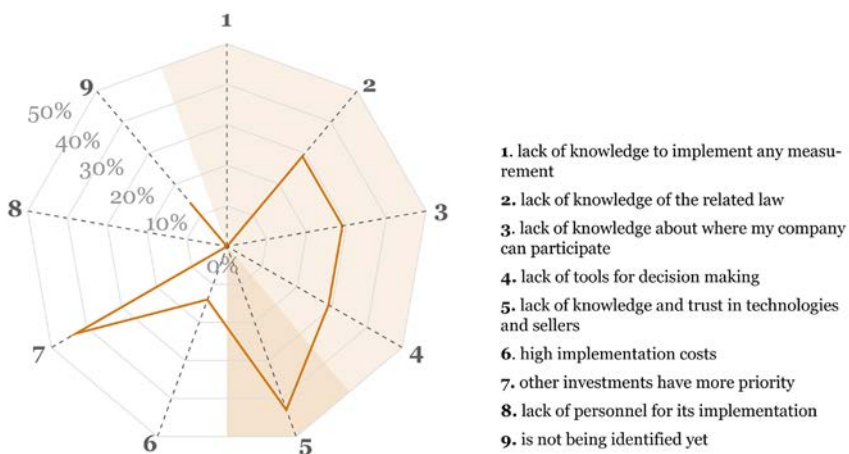


Figure 52. Companies' barriers to implement sustainable policies. Source: the author

Do you know any initiatives concerning climate change that your company can participate in?

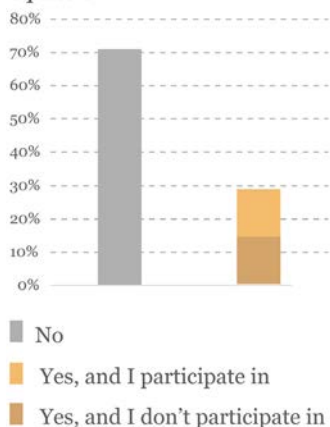


Figure 53. knowledge of initiatives.

Source: the author

In fig. 53, one can see how company owners do not know what initiatives they can implement concerning climate change adaptation and/or mitigation with 71% of the answers being no. Even when 86% of them perceive that their companies are directly related to climate change. Moreover, only 14% of the responders participate in any initiatives.

Climate change adaptation in the construction sector is a topic that often is left behind. For example, the Territorial Management Plan POT of Bucaramanga mentions very little about it. There is, though, the Colombian Institute of Technical Standards and Certification ICONTEC. In the ICONTEC they have a standardization group for sustainable construction. The committee is in charge of creating the Colombian Technical Norms NTC *in Spanish*. The sustainable construction committee made the NTC 15392:2021 “Sustainability in buildings and civil engineering works. General principles” This standard comes from an international norm ISO 15392. However, this norm does not come from actual Colombian experiments or the committee’s expertise. The last NTC derived from the committee’s expertise was the NTC 6112, “Colombian environmental mark of sustainable building for uses different than housing” it has some consideration for water, energy, materials, and air use. This norm was a good starting point for a more comprehensive sustainable law. This NTC was the product of cooperation between the public and private sectors in 2016. Since the NTC 6112 in 2016, ICONTEC has not created new norms based on the committee’s expertise but instead focused on translating international ISO to Spanish and adapting it to Colombia.

Had the company done action to introduce measurements of energy efficiency and sustainability?

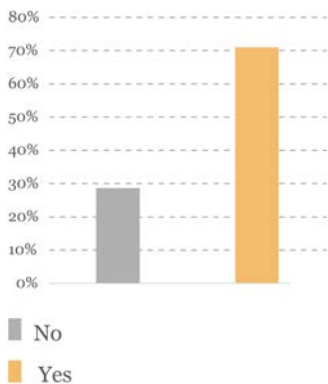


Figure 54. Actions that are done by the company. Source: the author

Do you consider that your clients would be interested in knowing your initiatives related to climate change adaptation and/or mitigation?

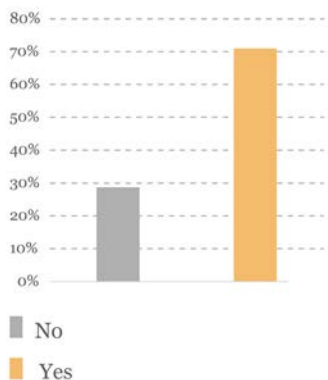


Figure 55. Client's interest. Source: the author

Nevertheless, the NTC are a private standard that people would have to buy even for reading them, it is a good start, but they are not a law of mandatory compliance. Being unfamiliar of the impact of the construction sector on climate change is not an issue exclusive to the study area or developing countries. For example, a study done in Australia concludes that legislation and climate change awareness are some of the key recommendations to enhance the preparedness of residential construction companies to adapt to climate change due to their lack of awareness (Jayasinghe & Stewart, 2022). It is interesting to see the difference between fig.54 and fig.55. One can see how companies lack knowledge about climate change initiatives but manifest to have a good application of measurements to improve energy efficiency. One can infer this situation is due to the accessibility in the Colombian market to find sanitary and lighting appliances with energy-saving technology, which is becoming a common practice. However, it is necessary to go forward to the mere installation of devices. Unfortunately, that is the principal focus of Colombian resolution 549/2015.

The author also asked companies if they think clients are interested in their sustainable practices; 71% said yes. Clients (users) can potentially influence the application of sustainable practices. For example, article shows that consumers of both developing and developed countries are demanding more sustainable goods and sustainable practices from companies. An astounding 71 percent increase in internet searches for sustainable products worldwide over the previous five years is revealed in a recent global report from

The Economist Intelligence Unit, commissioned by WWF (WWF International, 2021).

At the end of the survey, company owners were asked what measures they could implement to improve energy efficiency in their operations. Strategies 1 to 5 are related to water and energy consumption. Most answers in that category were similar, with water consumption optimization being the most applied strategy (see fig.56). Optimizing materials, creating the company's environmental diagnosis, and modernizing their automobiles are not so appealing to the surveyed. Still, sustainable transportation measurements like going to work by cycling or carpooling are encouraged by some companies having 29% of positive responses.

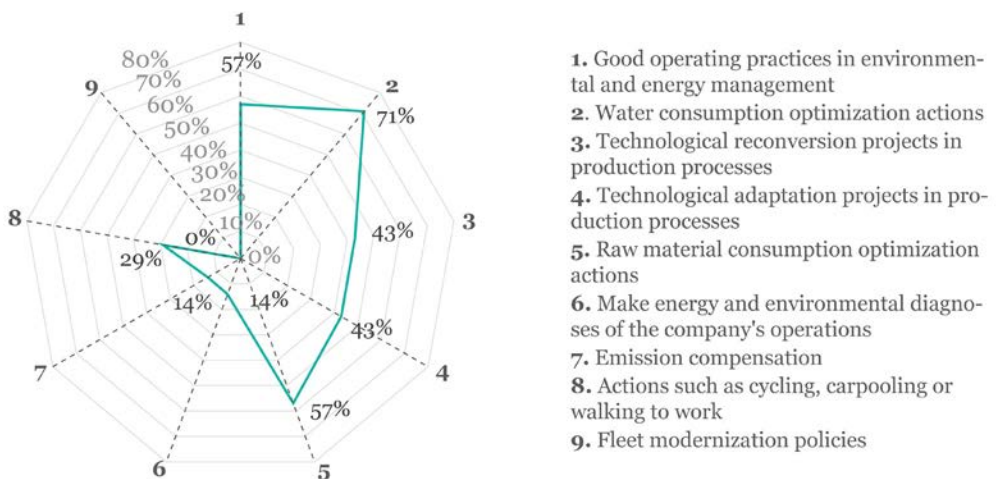


Figure 56. Preferred strategies by companies. Source: the author



Part 3. How could be improved?

Fig. 57 Illustration by the author



5. Improvement possibilities

5.1 Re-construction of a sustainable policy

In Colombia, the control and verification of the energy and water savings regulation, resolution 549/2015, is the role of local governments. The idea of cities being policy-makers and not policy-takers is interesting. It aligns with what scholars and other advocates have proposed for allowing cities to have a more active role in their governance (Kern, 2019). Nevertheless, the national government must implement different mechanisms for this to become a reality.

In the case of Colombia, as was reviewed in this research, local efforts are not shared between entities and other localities. There is a big gap in communication between different local governments nationally. There is a perceived unbalanced division of power in who enters the sustainable construction arena. Due to the fact that the main stakeholders in the sustainable construction arena in Colombia are all from the private sector, the ones that make the green building certification systems, the companies' clusters that launch programs related to sustainability or promulgating the use of these certifications, and even the Colombian Council of Sustainable Construction is private. Having a plurality of private stakeholders on its own is not a problem. However, it makes the process less reflective and transparent. It does not allow necessary actors to enter the conversation about how these policies should be made, like small companies, architecture startup firms, local NGOs and ordinary people.

In March of 2022, in a local forum, the vice minister of housing said (Ruiz, 2022) that the national government does not want to control sustainable housing because it "is too cumbersome" and that the responsibility should be then in the green building certifications auditors. However, this cannot continue being the government's opinion if Colombia wants to achieve a genuinely sustainable policy and adapt to the local conditions. Because the change does not come from one sector of society but from the integration of all. Due to all these reasons, the research proposes a reconstruction of sustainable policies, it incorporate the dif-

ferent actors, from technical, ecopolitical and the behavioral group, and considers the different scales of government and the construction processes (see fig. 58)

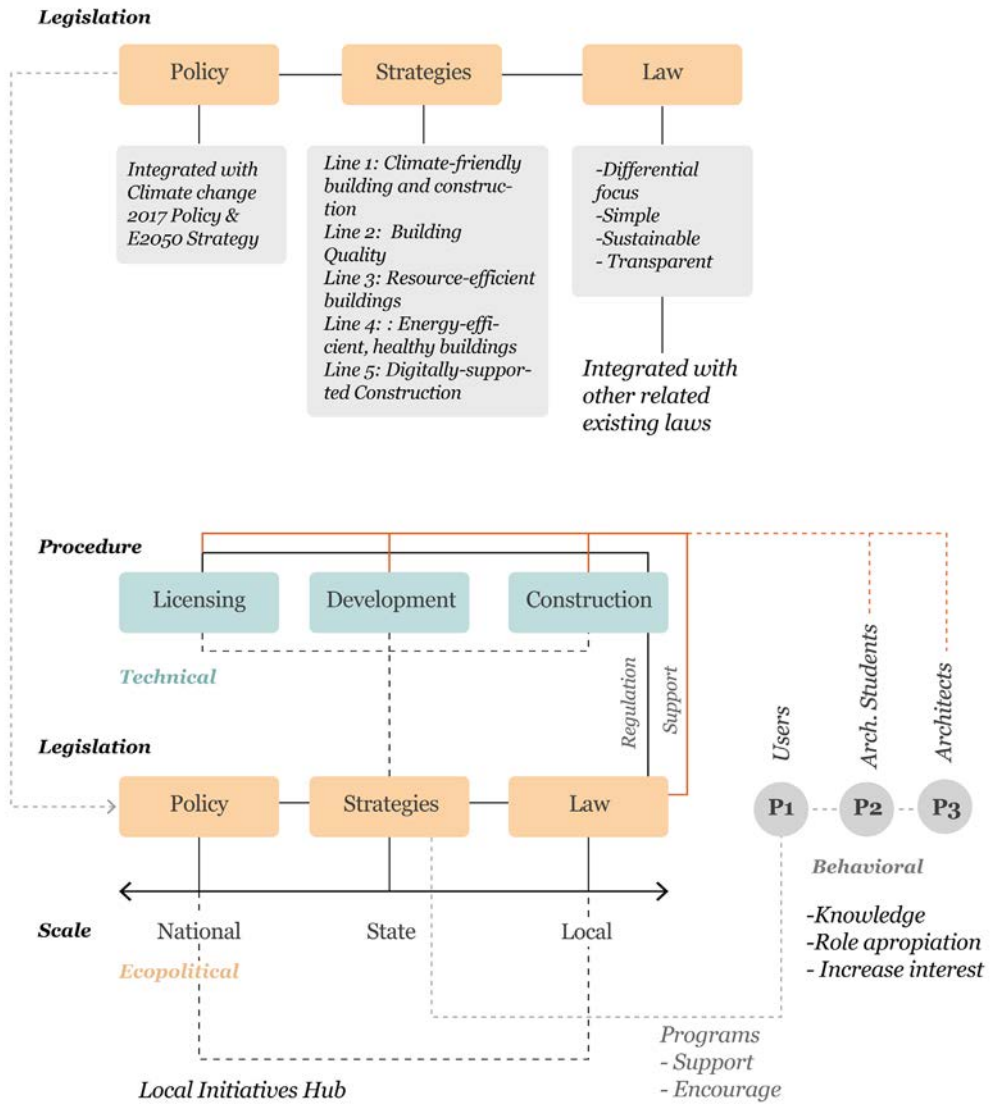


Figure 58. Reconstruction of a sustainable construction policy, suggestion. Source: the author

5.2 Discussion

This research advises continuing to give local governments the power to control and verify the implementation of sustainable construction regulations. Yet, based on the findings of this research, the need for improvement is considerable. In this section, the author will discuss based on the key findings of the interviews with the eco-political, technical, and behavioral stakeholders, along with the author’s reflections and analysis. The main concepts can be seen in figure 59.

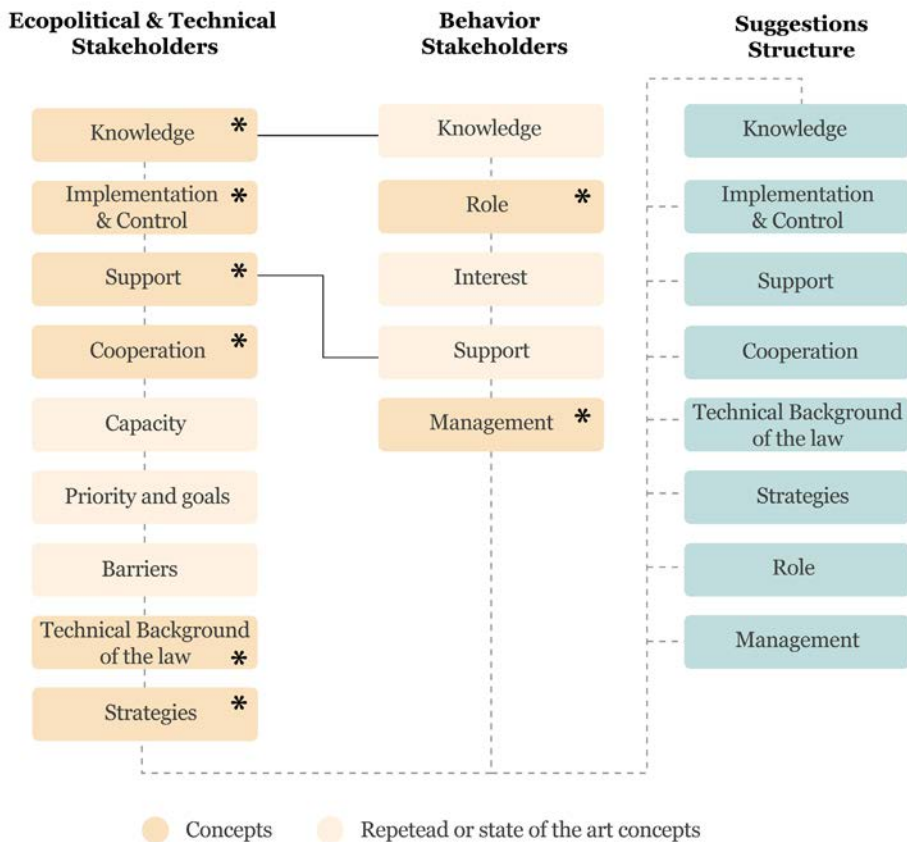


Figure 59. Suggestion structure based on the research analysis of the different stakeholders. Source: The Author

5.2.1 Knowledge

In terms of knowledge, government officials seem to not know much about the existing Colombian energy and water regulations (res. 549/2015), and in general,

there is little knowledge from them about sustainable construction. This issue can be explained because there is no government control and verification of any regulation addressing sustainable construction, meaning there is no need from them to know. This research advises tracking this problem from the inside by creating internal programs that will help public workers to know more about sustainability construction, climate change, and sustainable development, among other related subjects. Possibly also, creating a secretary of sustainable development in the local governments would help every dependency to address sustainable development issues holistically, not just related to the building sector.

To overcome the barrier of the lack of knowledge in the study area, the government can create different programs considering the current interest of the students and architects to learn more, as shown in this research. Furthermore, integrating users' needs and opinions to achieve sustainable development goals, because as the author exposed before, behavioral patterns of users can significantly impact the energy/water consumed in buildings. Next then is the list of the possible subjects that each program could have.

- a. *Users: Key strategies: Allow participation; equip people with knowledge; leverage the leaders.*

-Research shows that when people have a more knowledgeable opinion about sustainability, they will be motivated to adopt those practices, such as installing solar panels (Abram W Kaplan, 1999). Creating pilots with community leaders about climate change mitigation and eco-friendly practices is a good resource.

-Motivation by example can be an excellent persuasion strategy. For example, by making it mandatory for the public sector to adopt the (new) sustainable construction policy, building pilot projects can motivate users to implement possible actions if these buildings are close to them.

-Allow citizens to participate in the creation of sustainable construction policies. Considering communities' opinions will enrich both ways. To the government

by seeing communities' needs and to communities by learning more about how to live more sustainably, possible behaviors to change, and practices to put in place. After all, research shows that 77% of people want to learn how to live more sustainably (Southern Cross University, 2019). Furthermore, this research shows that 53% of the users have already implemented some action toward climate change mitigation.

- b. Arch. Students: Key strategies: *Allow participation; equip students with specific knowledge; leverage the leaders.*

- Incorporating sustainable manners as a cross-cutting issue, not just as a class.
- Having a person from the university who structure projects for the national government to finance, capturing those funds to create initiatives where students can be more connected with climate change, energy efficiency, and other environmental programs. The most prominent example of student initiatives around climate change has been developed recently—a new wave of students and young people committed to motivating others to act around the climate crisis. With the hashtag #FridaysForFuture (Fridays For Future, 2022) and organized strikes in multiple cities worldwide, this collective of mostly students is trying to change the world.

- Build a bridge between the government and academia, developing students' committees inside the university that can name a student representative to go to city council meetings and be part of the discussion table around sustainability manners.

- c. Professionals: Key strategies: *Allow participation; equip professionals with specific knowledge; leverage the leaders, networking, further support.*

- This research will advise strengthening public-private cooperation to develop workshops about climate engineering, in general, without having to do these

workshops about a particular certification. But how to teach on free-license software, or by using rules of thumb, teaching professionals how to use analogic charts, and switching the central core of sustainability based on passive strategies that perform very well in the tropical contexts. In related research, authors applied passive cooling design strategies as adaptation measures to lower indoor overheating risk in tropical climates, showing outstanding results. (Gamero-Salinas, Monge-Barrio, Kishnanic, López-Fidalgo, & Sánchez-Ostiz, 2021).

These workshops will serve as an opportunity to integrate the professionals here certified to enter the advisory support line that the government would have to offer to be able to enforce a more mandatory sustainable construction regulation. That is why is important from the government officials to still be involved in these programs. The programs will also serve as networking opportunity to professionals, creating business opportunities.

5.2.2 Implementation and control

The policy should come from a collective effort involving different social sectors. Examples of initiatives in Colombia exist. The Metropolitan Area of “Valle de Abura” in Antioquia created a Public Policy of Sustainable Construction and a guide for sustainable construction buildings. The Metropolitan Aburra Government made this guide following the Handbook of Sustainable Building Policies of UNEP (UNEP, 2013). Nevertheless, this is still of voluntary compliance. No municipality in Valle de Abura has yet implemented it. Hence, this shows that there is a need for the national government to push and support these initiatives. Otherwise, they will continue to be just a set of recommendations. Multiple actors throughout the research have reiterated the need to make mandatory the regulation for sustainable construction, at least to start by enforcing the current water/energy regulation, resolution 549 of 2015.

There is also a need to set goals to include sustainable urban development indicators. This framework can operate over existing infrastructure (government bodies) and legislation (included inside the Territorial Management Plan) to link

urban and construction levels. Again, a sustainable construction policy should be integrated into a holistic, multiscale framework and not be limited to just buildings. Similarly, since the CONPES 3343 in 2005 is highlighted the disarticulation of the climate change and sustainable policies in the country. Nonetheless, since then work have been done to improve this situation, after the underlined mismatches and opportunities contained in the CONPES 3700 “Institutional Strategy for the Coordination of Policies and Actions on Climate Change in Colombia,” the Colombian government created in 2018 the National Policy on climate change (Colombia. Ministerio de Ambiente y Desarrollo Sostenible, 2017).

However, when consulting the 2017 national policy on climate change, under its urban action plans, it focuses on transportation, water management, energy, and waste. There is not a lot of mention of the construction sector and its environmental repercussions. Henceforth, this policy can be complemented by a national sustainable construction policy, allowing the possibility of creating a network of cities, different interlinking programs, and initiatives. The later will enable the creation of synergies between local-national actors.

There is a necessity to improve the monitoring mechanism of water, gas, and energy consumption in the county. For this, there is the need to invest in the reform of the platform of the SUI, as the platform does not work well most of the time. It is noted that 33% of the providers are located in rural providers there are often inconsistencies in the information submitted by them. This issue is due to a lack of knowledge and comprehension about the information that local public services providers must report, the preparation of the data subject to report using formats and forms, and the qualities of quality that each registered data must meet, among other factors. From 100% of the stated information results in Colombia, 30% of them presents inconsistencies (Cáceres-Torrado & Mejía-García, 2020). To fix these issues, the authors proposed using the Information and Communication Technologies TIC in Spanish (Cáceres-Torrado & Mejía-García, 2020), a Colombian initiative to provide people with education programs about technology and communication, often focused in rural and low-income communities.

Nonetheless, creating an organism for implementation and control requires increased funding. This situation will require the destination of a part of the local taxes to these programs, but also local governments could apply to get funded by the national government. Local governments would need a person/entity that structures the projects and applies to calls from organizations like Innpulsa and Colombia Productiva. After all, this is how the Construction Chamber gets funded. There are possibilities, but it is necessary to have the political willingness.

5.2.3 Support

There is a solid need to establish a multilateral partnership between local government, academia, and the private sector. As this research had suggested, local governments should create programs that support the technical knowledge that companies need. Still, at the same time, the private sector must help to bring their expertise to transform this process.

Several studies have identified the research gaps in the analysis of energy efficiency/comfort/building performance and related projects in tropical contexts (Gamero-Salinas, Monge-Barrio, Kishnanic, López-Fidalgo, & Sánchez-Ostiz, 2021) (Rodriguez, Coronado, D'Alessandro, & Medina, 2019) (Rodriguez & D'Alessandro, 2019). The lack of research support is an issue that Latin America generally faces. As this research has exposed in the theoretical framework, little research has been done about sustainable construction in the region. Nevertheless, research is vital to overcome these issues. Ultimately, all these strategies and plans must be proven with data, examples, and pilot projects to know if the direction is right or to improve. The interviewed researchers had a lot of experience in this manner and were looking for ways to break the status quo of the sustainable construction sector. The results would genuinely impact the region if more people could do this.

5.2.4 Cooperation

Multiple projects in Colombia have come from international cooperation. Currently, the Colombian Strategy in Low Carbon ECDBC in Spanish is a program that originated from the strategy E2050 (Gobierno de Colombia, 2021). It was financed by international cooperation between the Spanish Cooperation Agency-Aeacid-, the European Union, and the German Government.

In the local case study, these cooperation's have probe been successful. If the national government could get more involved to catalyze this international cooperation into local actions and create a network of interventions that will help other localities in different parts of the process, allowing them to learn from success and mistakes. This funding would be even magnified, as other localities could use the same methodology to implement it and will allow that small towns with not such a big cooperation network to still be part of this initiatives.

The author would also recommend that local entities unite efforts with the academia to develop cooperation projects between other universities and localities overseas. Initiatives like Go Glocal! From the University of Stuttgart are an excellent example of small local actions' contribution to producing global results. A partnership between the city of Windhoek (Namibia) and Stuttgart (Baden-Württemberg), funded by Baden-Württemberg Ministry of Science, Research, and the Arts. The goal of this initiative was to make the Sustainable Development Goals (SDGs) applicable to climate change appropriate to local requirements while ensuring that civil society is heard equally (Ley, 2022).

5.2.5 Technical background of the law

This part of the research will summarize the suggestions from the technical perspective of the water and energy regulation, the resolution 549 of 2015. Still, these suggestions can be applied in general for this regulation or other new ones that could come in the future.

a. In the Building Performance Code creation:

- There is a need for a static baseline that will be the starting point for all the saving measurements and not a baseline that is constructed every time a new version of the law is created.
- There should be a national effort to have an energy standard adapted to the tropics, made by the government, not just an adaptation of an international standard.
- Must include the study of other Indoor Environmental Quality IEQ elements like good indoor acoustic comfort, visual comfort, and indoor air quality, not just focused on the thermal comfort.
- The law must have a set of goals and objectives that involves as a whole sustainable construction, not just considering the reduction of the building operative energy.
- The law must be created from the recollection of opinions of different sector of society, users, designers, company owners, government officials, experts, local ONGs, material producers, material extractors among others.
- Own based Colombian energy simulation software necessary for new edifications, and the adoption of an outcome base method for existing buildings, where one can have the goals set based on the building actual energy and water consumption to later achieve the desired goals in a given time. This last strategy could be the one that would work the most in developing countries at it will compare the building in a straightforward manner. Nevertheless, it would be necessary to have in mind realistic goals that users can comply with.
- Multiscale integration beyond buildings, considering the urban ecosystem as a whole.

b. Economic and non-economic incentives

- Financial incentives for users besides bank credits reduction to incentive users that want to invest in sustainable housing but do not need a bank credit.
- Better construction index when proving building construction with sustainable practices.

- Creating a set of Renewable Energy Credits (RECs). To incentivize citizens to become renewable energy producers, providing this credit helps them overcome the initial investment for the installation.
- There is a need to provide economic support for social housing projects that prove sustainable measurements. Since low-income households are the ones that consume less energy, these benefits should be given to the builders that implement innovative proposals like using renewable energy, having a more significant percentage of green areas, and introducing passive strategies that prove better indoor environmental quality, among others.

5.2.6 Strategies

As is presented at the beginning of this chapter (see fig. 58). There is a need to create a holistic, sustainable construction policy, not just the development of regulation or some pilots. In terms of policy, the new construction policy should be integrated with the 2017 Climate Change policy of the national government (Colombia. Ministerio de Ambiente y Desarrollo Sostenible, 2017). It must align with the strategy 2050 for the decarbonization of the county having the 2050 goal (Gobierno de Colombia, 2021). Based on the documents from the ministry of interior and housing in Denmark (Ministry of Interior and Housing, 2021), a similar structure could be implemented as a strategic plan for the case of Colombia, composed of five strategic lines.

Line one focused on producing climate-friendly constructions by studying the use of Life Cycle Assessments methodologies, considering the integration of the whole construction cycle from services to material producers. Line two concentrated on building quality, with initiatives like promoting climate-friendly local materials, creating local material databases, and assessment methods for refurbishes, among others. Line three initiatives look to integrate experts into controlling the construction processes to advise on ways to reduce material waste. Line four will be focused on the incursion of energy efficiency design methods and calculation but also incorporating concepts of Indoor Environmental Qual-

ity. And Finally, Line five could be focused on bringing educational programs within the thematic axes of BIM, LEAN, IOT, BIG DATA, and VDC. It aims to sophisticate the demand.

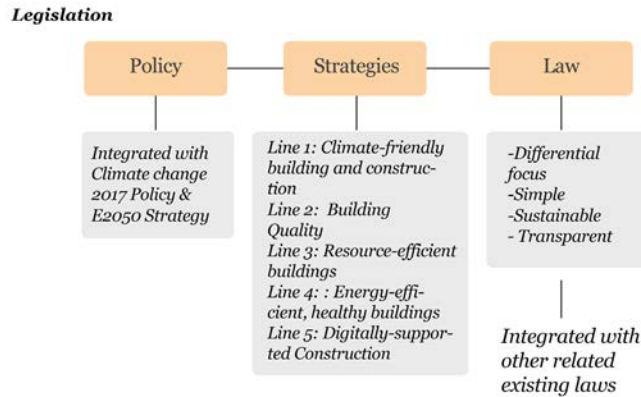


Figure 60. Dissection of the strategies. Source: the author

5.2.7 Management

One of the questions in the management part of this research was to know how there could be a way to bring companies to see sustainability as a good investment and move this issue into their priorities? In terms of investment, sustainable construction is a good one. Research by the World Green Council shows that the business benefits of building green are the reduction of the design and construction cost, higher asset value, better operation cost, increase in workplace productivity and health, and finally, there is mitigation of risk (World Green Building Council, 2013). This situation can be explained as in general better planning when building can have very positive results, as the study proves. Yet, in developing countries, often time constraints and a few personnel makes more planning very difficult.

For this reason, the research will suggest creating a government program for sustainable planning for the private sector, where material extractors, material manufacturers, and construction companies could apply. The government will

send a representative to help companies improve their sustainable development management practices. Touching on topics like optimization of resources, waste management, and promotion of climate-friendly materials, among other topics. The funding opportunities for the use of renewable energy by the national government already exist, but as this research shows, most companies do not know about these incentives. Local entities like the Commerce Chamber already have programs in place to increase productivity in companies, but this program could be potentialized by interlinking productivity with sustainable practices.

Aside from the economic incentives, there is a need for decision-making tools where companies can prioritize what to invest in to have the maximum benefits. For this reason, the author recommends applying decision-making tools available in sustainable construction like research by Mudholkar and Dhawale validates; implementing evaluations like Life Cycle Assessments, Cost Base Assessments, or Risk Based Assessments (Mudholkar & Dhawale, 2019).

5.3 Scenarios

Here the research will envision three scenarios following different paths that sustainable construction regulation in the country could take—first, business, as usual, a portrayal of the current model of private seals to certify green buildings. Secondly, a certification in a 4.0 era, in this case, the author would reflect on what could happen if private certifications were mixed with more input and control from the national government. Finally, with the third scenario, a mixed-methodology for the tropics, which could be the case if federal and local governments work together, in this case also integrating different scales, stakeholders and deriving from a sustainable policy framework.

5.3.1 Business as usual

This scenario is based on the actual enforcement of sustainable construction policies in Colombia. Where clusters and other associations will continue financing their projects through government funds. The level of sustainability in con-

struction is be measured by the number of certifications each city has, which would make that specific certification more used. Construction companies will apply certifications in an exchangeable way. Most residential projects will go with EDGE as it is easier to comply with, while offices will go with LEED, the current leader in that sector.

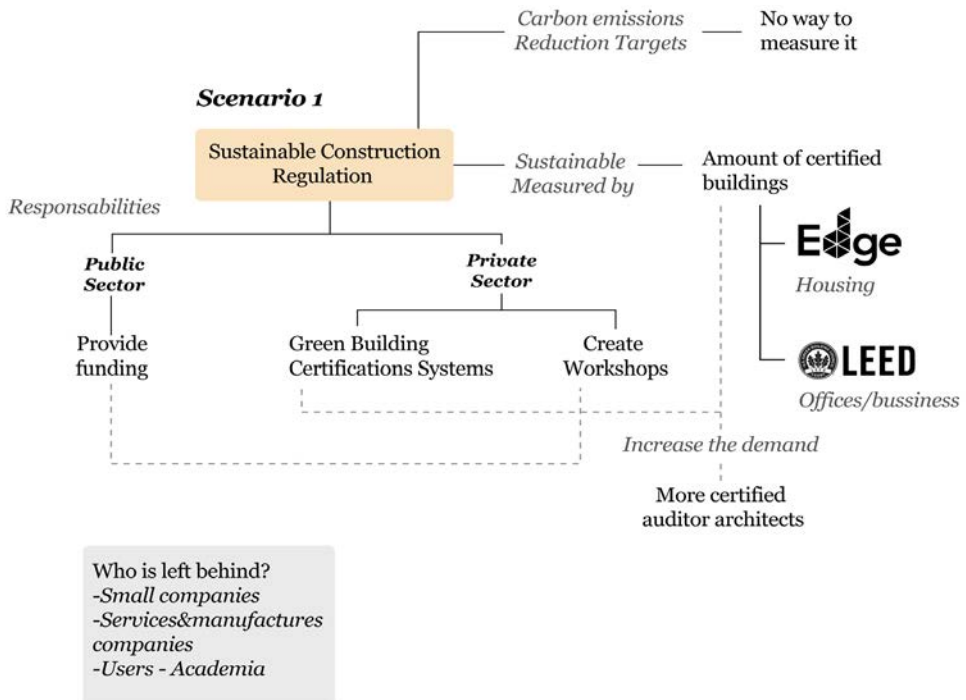


Figure 61. Business as usual, source: the author

The population increase will derive in energy requirements increase for Colombia. Situation that will be even more affected by the increase of use of air conditioners some people installed as means to achieve a green certification as the building did not meet its comfort target. This mostly will be the case for the projects that look into incorporating a LEED certification. Due to the national program of incentives for buildings that are certified with a green building certification and the promotion programs by the construction cluster, there will be a demand for accredited architects to auditor these certifications. This situation

will make more architects get certified in particular codes.

There will be more knowledge of certifications but little environmental benefits. Companies will use green codes that can do from little to harm. Most big cities will look into these matters, and small towns will be left behind due to the lack of professionals in these areas and the lack of economic incentives, as the subsidies to green-certified buildings apply only to cities with more than 500.000 inhabitants.

5.3.2 Certifications in a 4.0 era

After the implementation of the subsidies for “green construction,” using as a certified method the green certifications like LEED, HQE, EDGE, or Casa Colombia. The government will then focus its interest on applying these certifications, leaving behind other projects of changing or creating a similar certification specifically made for the country.

In this scenario, the government will take a mediator role, controlling how much these certifications get implemented and producing incentives for companies to apply them. Converting this tool will be the primary indicator of advance in the sustainable construction of roads. For this, the Colombian government will create a database that the banks and construction companies must fill after the certification of a project to have access to the “eco-subsidie.”

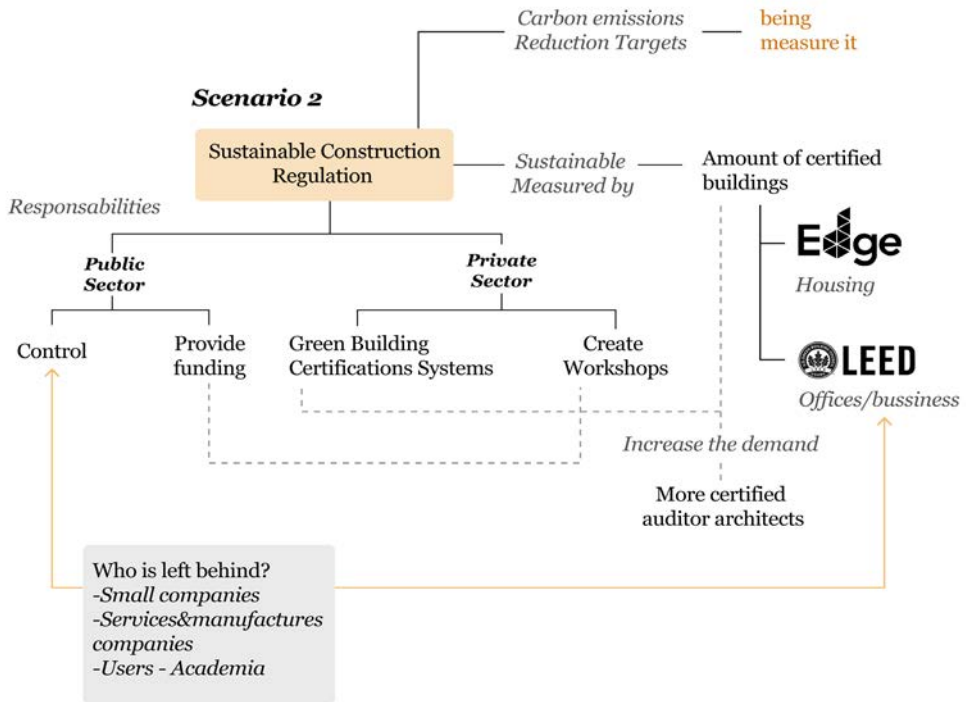


Figure 62. Certifications in a 4.0 era. Source: the author

A more dynamic data collection method will allow the certification statistics by track and more data about the projects for further regulations or even research. The assessment and control of this information will oversee by the DANE (National Statistics Service). This will allow measuring its implementation better, to have data from certified buildings like construction typologies, profiles of possible consumption, and so on.

5.3.3 Mixed-methodology for the tropics

In the third scenario, a new national government realized the role of cutting carbon emissions in the construction sector to reach the goals of the Paris Agreement. The government recognizes Colombia's complex socio-economic and climatic composition requires a differential focus. They see that in the past, some certification like EDGE has good acceptability since they are easy to implement. Nevertheless, they see that a Colombian sustainable construction regulation can

have a more significant impact on sustainability and can be integrated with existing policies under a sustainable construction strategy.

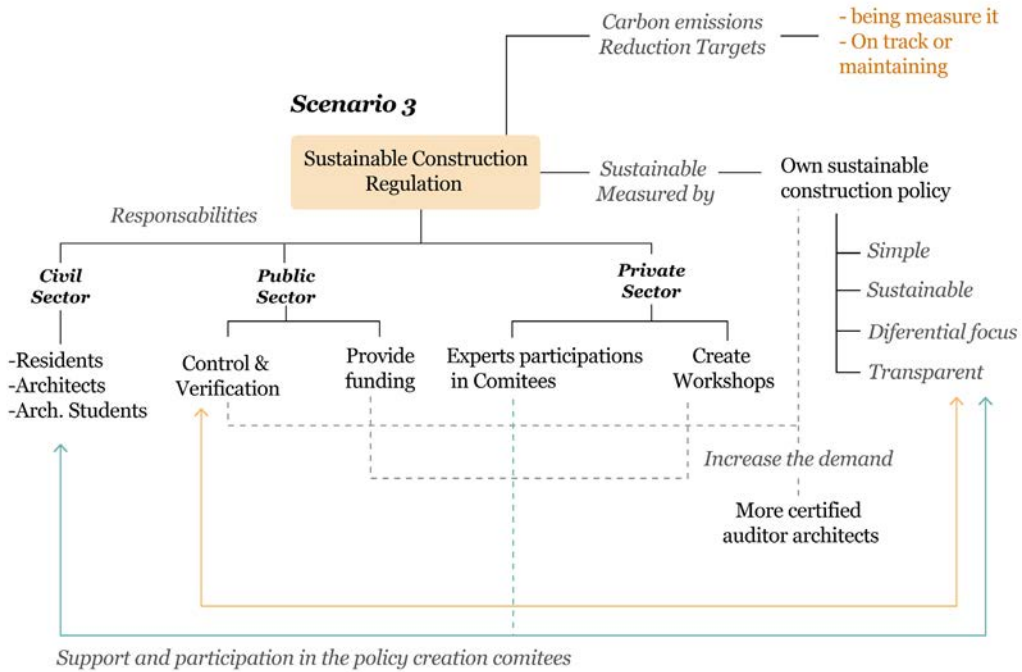


Figure 63. Mixed methodology for the tropics. Source: the author

6. Conclusions

6.1 Conclusion

This research suggested a more comprehensive framework around sustainable construction regulations in a tropical context. Often, research done around the tracking of the implementation of sustainable construction regulations (or energy codes) tends to only focus on one sector perspective like from the construction companies, the government, or the academia. Furthermore, it is not frequently that all parts in the equation are integrated (users, architects, companies, and government); that is one of the key results of this research. That all the participants could expose their different points of view.

This research aimed to understand how sustainable building codes and regulations are being implemented in the case of study Bucaramanga, Colombia. Based on the quantitative and qualitative analysis of in-depth interviews, semi-structured interviews, and surveys performed with multiple stakeholders from diverse contexts. It can be concluded that in the case of the study, there are deficiencies in knowledge, implementation, control, support, cooperation, technical background of the available regulations, and management.

The suggested strategies in chapter five come from the union of the findings of the three groups and their integration in a coherent structure, multidimensional and multiscale. Nevertheless, the practical implications of the suggestions require a significant compromise from both local and national government, as the research had stated before, a political willingness to develop sustainable construction, a transparent and comprehensive formulation, as well as control and verification from the national and local authorities.

In addition, for implementation to work, it will require a continuity of the poli-

cies, strategies, and programs and not be limited to a presidential term. There is a need to change the behavioral patterns of all the civil society, which is not an easy and short task.

Due to the time and practical limitations, the author concentrated this research on the local case of Bucaramanga, Colombia. Still, the author considers that other researchers can apply its findings to various similar socio-economic contexts.

6.2 Recommendations

It is advised that the information contained in the Single Information System SUI in Spanish that monitors water and energy consumption from Residential areas will be displayed on the National Administrative Department of Statistics (DANE). This recommendation is suggested to be able to see the consumption patterns of the different regions. Nevertheless, it is necessary to improve the SUI platform, which often crashes or presents inconsistencies in the information, especially in rural providers' cases.

The research has also found loopholes in the land plan that did not include many sustainability and climate change aspects. The recommendation, in this case, will be to perform a study that showcases different parts of the urban ecosystem, including climate, air pollution, noise maps, flooding risk (this is super important due to the area's phreatic level, and past catastrophic events with flooding) , and finally vulnerability areas. Then the local licensing law could incorporate a sustainable apart in the building permit that shows the user what aspects need to have in mind based on this study. Information will allow users and builders to make more informed decisions when building.

6.3 Further research

To start, one of the first recommendations for further research is to support academic research to produce the missing datasets on carbon emissions of construction materials in the Colombian context. A material database will allow a more transparent tracing of the emissions in the construction sector. It will provide a considerable milestone for research not just in Colombia but in the Latin American context, as there is not much information on this subject today. The creation of material datasets will also help the technical development of the policies around sustainable construction.

The second piece of advice is to create an energy standard for the tropics. In general, it would be an enormous improvement for research done in this area in Latin context that have to use other international standards. It would also help tremendously to create a Colombian-base energy code. The design of this standard will require a cooperation agreement between academia and the industry, along with help from international partners. It could even be created for and with the support of other Latin countries.

Further research is also needed to check the proposed suggestions, define the time framework that a proposal like this could take, and its cost—also, complementary research on the necessary trade-offs, especially for the first project stages. In addition, it would be required to re-check with the users again if the proposed recommendations are acceptable for them using some form of community-base participation research.

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Annexes

Survey Questions - Students - In Spanish



University of Stuttgart
Germany

DAAD

Deutscher Akademischer Austauschdienst
German Academic Exchange Service

Agenda de Construcción Sostenible entre Políticas Nacionales y Acciones Locales

Evaluación de la implementación de códigos de construcción sostenible en Bucaramanga, Colombia.

Esta es una investigación, realizada con fines académicos y financiada por el Servicio de Intercambio Alemán (DAAD), que busca establecer cuales son los retos que enfrentan los diferentes actores involucrados en la formulación e implementación de los códigos de eficiencia energética en el sector de la construcción en Colombia (academia, empresarios, profesionales y ciudadanía en general). Queremos conocer su punto de vista del tema, su opinión es importante para nosotros.

* Información requerida

* ¿Responde esta encuesta en calidad de?

¿En qué grupo de edad se encuentra?

- 14-18
- 18-22
- 22-30
- 30-40
- +40

¿Con cuál género se identifica?

¿En este momento cursa estudios de?

- Arquitectura y diseño
- Ingeniería civil
- Otras Ingenierías (Eléctrica, mecánica, etc.)
- Otros estudios relacionados

¿Además de estudiar, se desempeña laboralmente en algo relacionado con su profesión?

- No
- Sí, medio tiempo
- Sí, tiempo completo
- Sí, pero solo en vacaciones

¿Sabe usted qué es la construcción sostenible?

- Sí, se de que se trata
- He escuchado el término, pero no tengo muy claro en qué consiste
- No conozco el término

* ¿Sabe usted qué es el cambio climático?

- Conozco el concepto
- Lo he escuchado, pero no tengo muy claro en qué consiste
- No conozco el término

¿Sabe usted qué es la neutralidad de carbono? (Net-Zero Carbon)

- No tengo conocimiento
- Sí tengo conocimiento

¿Tiene conocimiento sobre la resolución (0549 del 2015) del gobierno nacional en pro de la eficiencia energética en las edificaciones?

- Si tengo conocimiento
 Se que existe pero no la he leído
 No tengo conocimiento

* ¿Conoce alguno de los sistemas de certificación en construcción sostenible que algunas constructoras aplican en el país? Marque los que conozca

- No conoce ninguno
 LEED
 EDGE
 CASA Colombia
 WELL
 BREEAM
 Living Building Challenge
 HQE
 Fitwell
 Other (Please specify)

¿Cree que la universidad a la que pertenece ha incluido apropiadamente temas relacionados con el cambio climático y la sostenibilidad dentro de su currículo?

- Si, hay suficientes oportunidades donde aprendemos sobre esto
 No, es muy incompleto en este sentido
 Si, pero considero que podría mejorar
 No, pero esta en proceso de hacerlo

Dentro de la universidad a la que pertenezco hay grupos interdisciplinarios donde puedo aprender sobre sostenibilidad, eficiencia energética y/o cambio climático.

- Si
 No
 No, pero esta en proceso de crearse
 N/R

* Ordene de menor a mayor donde 1 es nada importante y 5 es muy importante, las prácticas que su institución educativa debería aplicar para aumentar el conocimiento acerca de la eficiencia energética y sostenibilidad.

[Please rank all option(s).]

Cambio de currículo	-Rango -	☰
Incorporación de mas cursos/programas en eficiencia energética y sostenibilidad	-Rango -	☰
Aumento de la oferta de investigación en eficiencia energética y sostenibilidad	-Rango -	☰
Más personal educativo con conocimiento en el área.	-Rango -	☰
Talleres teórico - prácticos con personal especializado	-Rango -	☰

¿Cree que tener conocimientos sobre eficiencia energética, sostenibilidad y cambio climático influiría en su desarrollo profesional?

- Si, influiría sustancialmente
 Influiría pero muy poco
 No influiría

¿Tomaría más cursos sobre eficiencia energética y sostenibilidad si existiera la posibilidad?

- Si, totalmente.
 No, tomaría solo los necesarios.
 No, me interesa el tema, pero prefiero enfocarme en otros

* Ante la siguiente afirmación: "Estoy motivado a participar en iniciativas relacionadas con la mitigación del cambio climático" usted podría asegurar que:

- Si, hago parte de iniciativas relacionadas con la mitigación del cambio climático
 No, no hago parte de iniciativas pero me gustaría hacerlo
 No, no hago parte de iniciativas y no me interesa/puedo hacer parte de ellas

Survey Questions - Professionals - In Spanish

¿Con cuál género se identifica?

--Seleccionar--

¿Trabaja usted en?

- Empresa privada - empleado
- Empresa privada - trabajador por cuenta propia
- Sector público
- Academia

¿Qué grado académico posee?

- Técnico
- Profesional especializado
- Master (M.Sc.)
- Doctorado (Phd)

¿Conoce usted sobre el termino eficiencia energética en las edificaciones? Si lo conoce, podría decirnos cuando lo aprendió?

- No lo conozco
- Si lo conozco, aprendí sobre el termino hace un (1) año
- Si lo conozco, aprendí sobre el termino hace dos (2) años
- Si, hace mas de cinco (5) años

¿Cuál es su principal fuente de información sobre eficiencia energética ? Por fuente en este sentido quiero decir, ¿Dónde obtuvo la información?

- Empresa en la que trabajo o trabaje
- Iniciativa del gobierno
- Por iniciativa propia
- En un evento empresarial/academico
- Por medio de una ONG
- Academia (Universidad, Instituto)

¿Conoce la legislación colombiana que reglamenta las medidas de ahorro energético?

- Si tengo conocimiento
- No tengo conocimiento

¿Conoce alguna de las líneas de crédito ofrecidas por el gobierno nacional para la compra de vivienda sostenible?

- Si
- No

¿Conoce alguno de los sistemas de certificación en construcción sostenible que algunas constructoras aplican en el país? E.J. (LEED, EDGE, CASA)

- No los conozco
- Se que existen pero no los he leído
- Los he leído pero no los aplico
- Los he leído y los aplico
- Poseo certificación en el uso de alguno de estos códigos.

¿Conoce alguno de los sistemas de certificación en construcción sostenible que algunas constructoras aplican en el país?

- No conoce ninguno
- LEED
- EDGE
- CASA Colombia

- WELL
- BREEAM
- Living Building Challenge
- HQE
- Fitwell
- Other (Please specify)

¿Se maneja alguna metodología BIM en la empresa en la que trabaja?

- No, pero se contrata externamente a una oficina especializada
- No
- No, pero se encuentra en fase de estudio
- No, pero se encuentra en fase de planeación (fechas de implementación acordadas)
- Si, se encuentra en implementación
- Si y está en fase de seguimiento

¿Cree que tener conocimiento sobre eficiencia energética y sostenibilidad en las edificaciones influye en el desarrollo de su carrera profesional? (mejores posibilidades de empleo, facilidad de encontrar trabajo, entre otros)

- No influye
- No influye ahora, pero creo que influirá más en el futuro
- Si influye

¿Estaría interesado en aprender/desarrollar más su carrera en torno a la eficiencia energética y la sostenibilidad?

- Si me interesa
- No me interesa

¿Cuáles cree que son las barreras para la aplicación de códigos de eficiencia energética y sostenibilidad en las edificaciones? Marque las que considere

- Poco apoyo financiero por parte del gobierno
- Desconocimiento de los profesionales
- Falta de oferta en el mercado
- Falta de tecnologías de ahorro energético
- Altos costos para aplicar las tecnologías de ahorro energético
- Otra (por favor especifique)

¿Considera que cuenta con el apoyo necesario por parte de la empresa en la que trabaja para aprender más sobre la eficiencia energética en las edificaciones?

- Sí
- No
- NS/NR

¿Considera que cuenta con el apoyo necesario por parte de el Gobierno Nacional para aprender más sobre la eficiencia energética en las edificaciones?

- Sí
- No
- NS/NR

¿Piensa que como profesional podría influir dentro de la empresa en la que trabaja de forma que incorpore criterios de sostenibilidad y eficiencia energética de manera más completa?

- Si podría influir, pero no se como hacerlo
- Si podría influir y lo estoy haciendo
- No es de mi competencia

*** ¿Quién en su opinión es el actor con más responsabilidad para una correcta aplicación de los códigos de eficiencia energética?**

- Arquitectos y diseñadores
- Constructores
- Entidades gubernamentales
- Instituciones educativas
- Manufactureros de materiales de Construcción

Survey Questions - Construction companies - In Spanish

¿Con cuál género se identifica?

--Seleccionar--

¿Dentro de la empresa de construcción a la que pertenece, es usted?

- Profesional
- Coordinador
- Alto directivo - Dueño

La empresa a la que pertenece trabaja en proyectos... (marque los sectores a los que pertenece)

- Residenciales
- Comerciales
- Industriales
- Hoteleros
- Educativos y salud

¿Se maneja alguna metodología BIM en la empresa en la que trabaja?

- No pero se contrata externamente a una oficina especializada
- No
- No, pero se encuentra en fase de estudio
- No, pero se encuentra en fase de planeación (fechas de implementación acordadas)
- Si, se encuentra en implementación
- Si y esta en fase de seguimiento

¿Sabe usted qué es la construcción sostenible?

- Conozco el concepto
- Lo he escuchado, pero no tengo muy claro en qué consiste
- No conozco el término

¿Sabe usted qué es el cambio climático?

- Conozco el concepto y además conozco las medidas que puedo implementar en mi empresa
- Sé qué es el cambio climático, pero no conozco cómo puedo implementar medidas en mi empresa
- Lo he escuchado, pero no tengo muy claro en qué consiste
- No conozco el término

¿Sabe usted qué es la descarbonización? (Economía baja en carbono)

- No tengo conocimiento
- Si tengo conocimiento

¿Qué tan relacionada percibe usted que está su empresa con el cambio climático?

- Directamente relacionada
- Indirectamente
- No hay ningún nivel de relación
- NS/NR

¿Sabe usted que Colombia se comprometió a reducir sus emisiones de gases efecto invernadero en un 51% para el año 2030?

- Si tengo conocimiento
- No tengo conocimiento

¿Posee algún proyecto que este certificado bajo alguno de los sellos de eficiencia energética en el país? (LEED, EDGE, CASA Colombia)

- Ningún proyecto
- Menos de los 10% de los proyectos
- Entre el 10% y el 30% de los proyectos
- Entre el 30% y 50% de los proyectos
- Mas del 50% de los proyectos

¿Conoce de incentivos relacionados con cambio climático y descarbonización a los que su empresa pueda aplicar o participar?

- No conozco
- Sí conozco, pero por la actividad económica de la empresa creo que no aplica
- Los he escuchado, pero no tengo claro en qué consisten las iniciativas
- Sí conozco y sí participo
- Sí conozco, pero no participo

¿Conoce de alguna iniciativa relacionada con el cambio climático y la descarbonización en la que su empresa pueda participar?

- No conozco
- Sí conozco, pero por la actividad económica de la empresa creo que no aplica
- Los he escuchado, pero no tengo claro en qué consisten las iniciativas
- Sí conozco y sí participo
- Sí conozco, pero no participo

¿Cuáles son los retos internos que ha identificado su empresa para avanzar hacia la mitigación y adaptación al cambio climático?

- Falta de conocimiento para implementar alguna medida
- El desconocimiento de normatividad relacionada
- Falta de conocimiento de proyectos donde puede participar la empresa
- Falta de herramientas para la toma de decisiones
- Costos elevados para implementar alguna medida
- Falta de conocimiento y/o confianza en tecnologías o proveedores
- Otras inversiones tienen mayor prioridad
- No se cuenta con el área o personal interno para su implementación
- No los ha identificado

¿Considera usted que sus consumidores o clientes estarían interesados en conocer sus iniciativas o acciones relacionadas con el cambio climático?

- Sí
- No

* ¿La empresa a la que pertenece ha realizado alguna acción relacionada con medidas para introducir medidas de eficiencia energética y sostenibilidad?

- Sí
- No

* ¿Cuáles son las medidas que considera que podría implementar en su empresa para mejorar la eficiencia energética en sus operaciones?

- Buenas prácticas operativas en gestión ambiental y energética
- Acciones de optimización de consumo de agua
- Acciones como el uso de la bicicleta, compartir el vehículo o caminar para ir al trabajo
- Hacer un diagnóstico energético y ambiental de las operaciones de su empresa
- Proyectos de reconversión tecnológica en los procesos productivos
- Proyectos de adaptación tecnológica en los procesos productivos
- Acciones de optimización de consumo de materias primas
- Políticas de modernización de flotas
- Compensación de las emisiones

Survey Questions - Users - In Spanish

¿Cuál es su edad?

- 18-25 años
- 26-35 años
- 35-50 años
- 50-60 años
- mas de 60 años

¿Cuál es su género?

- masculino
- femenino
- no binario
- otro

¿Su condición?

- Empleado
- Trabajador por cuenta propia
- Estudiante
- Desempleado
- Retirado
- Otro

¿Su lugar de residencia se encuentra ubicado en?

- Bucaramanga
- Piedecuesta
- Girón
- Floridablanca

¿El estrato socioeconómico de su lugar de residencia es?

- 1 y 2
- 3
- 4
- 5 y 6

¿La casa en donde vive es?

- Vivienda propia
- Vivienda rentada

¿Conoce alguno de las líneas de crédito ofrecidas por las entidades financieras (Bancolombia, Davivienda, BBVA) para la compra de vivienda sostenible?

- Si
- No

¿Ha escuchado nombrar alguno de los los sistemas de certificación en construcción sostenible que se aplican en el país?

- No conoce ninguno
- LEED
- EDGE
- CASA Colombia
- WELL

- HQE
- Fitwell
- Other (Please specify)

Ordene de menor a mayor donde 1 es nada importante y 5 es muy importante, los requerimientos que tiene en cuenta a la hora de comprar/arrendar vivienda

[Please rank all option(s)]

- | | | |
|---|----------|---|
| El precio - factor económico | -Rango - | ☰ |
| Localización | -Rango - | ☰ |
| Materiales y acabados | -Rango - | ☰ |
| Su sostenibilidad y eficiencia energética | -Rango - | ☰ |
| Tamaño - área de la vivienda | -Rango - | ☰ |

¿Realiza usted alguna acción para el cuidado del medio ambiente? (reciclaje, instalación de paneles solares, instalación de aparatos ahorradores para agua y luz)

- No realiza ninguna acción
- Realiza muy pocas acciones
- Realiza pocas acciones
- Realiza algunas acciones
- Realiza varias acciones

¿Influiría, al momento de comprar o arrendar vivienda, que esta posea alguna certificación energética?

- No influiría para nada
- No influiría
- Me es indiferente
- Influiría
- Influiría bastante

¿Cree usted que el gobierno nacional da a conocer, suficientemente, los beneficios que existen para la compra de vivienda sostenible?

- Sí
- No

¿Cuál de los siguientes factores lo llevaría a usted a inclinarse por comprar una vivienda sostenible frente a una tradicional?

- Mejor tasa de crédito para la compra de vivienda sostenible
- Rebaja de impuestos cuando se elige vivienda sostenible
- Viendo que el certificado energético de la vivienda demuestra un menor consumo energético
- Subsidiando la implantación de medidas de ahorro energético (si se compra vivienda usada)
- Subsidiando la compra de vivienda sostenible

¿Quién en su opinión es el actor con más responsabilidad para una correcta aplicación de los códigos de eficiencia energética?

- Arquitectos y diseñadores
- Constructores
- Entidades gubernamentales
- Instituciones educativas
- Manufactureros de materiales de Construcción

Annexes - English Version

Students

Subject	#	<i>In English</i>
Statistics	Q2	What age group are you in? a. 14-18 b. 18-22 c. 22-30 d. 30-40 e. +40
	Q3	What gender do you identify with? a. Male b. Female c. Nonbinary d. Other
	Q4	What are you currently studying? a. Architecture and design b. Civil engineering c. Other engineering (electric, mechanical, etc.) d. Other related fields
	Q5	In addition to studying, do you work in something related to your profession? a. No b. Yes, half time c. Yes, full time d. Yes, but just during vacations
	knowledge	Q6
Q7		Do you know what climate change is? a. I know the concept b. I have heard the term, but I cannot really define it c. I have not heard the term
Q8		Do you know what carbon neutrality is? (Net-Zero Carbon) a. Yes, I know b. No, I do not know
Q9		Are you aware of the resolution (0549 of 2015) of the national government in favor of energy efficiency in buildings? a. Yes, I am aware b. Yes, I know it exists, but I have not read it c. No, I am not aware
Q10		Do you know any of the sustainable construction certification systems that some construction companies apply in the country? Check the ones you know. a. I do not know any b. LEED c. EDGE d. CASA Colombia e. WELL f. BREEAM g. Living Building Challenge h. HQE i. Fitwell j. Other (please specify)

Role	Q11	Do you think the university to which you belong has appropriately included climate change and sustainability topics within its curriculum? a. Yes, there are enough opportunities to learn about it. b. No, it is not really a subject c. Yes, but I think it could be better d. No, but it is in the process of being included
	Q12	There are interdisciplinary groups within the university to which I belong to learn about sustainability, energy efficiency, and climate change. a. Yes b. No c. No, but it is in the process of being created d. I do not know / no answer
	Q13	Order from smallest to largest where one is not essential and five is very important; your educational institution should apply the practices to increase energy efficiency and sustainability knowledge. a. Change of curriculum b. Incorporating more classes / programs in energy efficiency and sustainability c. Increase of research possibilities for energy efficiency and sustainability d. More experts in this field e. Theoretic workshops – practices with experts
Interest	Q14	Do you think that knowing energy efficiency, sustainability, and climate change would influence your professional development? a. Yes, it would influence it substantially b. Yes, but only a bit c. No, it would not influence it
	Q15	Would you take more classes on energy efficiency and sustainability if the possibility existed? a. Yes, totally b. No, only the necessary ones c. No, I am not interested in that topic, but I would like to focus on others
	Q16	Faced with the following statement: "I am motivated to participate in initiatives related to climate change mitigation," you could ensure that: a. Yes, I take part in initiatives related to climate change mitigation b. No, I do not take part in initiatives, but I would like to c. No, I do not take part in initiatives, and I am not interested / I cannot participate

Professionals

Subject	#	<i>In English</i>
Statistics	Q17	What gender do you identify with? a. Male b. Female c. Nonbinary d. Other
	Q18	What are you working in? a. Private sector – employed b. Private sector – self employed c. Public sector d. Academic sector
	Q19	What academic degree do you have? a. Technical b. Specialized professional c. Master (M.Sc.) d. Doctor (PhD)

knowledge	Q20	Do you know about the term energy efficiency in buildings? If you know it, could you tell us when you learned it? " a. No, I do not know it b. Yes, I know it. I learned about it a (1) year ago c. Yes, I know it. I learned about it two (2) years ago d. Yes, for more than five (5) years
	Q21	What is your primary source of information on energy efficiency? By reference in this sense, I mean, where did you get the information? a. The office that I am working in / used to work b. Government initiatives c. Self-initiative d. In a working / academic event e. Through an NGO f. In the academic (university, institute)
	Q22	Do you know the Colombian legislation that regulates energy-saving measures? a. Yes, I know it b. No, I don't know it
	Q23	Do you know of any of the lines of credit offered by the national government to purchase sustainable housing? a. Yes b. No
	Q24	Do you know any of the sustainable construction certification systems that some construction companies apply in the country? EDGE (LEED, EDGE, HOME) a. No, I do not know any b. I know they exist, but have not read any c. I have read them, but I don't apply them d. I have read them and apply them e. I am certified in the use of one or more of those codes
	Q25	Do you know any of the sustainable construction certification systems that some construction companies apply in the country? a. I do not know any b. LEED c. EDGE d. CASA Colombia e. WELL f. BREEAM g. Living Building Challenge h. HQE i. Fitwell j. Others (please specify)
Interest	Q26	Is there any BIM methodology used in the company where you work? a. No, but we hire an external office, which is specified in that b. No c. No, but it is in the study phase d. No, but it is in the planning phase (agreed implementation dates) e. Yes, it is being implemented f. Yes, and it is in the follow-up phase
	Q27	Do you think that knowing energy efficiency and sustainability in buildings influences your professional career development? (Better employment opportunities, ease of finding work, among others) a. Yes, it influences it b. No, it does not influence it yet, but I think it will in the future c. Yes, it influences it
	Q28	Would you be interested in learning more about energy efficiency and sustainability to apply it to your career? a. Yes, I would be interested b. No, I am not interested

Support	Q29	What do you think are the barriers to applying energy efficiency and sustainability codes in buildings? Check the ones you consider a. Little financial help from the government b. Ignorance of professionals c. Lack of supply in the market d. Lack of energy saving technologies e. Others (please specify)
	Q30	Do you think you have the necessary support from the company you work for to learn more about energy efficiency in buildings? a. Yes b. No c. I do not know / no answer
	Q31	Do you consider that you have the necessary support from the National Government to learn more about energy efficiency in buildings? a. Yes b. No c. I do not know / no answer
Role	Q32	Do you think that as a professional, you could influence the company you work for so that it incorporates sustainability and energy efficiency criteria more fully? a. Yes, I could influence it, but I do not know how b. Yes, I could influence it and I am doing it c. No, it is outside of my competence
	Q33	Who, in your opinion, is the actor with the most responsibility for the correct application of energy efficiency codes? a. Architects and designers b. Constructors c. Government entities d. Educational institutes e. Manufactures for building material

Companies

Subject	#	<i>In English</i>
Statistics	Q34	What gender do you identify with? a. Male b. Female c. Nonbinary d. Other
	Q35	Within the construction company to which you belong, are you? a. Professional b. Coordinator c. Senior Manager - Owner
	Q36	The company to which you belong works on projects... (check the sectors to which you belong) a. Residential b. Commercial c. Industrial d. Hotels e. Educational and health sector
knowledge	Q37	Is there any BIM methodology used in the company where you work? a. No, but we hire an external office, which is specified in that b. No c. No, but it is in the study phase d. No, but it is in the planning phase (agreed implementation dates) e. Yes, it is being implemented f. Yes, and it is in the follow-up phase

	Q38	Do you know what sustainable construction is? a. Yes, I know what it is b. I have heard the term, but I cannot really define it c. I have not heard the term
	Q39	Do you know what climate change is? a. I know the concept b. I have heard the term, but I cannot really define it c. I have not heard the term
	Q40	Do you know what decarbonization is? (Low carbon economy) a. No, I have not heard the term b. Yes, I know what it is
	Q41	How related do you perceive your company is to climate change? a. Directly related b. Indirectly related c. No relation d. I do not know / no answer
	Q42	Do you know that Colombia committed to reducing its greenhouse gas emissions by 51% by 2030? a. Yes, I know b. No, I do not know
	Q43	Do you have a certified project under any of the energy efficiency seals in the country? (LEED, EDGE, CASA Colombia) a. No project b. Less than 10% of the projects c. Between 10% and 30% of the projects d. Between 30% and 50% of the projects e. More than 50% of the projects
	Q44	Do you know of incentives related to climate change and decarbonization to which your company can apply or participate? a. I do not know any b. Yes, I know but due to the economic activity of the company I don't think it applies c. I have heard of them, but I am not sure what they consist of d. Yes, I know and participate e. Yes, I know but I do not participate
	Q45	Do you know of any initiative related to climate change and decarbonization in which your company can participate? a. I do not know any b. Yes, I know but due to the economic activity of the company I don't think it applies c. I have heard of them, but I am not sure what they consist of d. Yes, I know and participate e. Yes, I know but I do not participate
Capacity	Q46	What internal challenges have your company identified to move towards mitigation and adaptation to climate change? a. Lack of knowledge to implement measurements b. Ignorance of related regulations c. Lack of knowledge of projects where the company can participate d. Lack of tools for decision making e. Higher costs for implementing measurements f. Lack of knowledge and / or confidence in technologies or providers g. Other investments have higher priority h. There is no field or internal staff for its implementation i. Not identified yet
	Q47	Do you think your consumers or clients would be interested in learning about your initiatives or actions related to climate change? a. Yes b. No

Management	Q48	Has the company you belong to carried out any action related to introducing energy efficiency and sustainability measures? a. Yes b. No
Opportunities	Q49	What are the measures that you think you could implement in your company to improve energy efficiency in your operations? a. Good operating practices in environmental and energy management b. Actions to optimize water consumption c. Actions such as the use of bicycles, car sharing or walking to work d. Making an energy and environmental diagnoses of your company's operations e. Technological reconversion projects in production process f. Technological adaption measurements in production process g. Actions to optimize the consumption of raw materials h. Fleet modernization policies i. Compensation of emissions

Users

Subject	#	<i>In English</i>
Statistics	Q50	How old are you? a. 18-25 b. 26-35 c. 35-50 d. 50-60 e. Older than 60
	Q51	What is your gender? a. Male b. Female c. Nonbinary d. Other
	Q52	Your condition? a. Employed b. Self-employed c. Student d. Unemployed e. Retired f. Other
	Q53	Where is your place of residence located? a. Bucaramanga b. Piedecuesta c. Girón d. Floridablanca
	Q54	What is the socioeconomic status of your place of residence? a. 1 and 2 b. 3 c. 4 d. 5 and 6
	Q55	The house where you live is? a. My own house b. Rented house
knowledge	Q56	Do you know any of the lines of credit offered by financial institutions (Banco-lombia, Davivienda, BBVA) to purchase sustainable housing? a. Yes b. No

	Q57	Have you heard of any of the sustainable construction certification systems applied in the country? a. I have not heard of any b. LEED c. EDGE d. CASA Colombia e. WELL f. BREEAM g. Living Building Challenge h. HQE i. Fitwell j. Other (please specify)
Interest	Q58	Order from smallest to largest where one is not essential and five is very important, the requirements you consider when buying/leasing a home. a. The price – economic factor b. Localization c. Materials and finishes d. Its sustainability and energy efficiency e. Size – housing area
	Q59	Do you take any action to care for the environment? (Recycling, installation of solar panels, installation of saving devices for water and electricity) a. I have not taken any action b. I have taken only little action c. I have taken a few actions d. I have taken some actions e. I have taken a lot of actions
	Q60	Would it influence now to buy or rent a house with some energy certification? a. No, it would not influence it at all b. No, it would not influence it c. Indifferent d. Yes, it would influence it e. Yes, it would influence it a lot
Support	Q61	Do you think that the national government sufficiently discloses the benefits of the purchase of sustainable housing? a. Yes b. No
	Q62	Which of the following factors would lead you to buy a sustainable home over a traditional one? a. Better credit rate for the purchase of sustainable housing b. Tax reduction for choosing sustainable housing c. Seeing that the energy certificate of the housing shows less energy consumption d. Subsidizing the implementation of energy saving methods (if a used house is bought) e. Subsidizing the purchase of sustainable housing
Role	Q63	Who, in your opinion, is the actor the most responsible for the correct application of energy efficiency codes? a. Architects and designers b. Constructors c. Governmental entities d. Educational institutes e. Manufactures for building material

إقرار

هذه الرسالة مقدمة في جامعة عين شمس وجامعة شوتجارت للحصول على درجة العمران المتكامل هذه الأطروحة مقدمة لجامعة عين شمس (ASU) من شوتجارت - كلية الهندسة المعمارية والتخطيط العمراني (USTUTT) لدرجة العمران المتكامل والتصميم المستدام (IUSD) ، وفقاً لوائح IUSD-ASU.

أنجز المؤلف العمل المتضمن في هذه الرسالة خلال هذه الفترة من فبراير إلى أغسطس 2022.

يؤكد المؤلف أن العمل المقدم هو له / لها وأن المصادقية المناسبة قد تم منحها عندما تمت الإشارة إلى عمل الآخرين. أي نزاعات بشأن حقوق الطبع والنشر للمحتوى هي المسؤولية الوحيدة للمؤلف.

تحتفظ جامعة عين شمس بالحق في توزيع هذه الرسالة علناً في التنسيق القياسي الحالي للجامعة. المؤلف له الحق في نشر المحتوى بأي تنسيق آخر.

30/07/2022

إليانا باولا جوميز أسيفيدو

التوقيع

جدول أعمال البناء المستدام ، بين السياسات الوطنية والإجراءات المحلية

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بواسطة إيلانا باولا جوميز أسيفيدو

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الدراسات العليا

أجيزت الرسالة بتاريخ:

ختم الإجازة
موافقة مجلس الكلية .../.../...

جامعة عين شمس



جامعة شتوتغارت



07/30/2022



أجندة البناء المستدام ، بين السياسات الوطنية والإجراءات المحلية

، تنفيذ اللوائح ذات الصلة في حالة بوكارامانغا
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رسالة مقدمة للحصول على درجة الماجستير في العمران المتكامل والتصميم المستدام

إعداد

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