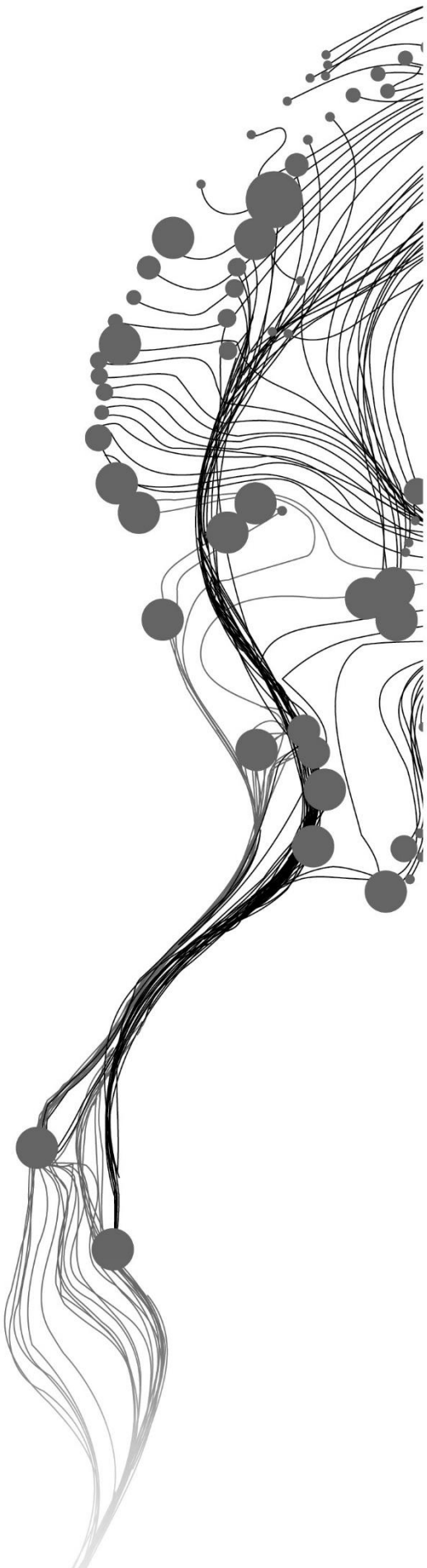
‘NO TIENEN PANTALONES Y QUIEREN CINTURONES’

SOCIAL VULNERABILITY ASSESSMENTS FOR SOCIAL JUSTICE AND EQUITY IN CLIMATE ADAPTATION PLANS

MASSIMO CATTINO

June, 2020

SUPERVISORS:
Dr. D. Reckien
Prof.Dr. R.V. Sliuzas



‘NO TIENEN PANTALONES Y QUIEREN CINTURONES’

SOCIAL VULNERABILITY ASSESSMENTS FOR SOCIAL JUSTICE AND EQUITY IN CLIMATE ADAPTATION PLANS

MASSIMO CATTINO
Enschede, The Netherlands, June, 2020

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Spatial Engineering

SUPERVISORS:
Dr. D. Reckien
Prof.Dr. R. Sliuzas

THESIS ASSESSMENT BOARD:

Prof.Dr. P.Y. Georgiadou	(Chair)
Prof. M. Magoni	(External Examiner, Politecnico di Milano)
Dr. D. Reckien	(1st Supervisor)
Prof.Dr. R.V. Sliuzas	(2nd Supervisor)

ABSTRACT

Climate adaptation planning has attracted more and more attention over the last few years in cities all around the world as a strategy to deal with the increasing threat of climate change. Climate change has greater impacts on people with high social vulnerability. However, climate adaptation plans rarely consider social vulnerability, potentially leading climate adaptive interventions to cases of *maladaptation*, affecting already vulnerable portions of citizens. This research had the objective of ensuring social justice and equity in climate adaptation through the systematic implementation of social vulnerability assessments.
Medellin, Colombia, has been selected as the study area for the research. The city is known world-wide for being a hub of urban innovation, and in this context measures to increase resilience to climate-related hazards have been implemented as well. The study has been tackled with a combination of both quantitative and qualitative methods. A quantitative social vulnerability assessment has been carried out through the construction of a Social Vulnerability Index (SoVI). The procedure has been repeated for two years, 2013 and 2017, in order to evaluate the variations over space and time of social vulnerability in Medellin. The qualitative part of the research, tackled analysing interviews collected during a fieldwork and secondary data, had the focus on the *process* and the *output* of climate adaptation planning, namely participation processes and climate adaptation plans, in order to understand their intrinsic social justice and equity. Finally, results obtained from both the quantitative and the qualitative approaches have been triangulated to judge the *outcome* of the implemented climate adaptive interventions in Medellin.
Results show minimal variations in social vulnerability over the period 2013-2017. The designed climate adaptation plans and climate adaptive interventions have raised many questions in terms of equity and social justice of *process*, *output*, and *outcome* of climate adaptation planning. Citizens were included in the decision-making processes, but not really considered. Serious efforts by Medellin's municipality in regards to climate adaptation are lacking. The only intervention stated to be (also) for climate adaptation is the Green Belt, a project ideated for the first time in 1950, when climate change was far from being a recognised global issue. The Green Belt project has been only partially completed, has brought debatable and inequitable benefits, and has received mostly popular disapproval by the communities living in the interested areas. Low-income residents have been discriminatorily relocated, have lost their social infrastructure and have "sacrificed as collateral damages" for the city's economic aspirations. In the area where the project has been implemented, although the SoVI results show minor variations in social vulnerability, over the period 2013-2017 citizens' political trust towards the institutions significantly decreased.
The combination of qualitative and quantitative results failed in attributing variations of social vulnerability to the implementation of the Green Belt project. However, this combined approach showed a great potential in communicating the urgency of just and equitable climate adaptation actions.

ACKNOWLEDGEMENTS

To my supervisors Dr. Diana Reckien, and Prof.Dr. Richard Sliuzas, sources of great inspirations and constant guidance. I will never thank you enough for all the opportunities that you gave me and for supporting me and my ideas ever since our first meeting. I am infinitely grateful for how much I learned from you.

To Prof.Dr. Yola Georgiadou, for the great influence you had in refining my way of thinking and for your major contribution to shaping my inner "empathic engineer aiming to social justice".

To Veronica, Edier, Aura and all the interviewees in Medellin for your warm welcome, for sharing your valuable time and knowledge with me, and for giving me some of the most thought-provoking and emotional meetings of my life.

To Cristhian and Deepshikha for your immense help during the fieldwork and for the lasting memories together in Medellin.

To all the people of ITC, and in particular my classmates and most of all new family, as no course in the world could ever teach me as much as all the moments I spent with you. This unforgettable journey would not have been the same without you.

To my family and long-time friends back home, for your crucial support and motivation.

To Mudiwa Wangu, simply for changing me and my life for the better, and for being every day such a role model. Ndokuda.

To my parents and my sister, for all the sacrifices you made for allowing me to take such an important step for my life. Thank you for being always on my side.

To my grandparents, the most influential persons in my life. This is for you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

Climate adaptation: "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities" (IPCC, 2014a).

Disaster risk: "The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity" (UN, 2016).

Disaster risk reduction: "Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development" (UN, 2016).

Equity: "Equity implies fairness in the relationship between the individual and the state, including a just distribution of the benefits and services in a society with respect to a universal standard or values such as human rights. For example, no individual or institution should act in a way to damage, compromise, or limit the freedom and rights of others" (Lawrence, 2002).

Gentrification: "Gentrification is a process of socio-spatial change where the rehabilitation of residential property in a working-class neighbourhood by relatively affluent incomers leads to the displacement of former residents unable to afford the increased costs of housing that accompany regeneration" (Pacione, 2001).

Resilience: "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UN, 2016).

Social justice: "Fair distributions of wealth, opportunity, and privileges by means of fair treatment, proportional distribution, and the meaningful involvement of all people in social decision-making" (Reckien, Lwasa, et al., 2018).

Vulnerability: "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (UN, 2016).

I think we are blind, Blind but seeing,
Blind people who can see, but do not see.

José Saramago, 1995

1. INTRODUCTION

1.1. Context and social vulnerability

Climate change adaptation plans have attracted more and more attention and have seen a notable boost in the last few years over cities all around the world, as a strategy to deal with the increasing threat of climate change (EEA, 2016; IPCC, 2014b). In fact, evidences are showing a dramatic increase in the frequency of climate-related disasters over the last 50 years (V. Thomas & Lopez, 2015). Disasters, however, only occur when an extreme event interacts with humans, causing damages and disrupting communities. This is why even so-called "natural" disasters are always the result of human actions, or a lack of them (Cannon, 1994). Furthermore, the impact of disasters is not homogeneous among countries, cities, communities and individuals, as they disproportionately affect people closer to the specific risk and most of all people with a high social vulnerability (Yoon, 2012). Social vulnerability focuses on the socio-economic and demographic components affecting the impact and the response of communities and individuals to hazards (Huynh & Stringer, 2018), and it describes those characteristics of the population that influence "the capacity of the community to prepare for, respond to, and recover from disasters" (Yoon, 2012, p.824).

In order to assess social vulnerability, a widely used method among scholars and researchers is the creation of a Social Vulnerability Index (SoVI), through the aggregation/combination of carefully selected socio-economic indicators (Chen, Cutter, Emrich, & Shi, 2013; Huynh & Stringer, 2018; Kashem, Wilson, & Van Zandt, 2016; Mavhura, Manyena, & Collins, 2017; Reckien, 2018; Shirley, Cutter, & Boruff, 2003; Yoon, 2012, among others). Since a variation in population characteristics determines an advantage or disadvantage regarding disasters outcomes (Mavhura et al., 2017), a social vulnerability assessment can show clear patterns of inequality among the urban landscape and can be an important tool for helping decision-makers to target policies in order to reduce social vulnerability and increase resilience to disasters.

Local climate adaptation plans rarely consider social vulnerability (Benzie, 2014; Ford et al., 2015; Ford, Berrang-Ford, & Paterson, 2011), potentially leading climate adaptive interventions to cases of *maladaptation*, affecting already vulnerable portions of citizens (Anguelovski, Irazábal-Zurita, & Connolly, 2018; Anguelovski et al., 2016; Antwi-Agyei, Dougill, Stringer, & Codjoe, 2018; Benzie, 2014; Magnan et al., 2016; Ncube-Phiri, Mundavanhu, & Mucherera, 2014; Reckien, Lwasa, et al., 2018). Additionally, growing attention is dedicated to circumstances in which climate adaptive interventions satisfy hidden economical-political interests, "in the name of" sustainability, disaster risk reduction, or the now often abused term of resilience (Anguelovski et al., 2018; Chelleri, Waters, Olazabal, & Minucci, 2015). It is therefore pivotal to investigate these negative and worrying trends regarding climate change adaptation, and their consequences in terms of social vulnerability, social justice and equity.

1.2. Problem definition

Local climate change adaptation plans often do not take into consideration social vulnerability assessments, despite the great importance these can have in increasing the resilience of most at-risk communities and individuals by guiding "investment decisions and efficient allocation of resources" (Mavhura et al., 2017, p.115). Furthermore, examples can be found in the literature (Anguelovski et al., 2018, 2016; Antwi-Agyei et al., 2018; Benzie, 2014; Magnan et al., 2016; Ncube-Phiri et al., 2014; Reckien, Lwasa, et al., 2018) describing how climate adaptive interventions have negatively affected people who are

more vulnerable than others in many countries all over the world (Bangladesh, Chile, Colombia, Ghana, India, UK, USA, Zimbabwe among others). As seen in Magnan (2014, adapted from Barnett & O'Neill, 2010), adaptation actions "disproportionately burdening the most vulnerable" are examples of so-called "*maladaptation*". This situation can occur when the vulnerability of communities and individuals is not only not taken into account, but actually exacerbated, as a consequence of interventions and policies for adaptation to climate change related hazards.

For what concerns the study area, Medellin has been identified as a suitable one. It is known world-wide for being a hub of urban innovation (Garcia Ferrari, Smith, Coupe, & Rivera, 2018), and in this context measures to increase resilience to climate-related hazards have been implemented as well. However, these have been subject to doubts regarding the effective reduction of social vulnerability and instead raised questions on equity and social justice in regards to both the process as well as the outcome of the adaptation planning and resilience measures (Anguelovski et al., 2018, 2016; Reckien, Lwasa, et al., 2018). The most studied case is certainly the Green Belt of Medellin, whose project conceptual model is shown in Figure 1. According to Anguelovski et al. (2018), the Green Belt was framed as green intervention to limit urban sprawl, to 'regreen' the city and to increase the city's climate resilience. However, it also led to "environmental gentrification" and new socio-spatial inequalities, instead of addressing already existing vulnerabilities and reducing disaster risk. Low-income residents have been discriminatorily relocated, have lost their social infrastructure and have been deprived of their practises and culture of nature in order to create "new environmental privileges for upper-class locals and visitors" (Anguelovski et al., 2018). This has raised the doubt about how, and if, social vulnerability assessments were used when designing these interventions, given the fact that social vulnerability assessments for the city of Medellin are lacking among scholars. Investigating all the other implemented climate adaptive interventions, spatially analysing them with social vulnerability assessments pre and post intervention, would give more insights on the matter, and may be an opportunity to improve the fairness and the success of the implemented measures.

The climate adaptive interventions have been designed and implemented through processes of public participation with local citizens (Anguelovski et al., 2018; Garcia Ferrari et al., 2018). The participation, however, was not evenly distributed, as only people with certain *socio-political* characteristics have been involved (Garcia Ferrari et al., 2018), and residents were much less considered compared to the successful "social urbanism" era that made Medellin well known in the past (Anguelovski et al., 2018). The outcome of the Green Belt (the most notorious case) indicates the need for a democratization of local urban climate adaptation plans to achieve a level of good governance, in which the decision-makers meet the needs of people, and social justice, reducing *collateral damages* to vulnerable portions of the population. This would be crucial for transforming the current more top-down panoptical view about the concepts of social vulnerability and climate change adaptation into a much more practical human-scale approach. Adaptation actions that incorporate a deeper knowledge and awareness of social vulnerability and urban inequalities would be necessary in order to increase the effectiveness, the social justice and the equity of the climate change adaptation and disaster risk reduction strategies.

Figure 1: Conceptual model of the Green Belt project Source: Irazábal-Zurita et al., 2013

1.3. Research objectives and questions

Based on the identified research problems, the main objective of this research is to improve equity and social justice of climate adaptive interventions, through the systematic implementation of social vulnerability assessments. Social vulnerability assessments, indeed, can be used in an innovative way in order to verify if the frame given to climate adaptive interventions really has as main goals reducing disaster risk, guaranteeing climate adaptation and addressing existing vulnerabilities, or hides other economical-political interests that may have repercussions on fragile segments of citizens. As seen in several studies (Anguelovski et al., 2016; Benzie, 2014; Reckien, Lwasa, et al., 2018; Ribot, 2010, 2011; Shi et al., 2016), equity, justice and vulnerability need to be considered when designing climate adaptive interventions, and social vulnerability assessments, assisted by an inclusive citizens participation, can help advance the process.

In order to achieve the main research objective, four auxiliary research sub-objectives have been formulated. For each of these four sub-objectives, research questions have been developed, whose answers will help reaching the ultimate aim of the research. Sub-objectives and relative research questions are shown in Table 1.

Table 1: Sub-objectives and relative research questions

Sub-objective	Research questions
1] Produce a social vulnerability assessment for Medellin for different years	[1.1] Which indicators can be used to assess social vulnerability over space and time? [1.2] Was social vulnerability in Medellin reduced, increased or spatially displaced over time?
2] Analyse how citizens were included in the formulation of local climate adaptation plans (*process-related*)	[2.1] With which criteria were citizens chosen for participating in the redaction of local climate adaptation plans? [2.2] How were citizens involved in the decision-making processes and in the design of local climate adaptation plans in Medellin?

3] Investigate how local climate adaptation plans are addressing contextual social vulnerability (*output-related*)	[3.1] Which climate adaptive interventions are proposed? [3.2] How do the climate adaptive interventions propose to address socially vulnerable groups?
4] Uncover the effect/consequences of climate adaptive interventions on social vulnerability over the city of Medellin (*outcome-related*)	[4.1] Which climate adaptive interventions are already implemented? [4.2] How do implemented (and planned) climate adaptive interventions in Medellin compare spatially with the most socially vulnerable areas of Medellin? [4.3] How much of the variation over space and time of social vulnerability in Medellin can be ascribed to the implemented climate adaptive interventions?

1.4. Scientific significance

The desired outcomes for this research have been achieved through the combination of both quantitative and qualitative approaches. First of all, a social vulnerability assessment over space and time for the city of Medellin has been carried out. Although social vulnerability assessments are popular among scholars, especially through the construction of Social Vulnerability Indexes (SoVI), they usually do not measure the evolution of social vulnerability over space and time, mostly because of the complications in data comparability (Cutter & Finch, 2008). Given the dataset that Medellin authorities provide (Alcaldia de Medellin and Area Metropolitana del Valle de Aburrá), the Colombian city gave the opportunity to explore this topic, especially given the fact that even "classic" social vulnerability assessments for Medellin are lacking in the academic context. Furthermore, social vulnerability assessments have never been used in a systematic way as a tool for ensuring equity and social justice in climate adaptation planning, and have a great potential for doing so. Social vulnerability is the measure of a dynamic and contextual process, but the approach can be followed in other areas as well. Medellin has been chosen as the perfect study area to try this new approach, being the paradigmatic example of urban innovation hub, in which green interventions have been already implemented and criticised. The current trend of green interventions and similar "in the name of" interventions (Anguelovski et al., 2018) as popular climate adaptation and disaster risk reduction measures (promoted by the EU as well for the implementation of the Sendai Framework (Faivre, Sgobbi, Happaerts, Raynal, & Schmidt, 2018)) needs to be investigated and tackled, as they can negatively affect vulnerable groups if equity and justice are not targeted directly (Anguelovski et al., 2016; Ribot, 2010, 2011; Shi et al., 2016). Climate adaptation will be at the centre of urban agendas in the next years (Lesnikowski et al., 2017), and a systematic implementation of social vulnerability assessments can guarantee the spotlight on vulnerability, justice and equity. This would also represent a great opportunity for reducing urban inequalities, constantly increasing since many decades (Sassen, 1991), and for achieving sustainable cities and communities, both seen as urgent necessities and listed among the 17 goals of the 2030 Agenda for Sustainable Development (Goal 10: Reduce inequalities & Goal 11: Sustainable Cities and Communities) (United Nations, 2017).

Another relevant outcome from the research will be the qualitative impact evaluation of the effects of climate adaptive interventions on social vulnerability. A key identified research gap is specifically the evaluation of adaptation measures in respect to vulnerable groups (Breil et al., 2018; Ford et al., 2011). The need for monitoring and evaluating climate adaptation interventions in order to assess their effectiveness has been widely reported among scholars (among others Aguiar et al., 2018; Atteridge, Remling, Carmen, Editor, & Hulme, 2018; Berrang-Ford et al., 2019; Breil et al., 2018; Ford et al., 2015,

2011; Olazabal et al., 2019; Sherman & Ford, 2014). However, to the best of the author's knowledge this topic has never been investigated among scholars. Qualitative evaluations of the impacts of climate adaptation are substantially lacking, amongst others, due to their underlying long-term horizon (Ford et al., 2015; Olazabal et al., 2019), and considering that "between 1990 and 2018, the natural and technical sciences received 770% more funding than the social sciences for research on issues related to climate change" (Overland & Sovacool, 2020, p.1).

The qualitative impact evaluation is usually used in the judgment of interventions for international development (Copestake, Morsink, & Remnant, 2019; Leeuw & Vaessen, 2009), but its structure has been identified as capable of giving significant outcomes for this research as well. This research tries to fill the identified gap following an approach inspired by the Qualitative Impact Protocol of Copestake, Morsink, & Remnant (2019). Copestake et al. (2019, p. 2) affirm that the approach:

> "*is concerned with the production of useful evidence about whether actions taken in the name of development (variously defined) are contributing to intended improvements in the wellbeing of specified individuals, households, and communities. A first step is to find out how 'intended beneficiaries' themselves think their wellbeing has changed and why.*"

In the qualitative part of the research, findings from interviews with citizens and policy-makers will give valuable information in order to quantify and attribute the effects of climate adaptive interventions on social vulnerability in Medellin. The inclusive (or not) participation of citizens will be investigated as well, given the great involvement and importance that they should have in order to reach an equitable and just climate adaptation planning (Shi et al., 2016).

2. SOCIAL JUSTICE AND EQUITY IN CLIMATE ADAPTATION

"If I have seen further it is by standing on the shoulders of Giants"
Isaac Newton, 1675

This chapter presents the key concepts that inspired and guided this research. Furthermore, an explanation on why the selected study area was identified as the most suitable for investigating these concepts is provided, as well as the conceptual framework that drove the study.

2.1. Credibility and Legitimacy of climate adaptation

Climate adaptation has been increasingly recognized over the last years as crucial in fighting the impacts of climate change (EEA, 2016; IPCC, 2014b; Lesnikowski et al., 2017). Climate adaptation plans and policies have been implemented all over the world (among others Ford et al., 2015; Olazabal, Galarraga, Ford, Sainz De Murieta, & Lesnikowski, 2019; Pietrapertosa et al., 2018; Reckien, et al., 2018), but the development of climate adaptation policies does not always mean disaster risk and vulnerability reduction (Olazabal et al., 2019), especially in respect of vulnerable groups (Ford et al., 2011). Furthermore, cases of *maladaptation* are identified more and more frequently in the literature (among others Anguelovski et al., 2018, 2016; Antwi-Agyei et al., 2018; Benzie, 2014; Magnan et al., 2016; Ncube-Phiri et al., 2014; Reckien, Lwasa, et al., 2018), due to the failure of targeting specified social vulnerabilities and therefore implementing adaptive measures that negatively affect already vulnerable portions of the population, sometimes even for economic and political interests "in the name of" sustainability, disaster risk reduction, or the now often abused term of resilience (Anguelovski et al., 2018; Chelleri et al., 2015).

The concept of credibility for climate adaptation policies has been introduced by Olazabal et al., (2019), and refers to "the likelihood that such policies will be effective in reducing or avoiding the impacts of climate change" (Olazabal et al., 2019, p. 3). According to the authors, the credibility of adaptation measures rests on the "context and conditions" under which plans or policies are put in action, as well as the driving motivations of who is in charge, and not only on the plan or policy per se. They also identify as crucial for the success of adaptation actions their legitimacy, following what already presented by Adger, Arnell, & Tompkins (2005). Adger et al. recognize legitimacy as one of the three aspects that make adaptation measures successful, together with effectiveness (in reaching the pre-established objectives) and equity (in terms of both outcomes and decision-making processes – *Who are the winners / losers?, Who made the decisions?*). Legitimacy, in turn, is achieved through justice and equity in policy-making and scientific processes, engagement of civic society, and transparency and social acceptability of adaptation actions. Interventions lacking equity and legitimacy will struggle in getting fully implemented (Adger et al., 2005).

2.2. Climate adaptation, social vulnerability and political power

Linking with concepts from the previous section, Adger et al. (2005) underlines the importance of engaging stakeholders from the civic society for achieving successful climate adaptative interventions. In regards to this, the authors also affirm that the fairness of the undertaken choices depends on how power is distributed among the different institutions included in the decision-making processes.

Of the same opinion is Mikulewicz (2018, p.3), who states:

"Equitable adaptation is considered possible only if the distribution of power in the process of adaptation decision-making and implementation is spread evenly among all community members."

He also affirms that different exercises of power by different actors cause inequitable outcomes in adaptation actions. Decision-making processes are seldom egalitarian, with powerful actors that manage the process to gain more benefits from the implemented measures, leaving the already vulnerable segments of the population behind. In such a way, top-down infrastructural interventions for climate adaptation thrive, that "ignore the social and political drivers of vulnerability" (Mikulewicz, 2018, p. 5), or as Fraser (2008, seen in Ribot, 2011) would say, that are "affirmative remedies" instead of "transformative remedies".

It is for these reasons that Mikulewicz (2018, p. 3) underlines the need for "conceptualizing social vulnerability in terms of political power" in order to show the different influences that different actors have on the decision-making processes and investigate the underlying causes of deeply-rooted social vulnerability. The present research follows this path, since "obscuring cause promotes superficial palliative while avoiding just redress" (Ribot, 2011, p. 1160).

2.3. Social justice in climate adaptation

Several scholars have attempted to conceptualize social justice in relation to climate adaptation (see also Adger, Paavola, Huq, & Mace, 2006; Begg, 2018). The main definition of social justice adopted for this research is:

"Fair distributions of wealth, opportunity, and privileges by means of fair treatment, proportional distribution, and the meaningful involvement of all people in social decision-making" (Reckien, Lwasa, et al., 2018, p.176)

More in general, for climate adaptation planning two different but highly complementary concepts are commonly identified: *procedural* and *distributive* justice:

- *Procedural* justice refers to the way decision-making process occur, especially focusing on who is involved and who influences the decisions (Breil et al., 2018; Chu, Anguelovski, & Carmin, 2016; Preston et al., 2014);

- *Distributive* justice deals with how benefits, responsibilities and burdens of adaptation action are shared among the interested stakeholders (Breil et al., 2018; Preston et al., 2014).

The two concepts are extremely interdependent, since a more inclusive and fair participation ensures more recognition and fairer distribution (Breil et al., 2018; Fraser, 2008). This applies to climate adaptation as well, where a more equitable and inclusive participation that goes beyond the "simple consultation" (as defined by Arnstein (1969)) between institutions and local communities would generate adaptation actions tailored to the local necessities and assets, increasing the adaptations' long-term success (Shi et al., 2016). It is interesting to see how these considerations are intrinsically related to the afore-mentioned concepts of credibility, legitimacy and political power, as they all tend to an *egalitarian* approach for climate adaptation. Egalitarian is here referred to giving the greatest benefits to the most vulnerable and ensuring the "equality of capability" (Rawls, 1971; Sen, 1992, as seen in Begg, 2018; Adger et al., 2006; Breil et al., 2018).

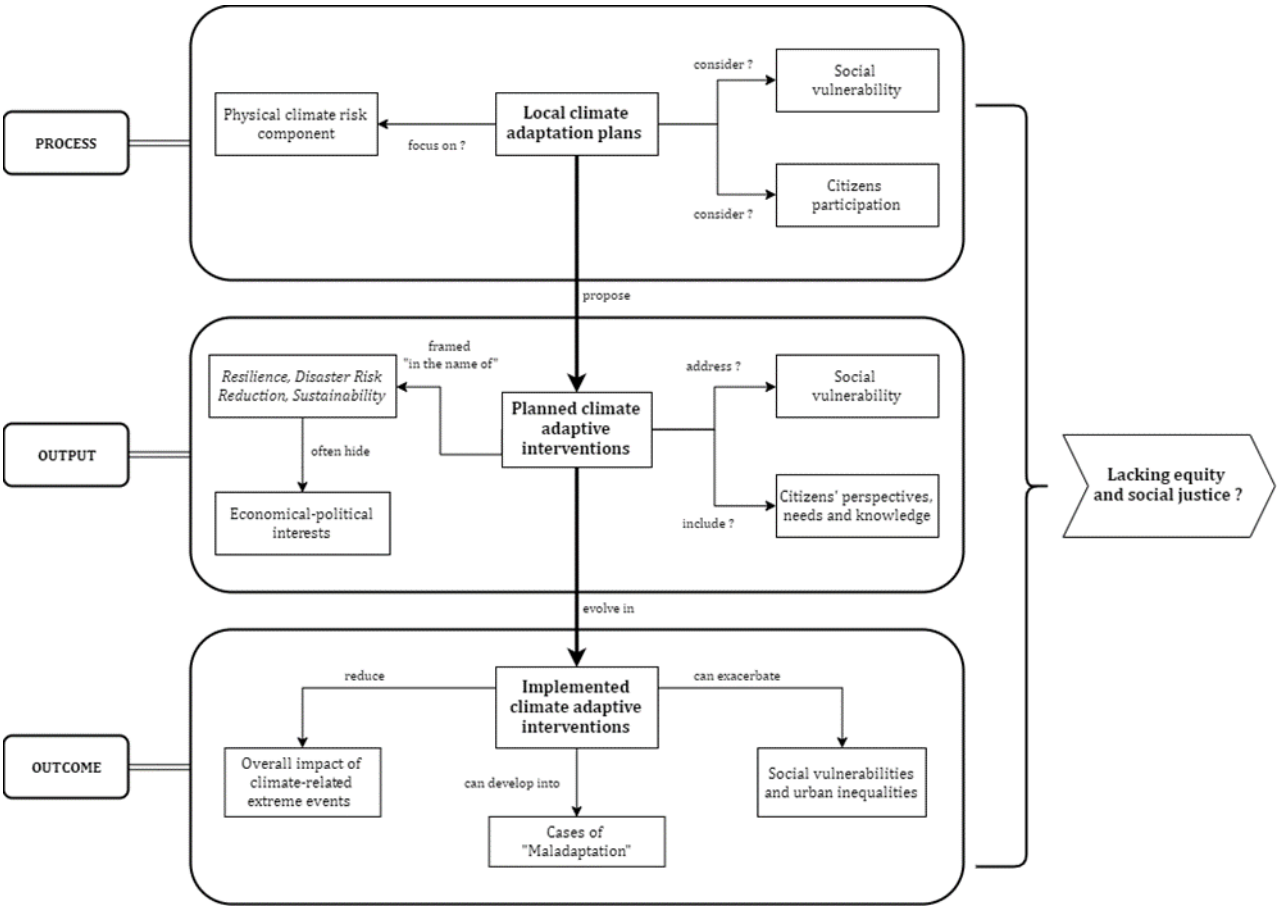


Figure 2: Conceptual framework driving the research. Source: the author

2.4. The choice of Medellin

The selected study area is Medellin, the largest city of the Aburra Valley and the second largest city in Colombia. The area is characterized by severe social segregation and high inequality, resulting from a troubled history and an uncontrolled urban development. The city, in fact, lies in the centre of the Aburra Valley and extends without interruptions all over the surrounding steep slopes, having as consequences difficulties in delivering public services, air pollution and sensitive geological conditions (Alcaldia de Medellin, 2014a). Unequal spatial population patterns are clearly visible, with more inadequate living conditions further away from the centre of the Aburra Valley up to the surrounding mountains. Low-income neighbourhoods, mostly situated in the mountains, are more susceptible to landslides and floods than their counterparts in the city centre and valley bottom. Landslides and floods are frequent in the area, with the level of risk likely to increase due to climate change (Garcia Ferrari et al., 2018; Hernandez Palacio, 2012; Sotomayor, 2015). Climate change and disaster risk management are therefore extremely relevant in the context of the city.

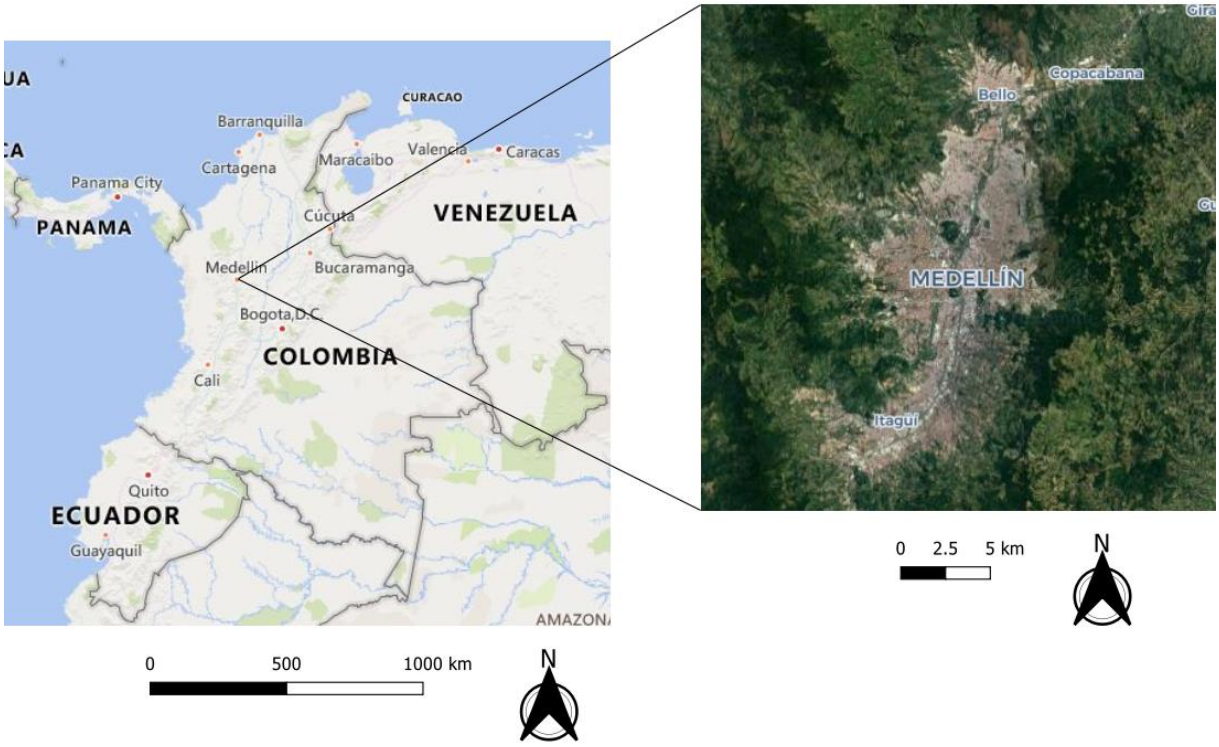


Figure 3: Geographical contextualization: Medellin. Source: the author

Figure 4: View of Medellin's urban core from Comuna 8, located in the north-eastern slopes of the valley. Source: the author

Medellin is deeply studied as an example of urban revitalization. Indeed, the city has seen a great comeback from a turbulent past in which it was known as the most dangerous city in the world, to becoming an admired and inspiring hub of urban planning innovation (Garcia Ferrari et al., 2018). In Medellin's resurgence, citizens participation had a major role. In the 90's, at the peak of the deep societal crisis affecting the city, mainly caused by the violent armed conflict and the economic crisis, citizens organizations, academia, cultural networks and private sector all joined together to make their home "governable" again (Urán, 2010). The city, in the last years, has won important awards and in general international recognition for many projects implemented in the city (100 Resilient Cities, 2016; Bakker & Brandwijk, 2016; Bergvall & Dah, 2015; EDU, 2016; Ellis, 2014; Garcia Ferrari et al., 2018; Sotomayor, 2015). One of the most acclaimed projects is the Green Belt. Framed as an intervention for climate adaptation, disaster risk management and for limiting the uncontrolled urban sprawl, it has been subject of debates in terms of its justice and equity dimensions. Many dwellers of areas influenced by the project have been relocated, while the implementation of the project has resulted in so-called environmental gentrification (Anguelovski et al., 2018).

For these reasons, Medellin has been recognized as a perfect study area for investigating the above-mentioned concepts. Doubts in regards of the *process*, the *output* and the *outcome* of the implemented interventions raise questions on the *procedural* and *distributive* justice of the decision-making processes, the *credibility* and *legitimacy* of plans and policies, as well as the *political power* exercisable by vulnerable groups.

Interesting to notice is what Anguelovski et al. (2018) affirm in regards to the investigated study area. The climate adaptive interventions in Medellin, and in particular the Green Belt project, have served the utilitarian perspective dispossessing land and nature of low income residents, the "*collateral damages"*, for the "greater common good" of green parks and disaster risk reduction. These considerations connect to what Bauman (2011, p. 4) states:

> *"Occupying the bottom end of the inequality ladder and becoming a 'collateral victim' of a human action or a natural disaster, interact with the way the opposite poles of magnets do: they tend to gravitate towards each other".*

These reflections lead to many questions: *Is this acceptable? Are there other solutions? Adaptation actions for who? How to balance risks and benefits/opportunities?* These are themes very interesting to investigate and, due to increasing climate change impacts (unavoidable due to already emitted GHG in the last decades) (IPCC, 2013), more and more relevant for climate adaptive planning in the future, not only in Medellin but in many cities around the world.

3. RESEARCH METHODOLOGY

3.1. Research design

The research has been tackled with both quantitative and qualitative approaches.

The research conducted to reach the first sub-objective put the focus on a quantitative analysis of social vulnerability for Medellin over space and time. To measure social vulnerability a Social Vulnerability Index (SoVI) was produced through the aggregation/combination of carefully selected socio-economic indicators adhering to the approach followed by many scholars (Chen et al., 2013; Huynh & Stringer, 2018; Kashem et al., 2016; Mavhura et al., 2017; Reckien, 2018; Shirley et al., 2003; Yoon, 2012, among others). Two main techniques are commonly used for creating a SoVI: the deductive approach and the inductive approach. Only the deductive approach has been used in this research, and the reasons of this choice are explained in Section 3.3. Social vulnerability assessments have been carried out for the years 2013 and 2017 in order to see the evolution of social vulnerability over space and time . This choice can be explained by the fact that this period coincides with the timeframe in which the Green Belt project has been implemented and a complete set of quantitative data was available for these two years.

The second part of the research, comprehending the second and third sub-objectives, has been tackled predominantly in a qualitative way. The attention was on determining the role of citizens in the design and the implementation of local climate adaptation plans, and on investigating how implemented climate adaptive interventions lend to address contextual social vulnerability. The *process* of developing local climate adaptation plans and the *output* of local climate adaptation plans itself have been explored in order to get to know more about their intrinsic equity and social justice aspects.

Subsequently, semi-structured interviews have been carried out during fieldwork. The interviews were conducted with policy-makers, experts and community leaders/members that were directly involved in climate adaptive interventions' design or implementation. Semi-structured interviews have been chosen for their flexibility/versatility and practicality (Bryman, 2012). This type of interviews was identified as the most appropriate given that interviewees had to be found while on fieldwork, using a snowball sampling starting from few key contacts in Medellin. Once appropriate interviewees were found, semi-structured interviews were conducted based on the specific interest/knowledge of the interviewee. The interview guidelines were prepared before going for fieldwork inspired by the guidelines and the approach followed by the Qualitative Impact Protocol (QuIP) of Copestake et al. (2019). More details on the QuIP approach can be found in Section 3.3.1.

The fourth sub-objective has the spotlight on the *outcome* of the implemented climate adaptive interventions on social vulnerability of Medellin. A combined quantitative-qualitative approach using the results from previous sub-objectives was followed to answer the research questions and to achieve the final conclusions of the whole research.

Table 2 shows a schematization of each sub-objective and research question with their respective research methods.

Table 2: Sub-objectives, research questions and relative research methods

Sub-objective	Research questions	Research methods	
1] Produce a social vulnerability assessment for Medellin for different years	[1.1] Which indicators can be used to assess social vulnerability over space and time? [1.2] Was social vulnerability in Medellin reduced, increased or spatially displaced over time?	- Literature review for the selection of appropriate Social Vulnerability Index (SoVI) indicators - Construction and analysis of Social Vulnerability Index (SoVI) for different years	Quantitative
2] Analyse how vulnerable groups were included in the formulation of local climate adaptation plans (process-related)	[2.1] With which criteria were citizens chosen for participating in the redaction of local climate adaptation plans? [2.2] How were citizens involved in the decision-making processes and in the design of local climate adaptation plans in Medellin?	- In-depth analysis of available media, community-produced documentaries, newspaper articles, urban development plans, climate adaptation plans, and existing literature - In-depth literature review for social research methods and sampling techniques - Semi-structured interviews (QuIP approach)	Qualitative
3] Investigate how local climate adaptation plans are addressing contextual social vulnerability (output-related)	[3.1] Which climate adaptive interventions are proposed? [3.2] How do the climate adaptive interventions propose to address socially vulnerable groups?		
4] Uncover the effect/consequences of climate adaptive interventions on social vulnerability over the city of Medellin (outcome-related)	[4.1] Which climate adaptive interventions are already implemented? [4.2] How do implemented (and planned) climate adaptive interventions in Medellin compare spatially with the most socially vulnerable areas of Medellin? [4.3] How much of the variation over space and time of social vulnerability in Medellin can be ascribed to the implemented climate adaptive interventions?	- Spatial comparison between social vulnerability assessments and climate adaptive interventions (pre and post interventions SoVI) - Qualitative development impact evaluation; triangulation between quantitative and qualitative results	Quantitative -Qualitative

3.2. Social vulnerability assessment (SO-1)

3.2.1. Baseline: Encuesta Calidad de Vida and dataset

The socio-economic indicators were collected from the *Encuesta Calidad de Vida* dataset, openly available from the Alcaldia de Medellin Open Data website. The *Encuesta Calidad de Vida*, in English *Quality of Life Investigation*, is an annual investigation carried out by Medellin Como Vamos, a private institution that has the primary tasks of analysing and monitoring the quality of life of the city of Medellin (Medellin Como Vamos, 2018). The results of this annual investigation are constantly used by the policy makers of Medellin's municipality and the Metropolitan Area (Alcaldia de Medellin, 2014; Departamento Administrativo de Gestión del Riesgo de Desastres (DAGRD) & Universidad EAFIT, 2016; UN-HABITAT, 2010; Interviewee-9, 2020; Medellin Como Vamos, 2018). The years chosen to see the evolution over space and time of social vulnerability for the city of Medellin are 2013 and 2017. This choice can be explained by the fact that a complete dataset was available for these two years, which also coincides with the period in which the Green Belt has been implemented. For the 2013 investigation

13378 households have been surveyed, while in 2017 a number of 9810 households were targeted. The data was gathered though a random stratified sampling, including every "strato" proportionally (Alcaldia de Medellin, 2014b). Colombia adopts a scheme of taxation for public services based on the classification of housing areas and neighbourhoods in different "stratos" (strata in English) (Garcia Ferrari et al., 2018). Figure 5 shows the classification for the city of Medellin.

The results of this annual investigation are presented through an index, the *Indicador Multidimensional de Calidad de Vida* (Multidimensional Index of Quality of Life). This index is yearly composed of different dimensions (15 in 2017: *Quality of building; Access to public services; Environment; Education; School desertion; Mobility; Physic capital of household; Participation; Freedom and security; Vulnerability; Health; Occupation; Recreation; Quality of life perception; Income*) which, in turn, are made by several variables each (Alcaldia de Medellin, 2014b). Different underlying causes of social vulnerability get in this way obscured. In contrast, this research employs a targeted social vulnerability assessment, with fewer, well-reasoned indicators and with a visual representation of each of the indicators, along with the overall cumulative result.

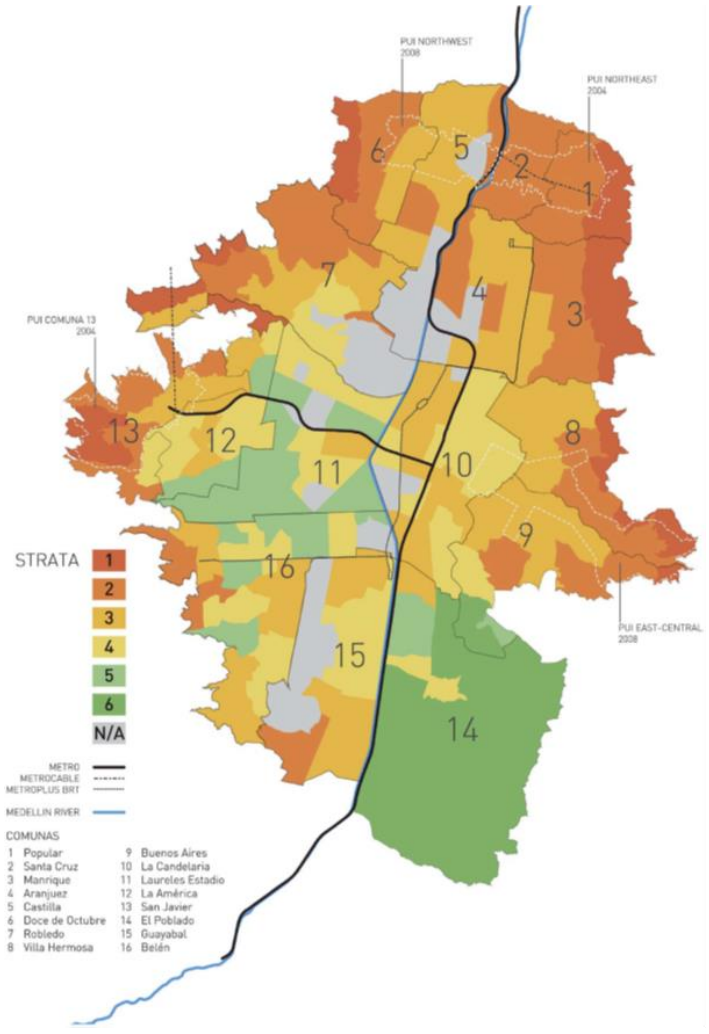


Figure 5: Strata for taxation of public services for Comunas and housing areas in Medellin. Source: Garcia Ferrari et al. (2018) (adapted from Ellis (2014)).

In addition to the socio-economic indicators for the social vulnerability assessment, the other data used for the quantitative analysis were the basic cartographic delimitation of the city, at the *Comuna* (neighbourhood) level, and the shapefile containing the measures planned in the 2014 *Plan de Ordenamiento Territorial* (POT - Territorial Ordinance Plan).

A description of the sources and formats of the utilized data for the social vulnerability assessment is shown in Table 3.

Table 3: Dataset used for the social vulnerability assessment

Data File	Format	Source (last access on 27th June 2020)
Serie de Indicadores Encuesta Calidad de Vida 2007 - 2017	Excel table	https://www.medellin.gov.co/irj/portal/medellin?NavigationTarget=navurl://acc92965877da2fec98a68595a60f0bd
Base de datos Encuesta de Calidad de Vida	Csv file	https://www.medellin.gov.co/irj/portal/medellin?NavigationTarget=navurl://acc92965877da2fec98a68595a60f0bd
Cartografia basica – Comunas	Shapefile	https://geomedellin-m-medellin.opendata.arcgis.com/datasets/limite-comuna-corregimiento
Plan de Ordenamiento Territorial 2014	Geodatabase	https://geomedellin-m-medellin.opendata.arcgis.com/datasets/gdb-pot-acuerdo48-de-2014

3.2.2. Social vulnerability assessment: indicators selection and rationales

Pacione (2001) describes how three general factors have emerged in his "factorial ecology" as necessary to identify spatial patterns on the urban landscape: socio-economic status, family status and ethnic status (Pacione, 2001). These three dimensions are mentioned, even though in a different approach and combined with many others, by several scholars for the assessment of social vulnerability (Breil et al., 2018; Chen et al., 2013; Cutter & Finch, 2008; Huynh & Stringer, 2018; Katic, 2017; Reckien, 2018; Shirley et al., 2003; Yoon, 2012). The selection of indicators for the assessment of social vulnerability in Medellin follows the same principles.

Indicators regarding the ethnicity or the migrants rate would have been fundamental for following the principles just mentioned (e.g. ethnic status). Unfortunately, this sort of indicator was not present in the available dataset. However, it is worth considering that most of the migrants arriving to Medellin come from other Colombian areas and Venezuela. In fact, Medellin is among the major destinations for the Internally Displaced People (IDP) of the long-lasting internal conflict in Colombia (Sanchez Mojica, 2013), and for neighbouring Venezuelans escaping from the severe socio-political crisis affecting their country (Vlugt, 2018). This fact points out that one of the vulnerabilities affecting migrants, the local language barrier (Breil et al., 2018; Shirley et al., 2003) does not arise in this context. The other characteristics of the migrants, in this case extreme poverty, without job and properties, young age, rural origin and mostly female (Sanchez Mojica, 2013; Vlugt, 2018) seem to fall all in the social vulnerabilities in terms of socio-economic and family status dimensions. It is for this reason that the other chosen indicators seem to be also representative for the ethnic status officially missing in the database.

Following the recommendations of Tate (2012), who suggests to justify properly the adoption of every indicator in order to enhance communicability and interpretation of the SoVI results, in Table 4 all the indicators used for this social vulnerability assessment and their respective rationale can be found.

Table 4: Indicators for the social vulnerability assessment for the city of Medellin with their respective rationale

Dimension	Indicator	Rationale	Influence on SV
Socio - economic status	Desertion rate	Education plays a vital role in coping with a disaster over the short and long term (Frankenberg, Sikoki, Sumantri, Suriastini, & Thomas, 2013), and people with low education are much more vulnerable than the highly educated ones. Early leaving from education often is due to familiar issues and/or economic reasons, and in Colombia is often related to kids joining illegal criminal groups (Radinger, Echazarra, Guerrero, & Valenzuela, 2018), other factor increasing social vulnerability to climate-related disasters (Breil et al., 2018).	Increases SV (+)
	Illiteracy rate	Illiterate groups are more vulnerable to climate-related disasters (Breil et al., 2018). Highly correlated with income and access to adequate information, and therefore knowledge and resources for coping with disasters (Hoffmann & Blecha, 2020).	Increases SV (+)
	Unemployment rate	Unemployed people lack economic stability and resources to cope with and recover from disasters. The higher the unemployment rate, the more precarious is the situation in case of environmental or climate-related disasters (Chen et al., 2013).	Increases SV (+)
	Contributory health system participation	An impactful health care reform has been introduced in Colombia since 1993, meant to improve access to health services especially for the poor. Employed and independent workers are required to register to the health contributory system, while poor people are included trough the subsidized health system (Glassman, Escobar, Giuffrida, & Giedion, 2009). This indicator is therefore directly related to income. It is important to mention that informal dwellers not participating in the subsidized health system, and hence more subject to suffering pathologies as heart diseases, respiratory problems or other syndromes, are even more vulnerable to climatic stresses (Breil et al., 2018).	Decreases SV (-)
	Food insecurity	People who are food insecure are likely to be among the first heavily affected by climate change and related disasters (FAO, 2008). Children who suffer food insecurity are twice as much exposed to poor health than the food secure ones, while adults have daily-living limitations ascribable to people fourteen years older (Gundersen & Ziliak, 2015).	Increases SV (+)
Family status	Female-headed households	Due to various reasons, including structural gender inequality, psychological and biological characteristics, and socially constructed familiar responsibilities (Breil et al., 2018; Chen et al., 2013; Reckien, Lwasa, et al., 2018; Shirley et al., 2003), women are considered more vulnerable than men. Female-headed households are often more vulnerable to shocks and poverty (Klasen, Lechtenfeld, & Povel, 2011), and are proved to be more vulnerable to climate variability and its causes/effects (Flatø, Muttarak, & Pelser, 2017).	Increases SV (+)
	Dependency ratio	The dependency ratio is a measure of the number of dependents aged zero to 14 and over the age of 65, compared with the total population aged 15 to 64 (Kenton, 2019). This indicator compares the number of people in non-working age, with the number of people in working age. A large number of dependents in the same family affects negatively its resilience to disasters (Breil et al., 2018; Chen et al., 2013; Shirley et al., 2003).	Increases SV (+)
	Household size	Families with a large number of components have a much lower resilience to disasters, and are much more exposed to health shocks that may happen after a disaster (Klasen et al., 2011; Shirley et al., 2003).	Increases SV (+)

3.2.3. Social vulnerability assessment: Social Vulnerability Index (SoVI) construction

After the selection of the indicators for assessing social vulnerability, a deductive approach has been used for the creation of a Social Vulnerability Index (SoVI). The deductive approach is based on a selection of appropriate indicators based on a priori knowledge and theoretical understanding (Reckien, 2018; Yoon, 2012). The deductive approach has been chosen over the inductive approach, because the latter may be perceived as a "black box", leading to unclarity and misconception of the obtained results (Reckien, 2018; Tate, 2012). In order to build a SoVI, each of the eight selected indicators were normalized using the *min-max rescaling transformation* (Equation 1):

$$Vi = \frac{Xi - Xmin}{Xmax - Xmin} \quad , \qquad Eq.1$$

where Vi is the i-value of the variable V, $Xmin$ is the minimum value of that variable in the dataset and $Xmax$ is the maximum value of that variable in the dataset (Yoon, 2012). This procedure transforms every variable in a range between 0 and 1, allowing the aggregation of different indicators, otherwise not comparable, with a simple addition. After the standardization the eight indicators were summed. It is worth to mention that the result is expressed on a *Comuna* (neighbourhood) level scale, and that no weighting scheme has been applied to the variables, as there was no local knowledge to assume that one variable had a greater importance than the others (Shirley et al., 2003). In addition, some values were missing for some of the variables. Following the strategy pursued by Cutter & Finch (2008), these missing values have been replaced by the arithmetic mean of each of the corresponding missing variable for each *Comuna*. The result is expressed using the standard deviation from the mean, since the absolute SoVI scores have no real interpretation (Yoon, 2012), and for showing the relative differences among Medellin's urban landscape. The same exact entire procedure has been carried out for both 2013 and 2017. Each of the individual indicators maps, instead, are presented with five equal interval classes, ranging from 0 to 1, to ensure the comparability between the two selected years. In fact, using the standard deviation from the mean, or the absolute values, there would not have been the same classes for the two different years, making the comparison impractical.

3.3. *Process-Output* investigation (SO-2, SO-3)

In order to achieve the second and third sub-objectives, a qualitative analysis has been carried out to investigate the *process* and the *output* of climate adaptation in the city of Medellin. This qualitative investigation has been carried out scrutinizing different types of qualitative data, which include existing literature, local plans and interviews realized during fieldwork.

3.3.1. Baseline: Data and QuIP approach

The data used for the qualitative analysis of this research was:

- Literature on social justice, (urban) equity, adaptation planning, social vulnerability, sociology and most of all on the context of Medellin, Colombia and Latin America in general;
- Climate Adaptation Plan of the Aburrá Valley Metropolitan Area (AMVA);
- Medellin's Urban Development Plans 2016-2019;
- Documentaries produced by the local community and local media coverage of climate adaptive interventions, both openly available;
- Medellin's universities academic outputs;

- Semi-structured interviews with policy-makers, experts and community leaders/members carried out on fieldwork.

The secondary data (literature, documentaries, media, plans) was analysed to get a general overview of the Medellin context, while the primary data (semi-structured interviews) was coded in order to analyse the impact of climate adaptive interventions in the city of Medellin. Local media coverage was targeted specifically searching news treating the design phase and the implementation of climate adaptive interventions (mainly the Green Belt project), with particular attention to the articles of *El Colombiano,* the principal Medellin-based newspaper. Common keywords utilized were *Cinturon Verde* (Spanish version of Green Belt) and *Jardin Circunvalar* (explained in detail in Section 4.4.1.1). On another note, the most interesting documentaries were found to be the ones produced by Ciudad Comuna, a community-led organization created by young residents of Comuna 8, the most affected by the Green Belt project (especially Ciudad Comuna, 2012, 2013, 2014, 2019a, 2019b, 2019c). Finally, the general structure of the semi-structured interviews was prepared before going for fieldwork inspired by the guidelines and the approach followed by the Qualitative Impact Protocol of Copestake, Morsink and Remnant (2019).

The Qualitative Impact Protocol (QuIP) is an approach developed by the Institute for Policy Research of Bath for evaluating the intended consequences and then the impact of a particular policy or intervention on a specified population. This is done through the identification, the collection and the systematic examination of narrative drivers of change and their outcomes on the identified population (causal attribution). Furthermore, the QuIP is a 'small *n'* approach, which means that the interviewees are selected keeping in mind that they have to "address questions about how an activity contributes to change, for whom, and in relation to what other complementary or rival causal explanations" (Copestake et al., 2019, p. 8). It is for this reason that the interviews were not strictly structured but prepared in such a way that the respondent had enough freedom to answer on questions in regard of the intended outcome of the designed intervention (especially for policy-makers) and of the impact that a particular intervention had on them or the identified population (especially for community members/leaders and experts).

The QuIP guidelines have also inspired the final part of the research for finding the causal attribution of changes in social vulnerability over the city of Medellin due to the implementation of climate adaptive interventions. To do so, claims of different interviews have been coded and triangulated in order to find communalities and evidences.

3.3.2. Description of fieldwork and interviewees

A fieldwork in Medellin has been carried out from the 18th of January 2020 until the 11th of February 2020. During the course of this fieldwork a snowball approach has been implemented, which has allowed the execution of semi-structured interviews with a number of different actors. The snowball approach has been valued as optimal given the QuIP guidelines and the most effective given the local context and the difficulties encountered on the ground. In that period Medellin was going through a period of political turmoil, like many other Latin American countries (for more see Bosworth, 2019; Phillips, 2019; Shifter, 2020) and was facing a change of the administration due to the election of a new mayor.

Thirteen semi-structured interviews have been carried out. In addition to these, a visit to a very critical area of Copacabana municipality severely affected by mass movements has been carried out, as well as participating in the 'Territorial Public Meeting' in Comuna 8 for the redaction of the new Urban Development Plan 2020-2023, organized by the Alcaldia de Medellin and in the conference on the URBE-LATAM research project (Comprehension of Risks and Capacity Development in Latin-American Cities). The interviews were carried out mainly in the interviewees' offices, excluding the community leaders and

members, interviewed at the University and in Comuna 8 itself, where they also showed the interventions implemented during the Green Belt project. Interviews were carried out in Spanish, with the valuable help of a local translator. More details on the interviewees can be found in Table 5.

Information gathered during all of these activities, including perspectives and evidence of how events really evolved, participation processes, and outcomes of climate adaptive interventions in Medellin, has been analysed in order to accomplish the second and the third sub-objectives.

Table 5: Description of the interviewees

Interviewee	Institution	Role/Description
Interviewee-1	Universidad Nacional de Colombia	Professor of Urban Planning and Architecture and Medellin's historian
Interviewee-2	Area Metropolitana del Valle de Aburrá (AMVA – Valle de Aburrá Metropolitan Area)	Head of planning department
Interviewee-3 and Interviewee-4	Empresa de Desarrollo Urbano (EDU – Urban Development Company)	Employees of EDU involved in the Green Belt project
Interviewee-5	Departamento Administrativo de Gestion del Riesgo de Desastres (DAGRD – Administrative Department of Risk Management)	Technical manager of Medellin's risk management and response department
Interviewee-6	Area Metropolitana del Valle de Aburrá (AMVA – Valle de Aburrá Metropolitan Area)	Head of 'culture and education' planning department
Interviewee-7	Area Metropolitana del Valle de Aburrá (AMVA – Valle de Aburrá Metropolitan Area)	Head of climate department, directly involved in the redaction of AMVA's climate adaptation plan
Interviewee-8	/	Retired professor, expert on Medellin and extremely involved in projects in Comuna 8
Interviewee-9	Alcaldia de Medellin (Medellin's Municipality)	Planning department officer
Interviewee-10, Interviewee-12 and Interviewee-13	Comuna 8 leaders and members	Comuna 8 leaders and members directly involved in and affected by the Green Belt project
Interviewee-11	Sistema de Alerta Temprana del Valle de Aburrá (SIATA – Early Warning System of Valle de Aburrá)	Head of the early warning system of AMVA and expert on Medellin

3.4. Application of SoVI: comparison with Political Perception indicator, POT and interviews (*Outcome,* SO-4)

The fourth and last sub-objective, focused on discerning the *outcome* of climate adaptive interventions in Medellin, has been reached with a quantitative-qualitative approach. Findings from the previous sub-objectives have been compared and analysed.

In social vulnerability assessments, drivers and root causes of social vulnerability are in some way obscured. Mikulewicz (2018) affirms how political power and representation are crucial for participating in the decision-making processes and therefore ensuring equitable climate change adaptation. He also affirms that given the highly political essence of adaptation, a conceptualization of vulnerability in terms of political power is then needed to show how power-relations between communities and other stakeholders, as well as within communities themselves, originate or affect social vulnerabilities and thus affect the outcome of climate adaptive interventions.

For this reason, another composite indicator has been created using the *Encuesta Calidad de Vida* dataset in order to show the political local context of the city of Medellin. Three variables have been identified in the dataset as relevant for the construction of the composite indicator for this analysis:

- Satisfaction with the Municipality;
- Interest about politics;
- Trust in public institutions.

These variables have been often mentioned in relation to arguments about participation increasing trust in institutions (and vice versa), and about power differentials on "secure funding to plan for, cope with, and respond to climate-related impacts" (Thomas et al., 2019, p. 7; see also Demos & Pi, 2019; Grisez Kweit & Kweit, 2007; Marzi et al., 2019;). Given the essence of what the different variables represent, the resulting composite indicator has been defined as "Political Perception". The three variables have been normalized, standardized, summed and normalized again with the same procedures explained Section 3.2.3. This has also been repeated for 2013 and 2017. The results of the construction of the Political Perception indicator have been used for further analysis and considerations regarding the process and the outcome of climate adaptive interventions for the city of Medellin.

Finally, the results of the social vulnerability assessment for the city of Medellin, for the years 2013 and 2017, have been used for a visual spatial comparison with the climate adaptive interventions planned in the 2014 *Plan de Ordenamiento Territorial* (POT - Territorial Ordinance Plan), to see eventual relations and/or discrepancies. Quotes from the interviews have been triangulated among each other and with the obtained maps, in order to recognize the real *outcome* of climate adaptive interventions in Medellin.

3.5. Ethical considerations

Given the nature of the research objectives, especially identifying and analysing intended and effective outcomes of climate adaptive interventions in the city of Medellin, learning perspectives of all the different stakeholders was needed and crucial in order to provide an unbiased and valuable research. The selection of interviewees goes in that direction, even though it has been certainly affected by the snowball approach followed for the reasons previously explained.

Particularly in regards of the community representatives, community leaders were much more approachable than normal community members, being well-known even outside the community itself. It is therefore important to mention how this may have caused a sampling bias. Power is in fact enjoyed

differently among the same community, between "leaderships and members, men and women, young and old people, land owners and the landless, the abled and the disabled, long-term residents and recent arrivals, members of different ethnic groups, and so forth" (Mikulewicz, 2018, p. 29).

For what concerns the ethical part as a researcher, the gathered data has been anonymized. Consent was asked before every interview, and the aim of the research in combination with how the findings would be used were explained in detail to the interviewees. Furthermore, the results of the social vulnerability assessment (with SoVI) will be openly accessible, and the used data has been explained in detail, to give opportunities to reproducibility.

4. RESULTS

"Participation without redistribution of power is an empty and frustrating process for the powerless"
Sherry R. Arnstein, 1969

This chapter illustrates the results obtained from both the quantitative and the qualitative analysis, in order to reach the identified sub-objectives and therefore answer the research questions. The results are presented per sub-objective in the following sections.

4.1. Social vulnerability assessment (SO-1)

This section presents the results obtained by the social vulnerability assessment carried out for the city of Medellin, for the years 2013 and 2017. The visualizations of the cumulative Social Vulnerability Indexes (SoVI) are presented, as well as the individual representation of each of the selected indicators in order to enhance the communicability of the results.

Figure 6 and 7 show the results of the cumulative SoVI for Medellin for the years 2013 and 2017.

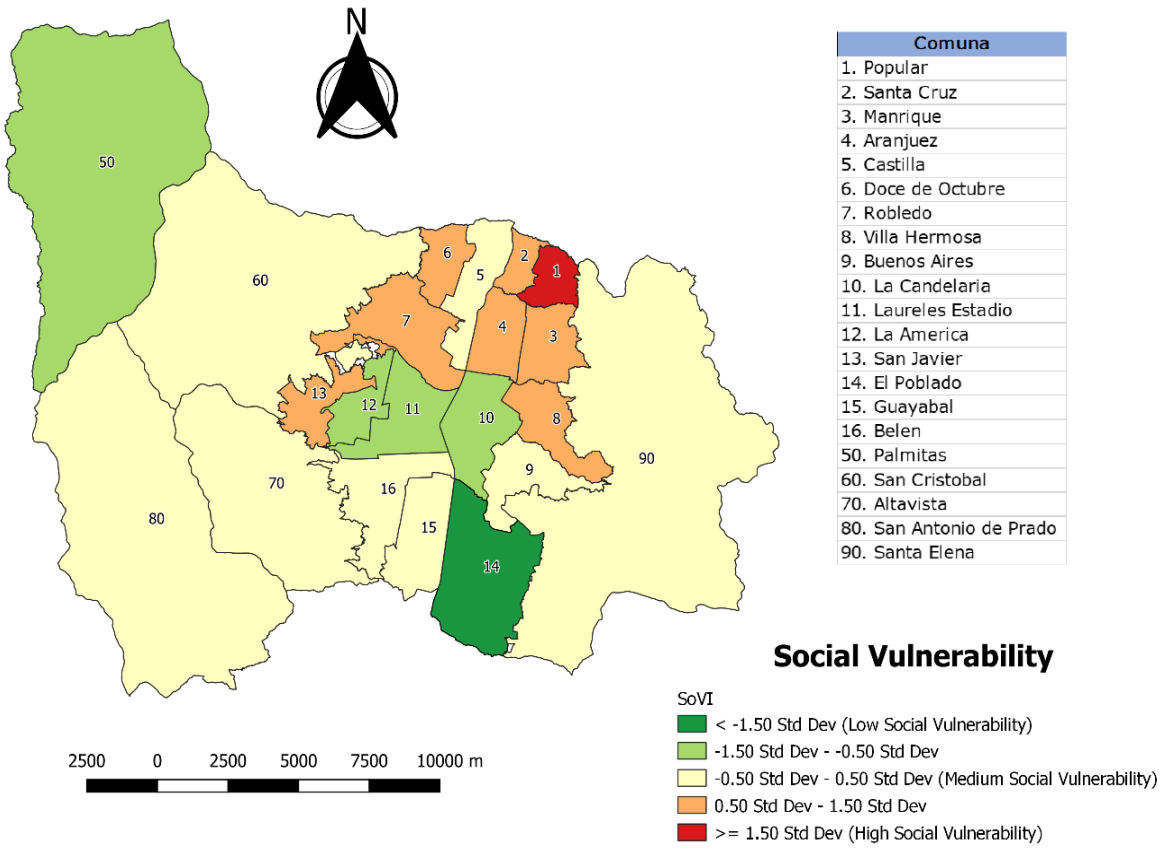


Figure 6: Result of the social vulnerability assessment: SoVI for the 21 Comunas of the city of Medellin, year 2013. Source: the author.

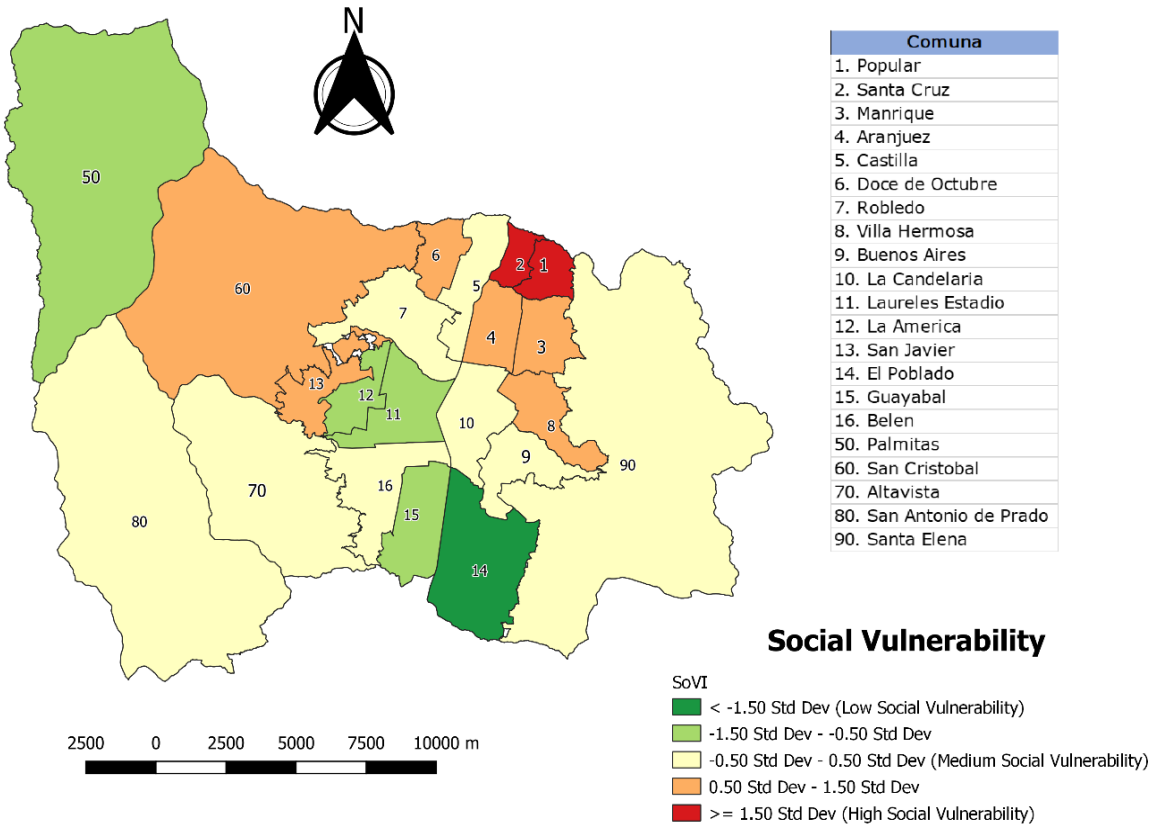


Figure 7: Result of the social vulnerability assessment: SoVI for the 21 Comunas of the city of Medellin, year 2017. Source: the author.

No drastic changes of social vulnerability are observed over space and time in Medellin, as minimal variations between 2013 and 2017 are visible. General social vulnerability patterns over Medellin's urban landscape are confirmed in both years. Nevertheless, in general the higher values of social vulnerability appear to concentrate in the northern-eastern part of the city, in both 2013 and 2017. Comuna 1 – Popular – has the highest value of social vulnerability in both years, while Comuna 2 – Santa Cruz – goes from Medium-High level of social vulnerability in 2013 to High level of social vulnerability in 2017. Comuna 14 – El Poblado – instead, undoubtedly stands out as the least social vulnerable Comuna in Medellin in both 2013 and 2017.

Looking at the individual indicators the following maps help with the further interpretation of the cumulative SoVI results. Figure 8, 9, 10 and 11 show the spatial distribution of the selected indicators over each of the neighbourhoods of Medellin. Although the two years under analysis are relatively close to each other, slight changes can be observed for each of the indicators, and patterns are clearly visible over Medellin's urban landscape. The Comunas with the higher social vulnerability values in the cumulative SoVI maps, are comprehensibly associated with higher dependency ratios, desertion rates, illiteracy rates, unemployment rates, household sizes and food insecurity, and lower participation to the contributory health system. It is interesting to focus on the cases of contributory health system participation, unemployment rate and food insecurity (Figure 9, 10 and 11). In both the years 2013 and 2017, the deep inequality afflicting the city between the wealthier neighbourhoods (El Poblado, Laureles and La America) and the other ones is incredibly pronounced, highlighting the socio-spatial inequalities of the city.

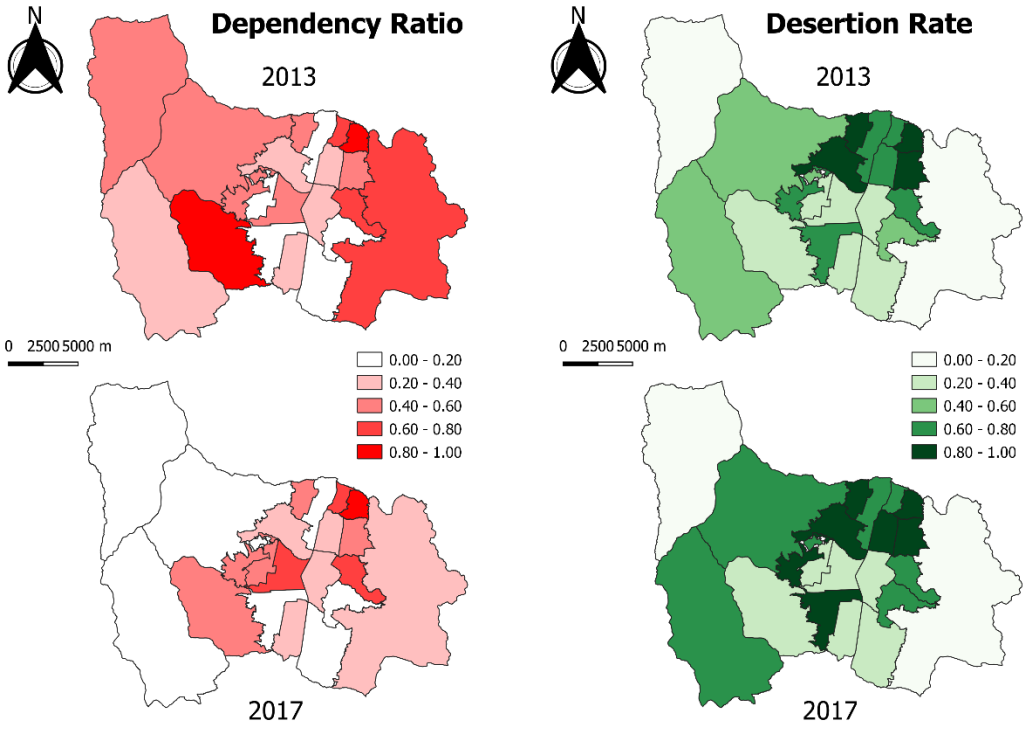


Figure 8: Distribution of "Dependency Ratio" and "Desertion Rate" indicators over Medellin's Comunas, for years 2013 and 2017. Source: the author.

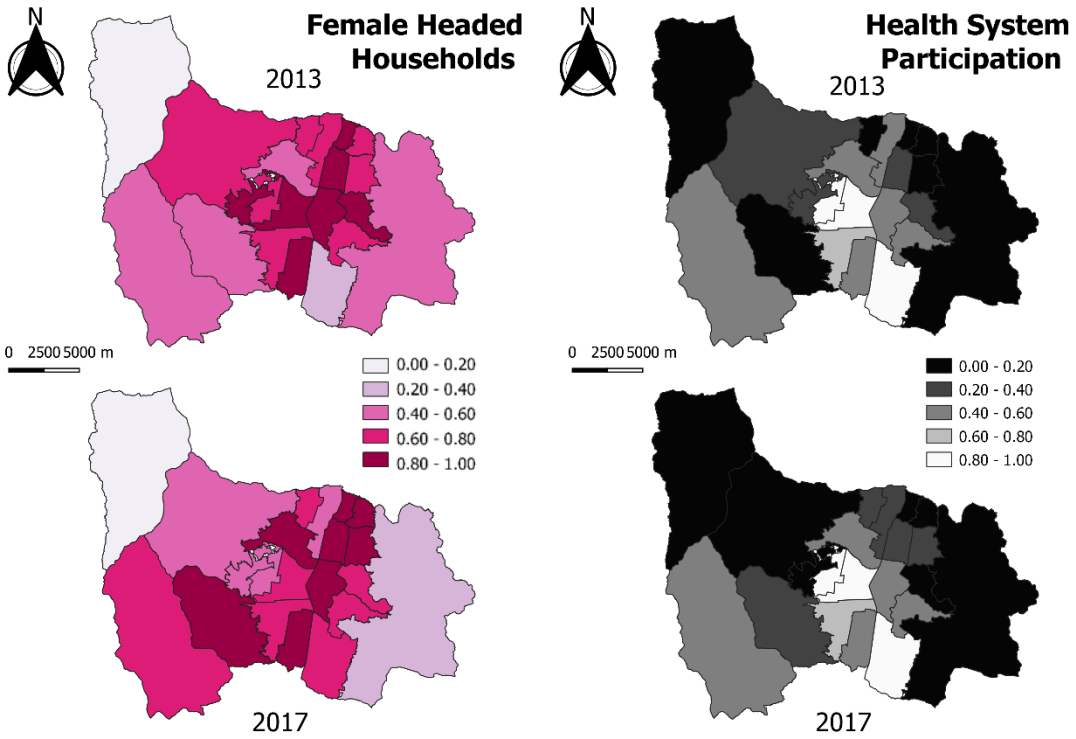


Figure 9: Distribution of "Female Headed Households" and "Contributory Health System Participation" indicators over Medellin's Comunas, for years 2013 and 2017. Source: the author.

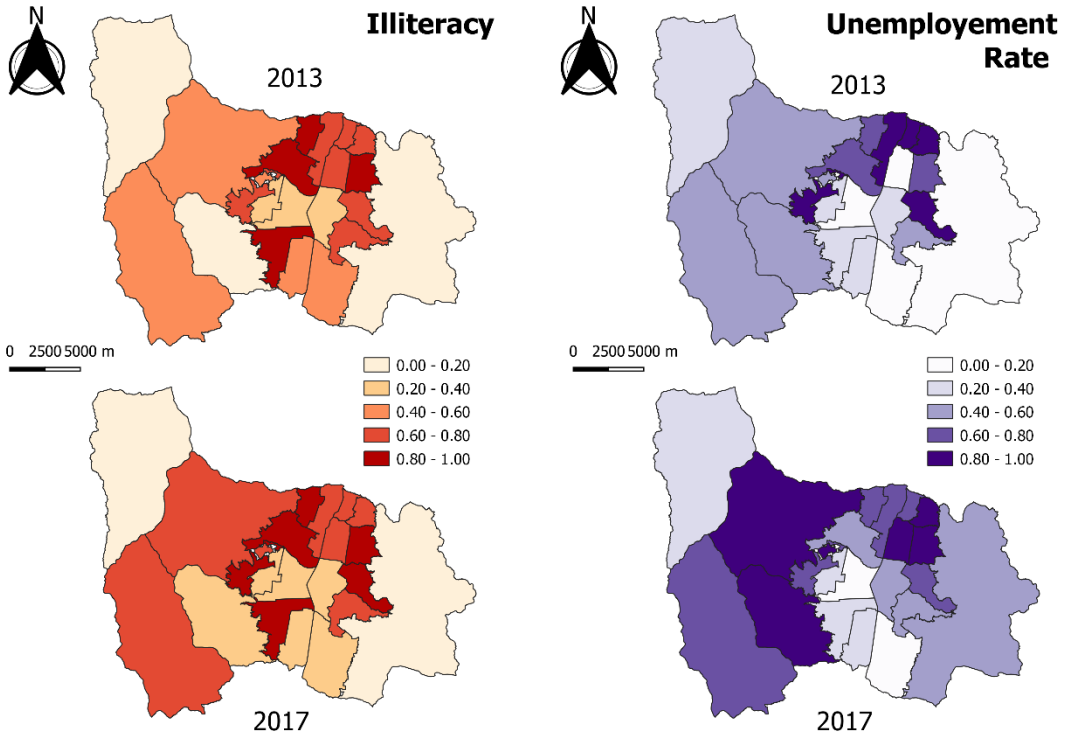


Figure 10: Distribution of "Illiteracy Rate" and "Unemployment Rate" indicators over Medellin's Comunas, for years 2013 and 2017. Source: the author.

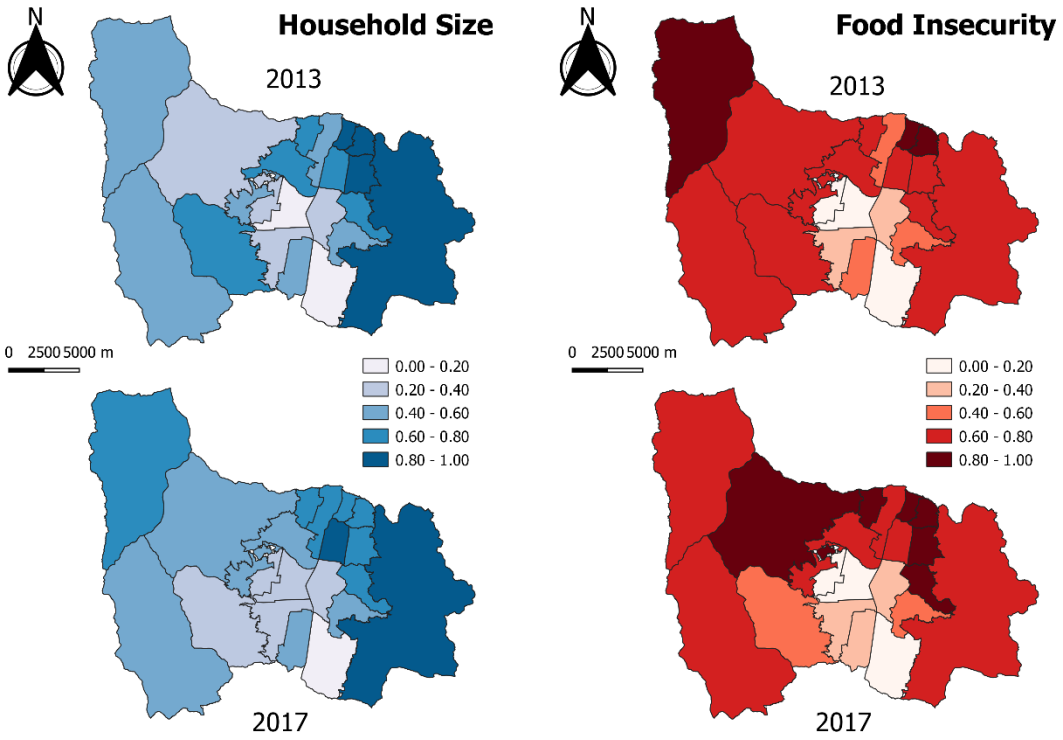


Figure 11: Distribution of "Household Size" and "Food Insecurity" indicators over Medellin's Comunas, for years 2013 and 2017. Source: the author.

4.2. Inclusion of citizens in climate adaptation decision-making (*Process*, SO-2)

From the information retrieved during the literature review and the interviews carried out on during fieldwork, three main actors emerged as pivotal for including citizens in the decision-making processes dealing with climate adaptation:

- Area Metropolitana del Valle de Aburrá (AMVA – Valle de Aburrá Metropolitan Area);
- Alcaldia de Medellin (Medellin's Municipality);
- Empresa de Desarrollo Urbano (EDU – Urban Development Company).

Each one of the identified actors will be separately treated in detail in the following sub-sections.

4.2.1. The role of AMVA (Valle de Aburrá Metropolitan Area)

4.2.1.1. Citizens' participation in urban development projects

In terms of urban planning in general, the role of AMVA is to help individual municipalities when developing and implementing important projects, mainly due to their budget restrictions, and to coordinate the process when there is the need for a big infrastructural project involving different municipalities.

In regards to citizens' participation AMVA has the tasks of socializing the projects with the interested communities, integrating their feedback on the design and the implementation of the projects, and monitoring the outcomes of the projects. As explained by a key interviewee at the planning department of the Metropolitan Area (Interviewee-6), three phases can then be identified: a "Before", a "During" and an "After" the project. "Before" the project, the interested communities are involved by AMVA in understanding the local reality and how it can be affected by the implementation of the work. This phase is crucial since it allows to "plan together" the territory, and the community has the chance of sharing its knowledge and give advice on the future work. "During" the implementation of the project AMVA educates the community, especially on environmental conservation matters, given that the Metropolitan Area has the authority on the topic. The community can therefore monitor the progress of the project, and reports to AMVA if eventual irregular activities are observed (e.g. destruction of flora and fauna, waste disposal not in line with regulations). "After" the implementation of the project, AMVA officially has the role of guaranteeing the sustainability of the latter. Therefore, it remains in contact with the community in order to evaluate how the project is evolving in the local context.

4.2.1.2. Citizens' participation in the redaction of climate adaptation plans

AMVA developed its first climate adaptation plan in 2018. Originally titled: *"Plan de Acción ante el Cambio y la Variabilidad Climática del Área Metropolitana del Valle de Aburrá 2019 – 2030"* (Action Plan for Climate Change and Climate Variability of the Valle de Aburrá Metropolitan Area 2019-2030), officially deals with both mitigation and adaptation. While for mitigation the actors that needed to be involved were very much targeted (identified from 5 sectors: agriculture, transport, energy, waste, sanitation) and there was small community involvement, for the adaptation part a wide range of stakeholders were involved, including community leaders and universities (according to Interviewee-7, working for AMVA and specifically on the redaction of this plan). They contributed to the design of fourteen adaptation measures suggested by the plan, that will we explained in Section 4.3.1.

4.2.2. The role of Alcaldia de Medellin (Medellin's Municipality)

Medellin's Municipality, as of today, has never produced a local climate adaptation plan. Therefore, the inclusion of citizens in the redaction of local climate adaptation plans in Medellin has never had the

chance to happen. However, in January 2020 it has been announced the upcoming formulation of a Medellin's "Climate Action Plan" (Alcaldia de Medellin, 2020).

Given this introduction, it is important to say that the Municipality involves citizens in the development of the Urban Development Plan (*Plan de Desarrollo*), occurring every four years. During the design phase of the Plan open "Territorial Public Meetings" are organized in each Comuna, where the community is encouraged to choose, design and suggest actions in regards to all the possible sectors/topics that need to be included in the final version of the Plan. Climate adaptation can therefore be in such a way part of it. Section 4.3.2 presents the results from Medellin's last Urban Development Plan (2016 – 2019), containing information in regards to the presence of climate adaptation.

The pictures showed in Figure 12 were taken during the participation in the 'Territorial Public Meeting' that was held in Comuna 8 for the redaction of the new Urban Development Plan 2020-2023. In the pictures it is possible to see the modalities in which the community discusses and prioritizes their required measures that will be sent (and eventually considered) by the Municipality. Figure 12d shows how the meeting was even attended by the newly elected mayor, Daniel Quintero Calle, in charge from the 1st of January 2020.

Figure 12: Four pictures taken during the 'Territorial Public Meeting' in Comuna 8 for the redaction of the new Urban Development Plan 2020-2023. Source: the author

4.2.3. The role of EDU (Urban Development Company)

As further explained in Sections 4.3.2 and 4.4.1, the Green Belt project is currently the only implemented intervention in Medellin that was clearly stated to be part of a strategy for climate adaptation. A crucial role in the implementation of the project and in the involvement of the community members in it was held by the Empresa de Desarrollo Urbano (EDU – Urban Development Company). This case is a paradigmatic example that needs to be part of the section analysing how citizens were involved in climate adaptation-related decision-making processes.

EDU was hired by the Municipality in order to carry out and manage a part of the Green Belt project (Jardin Circunvalar, more detail in Section 4.4.1), that lasted from 2012 to 2016 and that saw the community participating in different phases of the process. EDU involved community leaders in the first phase of the project in order to socialize with the whole community and to hear needs and suggestions from the dwellers. As affirmed during the interviews by two community leaders and an employee of EDU working on the Green Belt (Interviewee-4, Interviewee-12, Interviewee-13), community members were asked to engage in participative mapping activities driven by the question: "*How do you imagine the future of your neighbourhood?"*. During the implementation of the project, instead, community members were involved in two ways: (1) as workers in the construction of the Green Belt, after phases of selection and formation among the community; (2) as committees, that every two weeks would reunite with the people in charge of the project in order to constantly discuss about the current stage of the process and raise awareness on eventual issues. Interviewees from EDU affirmed how the community was also involved in other activities, such as choosing the names of parts of the project (e.g. roads, public areas).

4.3. Climate adaptation plans and social vulnerability (*Output,* SO-3)

4.3.1. AMVA's Climate Adaptation Plan

AMVA developed in 2018 its first plan dealing with climate change, entitled *"Plan de Acción ante el Cambio y la Variabilidad Climática del Área Metropolitana del Valle de Aburrá 2019 – 2030"* (Action Plan for Climate Change and Climate Variability of the Valle de Aburrá Metropolitan Area 2019-2030). Four major trends attributed to climate change are identified and mentioned in the plan: increase in temperature, storm intensity, and duration of both wet and dry seasons. In addition to these, it needs to be mentioned that these four trends further aggravate the situation of the region, which has to deal with a dramatic rise in population, due to migration from internal regions and Venezuela, and historical governance issues.

The plan, following the guidance of the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals (SDGs), gives directives to the ten municipalities of the Metropolitan Area in terms of climate mitigation and adaptation. Furthermore, the plan is guided by the National Laws 1523 (2012) and 1807 (2014)[1], that give to municipalities the power of designing their strategies and visions about urban planning and development, climate adaptation included. The Metropolitan Area therefore tries to coordinate and integrate the strategies of all the municipalities giving directions that should be followed for the common interest. However, the plan is not legally binding, and it gives no obligations to individual municipalities and local institutions.

In regards to climate mitigation, the municipalities are suggested to reduce by 35% the greenhouse gases emissions by 2030 (from 2019), while for adaptation they should implement fourteen selected measures, shown in Table 6. In the plan it is noticed how adaptation measures, being more abstract than the

[1] National Laws 1523 (2012) and 1807 (2014) give to municipalities the responsibility of developing their own urban development plans only constricted by general norms on urban density, environmental conservation and big development projects, as also respecting guidelines in regards to disaster risk management.

mitigation ones, are more difficult to prioritize and implement in terms of costs, dimensions and targets. Targets for adaptation measures are given to each specific measure when implementing it, in contrast to mitigation measures where targets of carbon emissions reduction, for example, are much more straight forward (Interviewee-7, a key interviewee from AMVA that worked in the redaction of the plan). Furthermore, many adaptation measures focus on activities that would have to take place in informal settlements, where the high level of informality makes it very difficult to estimate the official number of households impacted. Therefore, in the plan institutional continuity, public participation strategies and more in general open access to civil society in decision-making, and coordination between different cities and departments are stressed and heavily suggested. Trust between citizens, more empowered, and institutions, more present, is also identified as key to achieve climate adaptation. Finally, the social component is recognized as crucial in the plan. Education is defined as a transversal measure that would allow citizens to comprehend better the climate change reality, pushing responsibilities of individual behaviours in regards to sustainability issues and coexistence between local communities and biotic components (Área Metropolitana del Valle de Aburrá, 2018).

Table 6: Adaptation measures suggested by AMVA's climate adaptation plan *(Área Metropolitana del Valle de Aburrá, 2018)*. Translation by the author.

1.	Programme of Periodic Knowledge Update
2.	Comprehensive Risk Management Programme
3.	Comprehensive Regional Basic Sanitation Programme
4.	Comprehensive Food Security Programme
5.	Safe, Dignified and Sustainable Housing Programme
6.	Sustainable Transport/Mobility System
7.	Climate Change Education Programme
8.	Safe, Dignified and Accessible Recreation Programme
9.	Ecosystems and Biodiversity Conservation/Restoration Programme
10.	Instruments for Planning, Development and Management for Climate Change Programme
11.	Sustainable Competitiveness and Productivity Programme
12.	Technologic Appropriation, Innovation and Development Programme
13.	Governance, Governability, Co-living and Citizens Security Programme
14.	Health and Environment Programme

4.3.2. Medellin's Urban Development Plan (2016 – 2019) and POT (2014)

As mentioned in Section 4.2.2, Medellin is yet to develop a climate adaptation plan. The most recent important city plan is the Urban Development Plan 2016 – 2019 (Alcaldia de Medellin, 2016). This plan expressed the executive programme of Federico Gutierrez's administration, Medellin's Mayor until the end of his mandate in December 2019.

The plan treats a great number of topics, and emphasizes some elements in particular. First of all, the "collective construction" of the plan is heavily underlined, as it ideally allowed the citizens to participate and provoke changes in the society, with the modalities explained in Section 4.2.2. Education is recognized as pivotal in building a "new citizenship", needed to overcome the turbulent past of the city and create a new environment of coexistence among its dwellers. Furthermore, the plan mentions and pledges to target numerous justice-sensitive issues as gender inequality, minorities' segregation (including

migrants) and social exclusion of vulnerable people (e.g. disabled people and elderly). In regards to urban planning, the key pillars of the strategy appear to be the finalization of a fully sustainable transport system, the revitalization of the territory through urban transformation and containment of further expansion, and the preservation of the environment.

Climate change adaptation is only mentioned in Section 7.1.6 of the plan, titled: "*Environmental management for climate change"*. In this section it is affirmed how, following the directions of the 2014 *Plan de Ordenamiento Territorial* (POT - Territorial Ordinance Plan) (Alcaldia de Medellin, 2014a), the need of a "plan and relative action for mitigation and adaptation are identified and targeted" (Alcaldia de Medellin, 2016, p.354). However, no more clear indications are provided, and it is explained how the Environmental Secretary of the planning department would have the responsibility for their implementation (Alcaldia de Medellin, 2016, p.355).

The Territorial Ordinance Plan (POT), gives the regulatory framework under which every development of the city has to take place. Opposite to the Urban Development Plan, the POT gives a long term strategy, that every administration has to follow until a newer version is developed. At page 15 of the 2014's POT, a "territorial strategy" for the city of Medellin is presented, which states the following:

> *"To implement the Metropolitan Green Belt and set up a structural metropolitan ecological system as a basic natural provider of ecosystem services and as an adaptive strategy against climate change"* (Alcaldia de Medellin, 2014, p.15)

The Green Belt is one of the interventions planned in the sub-section of the POT dealing specifically with the Urban-Rural Border of the city, the SUB-POT BUR, shown in Figure 13.

The Green Belt project is thus the only intervention that is clearly stated to be (also) for climate adaptation by Medellin's municipality strategic planning documents.

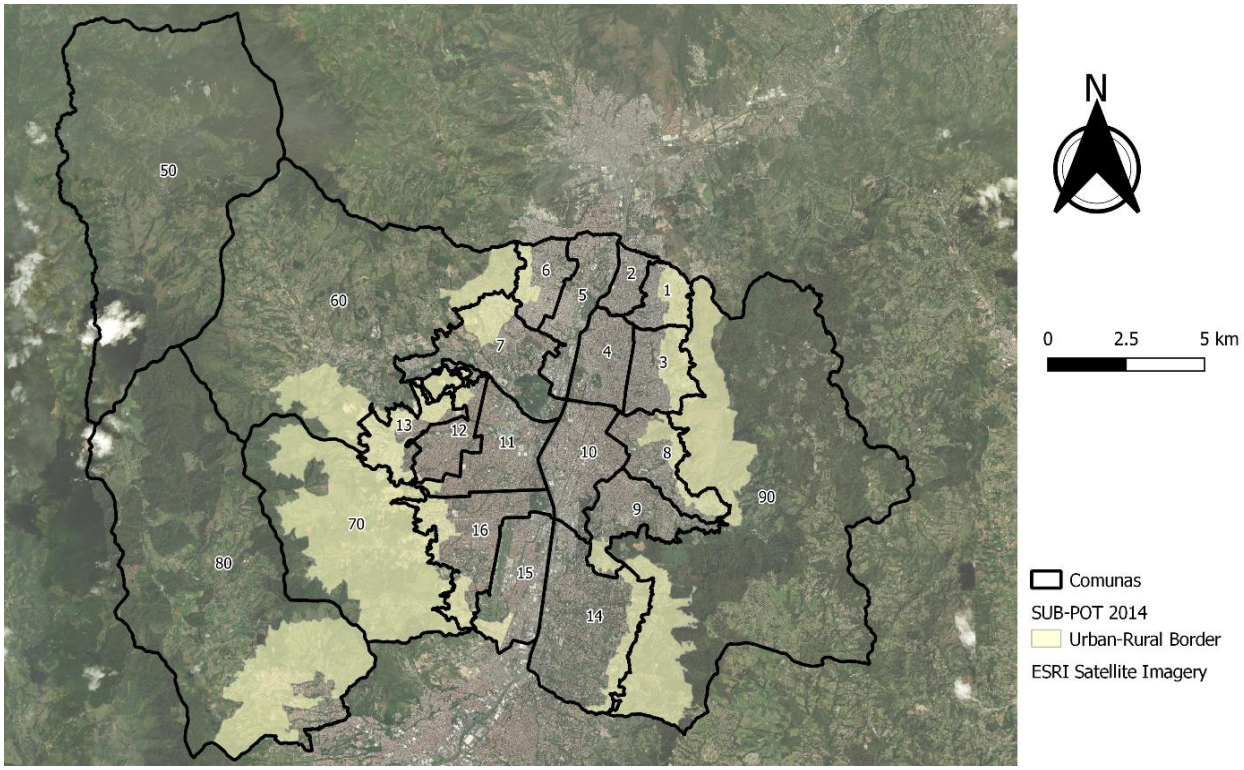


Figure 13: Urban Rural Border and Green Belt project planned in Medellin's 2014 POT. Source: the author

4.3.3. Community plans

During the fieldwork, the impressive efforts of Medellin's communities in regards to urban planning and disaster risk management powerfully emerged. As discovered during the interviews carried out on fieldwork (particularly with Interviewee-8, Interviewee-9, Interviewee-10 and Interviewee-13), each one of Medellin's Comuna has its own committees and participative budget for managing their territory. As affirmed by Interviewee-13, the overall participative budget is generated by the Municipality reinvesting the 5% from the city's taxes revenues, then distributed among the Comunas every four years (originally it was distributed every year). The communities develop local development plans and disaster risk management plans that are shared with the Municipality to give suggestions and express needs for the city's Urban Development Plan and for the municipal disaster risk management strategies. Documentaries produced by the local communities (Ciudad Comuna, 2019a, 2019b, 2019c) and interviews with community leaders and members of Comuna 8 (Interviewee-10 and Interviewee-13), neighbourhood highly susceptible to floods and landslides and with a high presence of informal settlements, showed how important their efforts are. Working closely with the University of Antioquia, EAFIT University, National University of Colombia and Medellin's DAGRD (Departamento Administrativo de Gestión del Riesgo de Desastres – Administrative Department for Disaster Risk Management) Comuna 8 has been extremely active and has produced a number of disaster risk management plans, studies of geological risk and zonification, programmes of co-production of knowledge and monitoring of landslide-prone areas (among others Grupo de Investigacion Ambiente Habitat y Sostenibilidad, Mesa de Vivienda Comuna 8 & Corporacion Montanoa, 2019; Irazábal-Zurita et al., 2013; Smith et al., 2018; Velásquez, 2013; Movimiento Laderas, 2018, 2020). In regards to social vulnerability, Movimiento Laderas (2020), for example, explicitly requests the municipality to undertake measures in the north-eastern part of the city in order to address structural poverty, food insecurity and inadequate housing and services, severely afflicting the area (as also seen in the results presented in Section 4.1).

4.4. Climate adaptive interventions and social vulnerability (*Outcome,* SO-4)

4.4.1. The Green Belt project

4.4.1.1. Explanation of the project, outcome and reactions from the community

Unfettered urban expansion has been a severe problem since the beginning of the last century for Medellin. The city has seen a sensational increase in population, going from five hundred thousand to three million inhabitants in half of a century (see also Figure 14), mainly due to internal displacement caused by historical conflicts in the country and industrialization (Anguelovski, Irazábal-Zurita, & Connolly, 2018; Perfetti del Corral, 1995). Lack of physical space forced the upcoming migrants to self-build informal settlements on higher and higher slopes of the valley surrounding the city. This type of informal development has had two main repercussions: firstly, it makes the provision of basic services highly prohibitive, and secondly it exposes the dwellers to extreme risks of natural disasters like landslides, floods and subsidence (Garcia Ferrari et al., 2018).

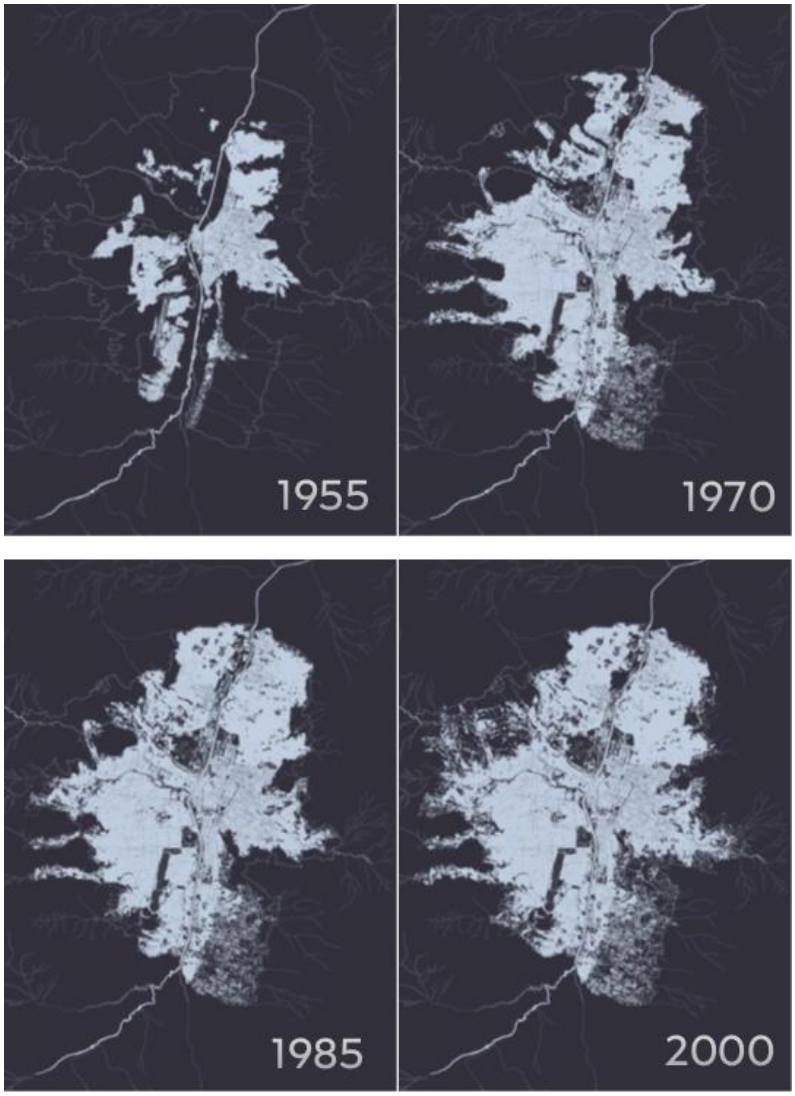


Figure 14: Medellin's urban growth over time. Source: Irazábal-Zurita et al., 2013 (original artist: Jota Semper)

It is in this context that the Green Belt project was ideated. Framed as a strategy for climate adaptation (Alcaldia de Medellin, 2014a), it also had the objectives of controlling urban sprawl, protecting the peculiar biodiversity of the area and reducing the risk of landslides (Anguelovski et al., 2018). Furthermore, integral improvement of the interested neighbourhoods, to guarantee dignified living conditions to the dwellers, and construction of public areas were established (EDU, 2015).

Of the fourteen parts that composed the original Green Belt project only a pilot project has been completed, the Jardin Circunvalar in Comuna 8, in the north-eastern part of the city. Figure 15 shows an aerial view of its finalized version. The project has already received in-depth appraisals and won international awards (EDU, 2014, 2016). Interviews with community leaders and members, employees of EDU in charge of the project and experts, however, showed that the outcomes are highly controversial. Benefits emerging from the construction of the Jardin Circunvalar are unequally distributed between the community of Comuna 8 and other different actors of the city, as also among the dwellers of Comuna 8 itself.

Figure 15: Aerial view of the Jardin Circunvalar. Source: EDU, 2015

Information collected during the interviews showed that there have been some improvements for the residents of houses and for the owners of activities close to the routes that have been built. Improvements include more income generated by revenues from the touristic influx provoked by the new attracting project (Interviewee-12), as well as sporadic structural elements built in the proximity of the routes, such as drainages (Interviewee-4, Interviewee-12, Interviewee-13), concrete channels and trails (Interviewee-4, Interviewee-12, Interviewee-13), playgrounds for kids and communal urban gardens (Interviewee-4, Interviewee-12, Interviewee-13). Figures 16 and 17 show some of these interventions. Nonetheless, according to interviewed community leaders and experts (Interviewee-1, Interviewee-10, Interviewee-13, as also a community leader that was a speaker in the URBE-LATAM conference), the much needed integral improvement of the neighbourhoods, that was part of the original plan and was the main action to address the underlying causes of social vulnerability of the dwellers, did not take place leaving many of the self-constructed houses in conditions of high-risk of landslides and without connection to basic services as water, heating and electricity.

Figure 16: Jardin Circunvalar's interventions in Comuna 8: concrete channels (pointed out in red) and trails. Source: the author

Figure 17: Jardin's Circunvalar interventions in Comuna 8: playgrounds for kids and communal urban garden. Source: the author

However, many residents of Comuna 8 that were living on the route where the Jardin Circunvalar has been built have been displaced, while other dwellers who do not live in the proximity of the new constructions received practically no benefits (Interviewee-1, Interviewee-13). This intervention has therefore not addressed the deep-rooted social vulnerabilities of the area, if not even exacerbated them, creating also internal conflict among the community members due to the differential outcomes (Interviewee-12). Further evidence of the negative impacts of the project and the popular disapproval came out from the interviews and the documentaries produced by the Comuna 8 community (Ciudad Comuna, 2013, 2014).

A Comuna 8 leader (Interviewee-10) stated in the interview:

"The community did not want the Jardin Circunvalar … if disaster risk is the problem, disaster risk management is the solution".

Another community leader (a speaker in the URBE-LATAM conference) affirmed:

"A Green Belt for the tourist has been realized … as Medellin is described as the city of the future, in the higher slopes of the city the future is lacking, with no water nor public services".

A recurrent theme among the interviewees (Interviewee-1, Interviewee-8, Interviewee-10, Interviewee-13) was the dichotomy between "high risk" and "high cost", and the fervent debate around it. The administration justified the forced relocation of the dwellers living in houses along the routes of the Jardin Circunvalar that have been constructed as an inevitable measure giving the conditions of not-mitigable high risk of the area. The community, however, always protested on this position for mainly two reasons.

First, they believe that the real problem was the high cost that the municipality would have had faced for the eventual reconstruction of all the residences of the area. Relocating some dwellers for the development of a big project capable of generating high revenues and increasing the value of the land was apparently considered as an easier and more convenient choice for the municipality (Interviewee-1, Interviewee-13). After the implementation of the Jardin Circunvalar, in fact, the price of the land in the area has increased, as well as the cost of living. This has caused a so-called "green gentrification", in which a commercialized nature, in combination with tourists and incoming wealthy people are pushing out former dwellers from their lands (Anguelovski et al., 2018). Land of relocated people has been sold to powerful actors who have more economic capabilities and are using this land to build residential flats (Interviewee-12, Interviewee-13). In addition to this, it is worth to mention an anecdote, narrated by a community member (Interviewee-13) during one of the interviews, that gives other details on the matter. The first version of the Jardin Circunvalar project was establishing the construction of a monorail, strongly contested by the community and then removed, that would have easily connected Comuna 8 to the centre of the city with the help of the already existing network of metro-cable and metro highly popular in Medellin. In regards to this, Interviewee-13 declared:

"The municipality first says we need to relocate due to the high risk of the area, and then wants to do such an expensive and heavy thing on this sensitive and risky land?!"

Secondly, community members strongly underlined how according to them relocation brings much more losses than gains. Communities living on the higher slopes of the valley surrounding Medellin's urban core are mostly composed of people displaced due to the violent armed conflicts or arrived in the city from rural areas hoping for more opportunities. Facing a second displacement is seen by the community as going through the same problems but elsewhere, with further losses of previously created social ties,

instead of the enhancement of quality of life that the improvement of neighbourhoods and households that they strongly request would stir (Interviewee-13; Ciudad Comuna, 2014).

Although confirming that they have been included in the early stages of the process, community members affirmed in the interviews that they "felt cheated" (Interviewee-13), since they do not see themselves "reflected in the project" as the municipality "imposed it to us, they did not have a real consultation with the community leaders" (Ciudad Comuna, 2014, 19:30). Clear requests were formulated in the community plans, as integrated improvement of neighbourhoods, risk mitigation and risk management, food security and urban agriculture (strongly connected with the traditions and the culture of the migrants from rural areas), guaranteed income, dignified housing, provision of water and other basic public services, and more in general benefits that would reach the vulnerable portions of the population and address their social vulnerabilities (Mesa Interbarriales De Desconectados, 2013; Velásquez, 2013). Most of these requests have not been considered nor delivered by the Jardin Circunvalar implementation, although has brought some other benefits to some of the dwellers (i.e. above mentioned touristic revenues, drainages, playgrounds, urban gardens).

Using the words of a community leader portrayed in one of the locally produced documentaries:

> *"They talk about development … potable water, public services and dignified housing is development for us"*
> (Ciudad Comuna, 2014, 13:10).

4.4.1.2. Revelations from the history: the Plan Piloto

It is important to narrate a detail that was discovered during the interview with a professor, urban planning expert and Medellin's historian (Interviewee-1), further scrutinized with an in-depth literature review, that gives a crucial context to the Green Belt project.

As previously mentioned, Medellin has seen an unregulated and dramatic urban growth over the last century, both in population and urban expansion. The first identification of these problems date back to the 1940's, when the administration hired the architects Jose Luis Sert (1902-1983) and Paul Lester-Wiener (1895-1967) in order to develop a pilot plan for the new city's Regulatory Plan: the *Plan Piloto* (Estrada Gil, 2012), partially visible in Figure 18. Wiener and Sert, as leading exponents of the Modernist movement alongside Le Corbusier, developed the *Plan Piloto* substantiating the pillars of the "Athens Charter", document produced in 1933 by the Congrès International d'Architecture Moderne (CIAM) that had a great influence on urban planning after its publication (Perfetti del Corral, 1995; Schnitter Castellanos, 2004). Under this ideal of the development of a modern city, Sert and Wiener produced in 1950 the *Plan Piloto* for Medellin following the Athens Charters' guidelines on living, working, recreation and circulation, and proposing a reorganization of the city recognizing its geographic and historical strengths (Estrada Gil, 2012). It is in order to give back the characteristic nature to Medellin and to control the expansion of the urban perimeter, that Wiener and Sert proposed a "Green Belt" for the city of Medellin.

The Green Belt was thus an intervention ideated more than half a century ago, when climate change (not to mention *adaptation*) was far from being recognized as a real global issue.

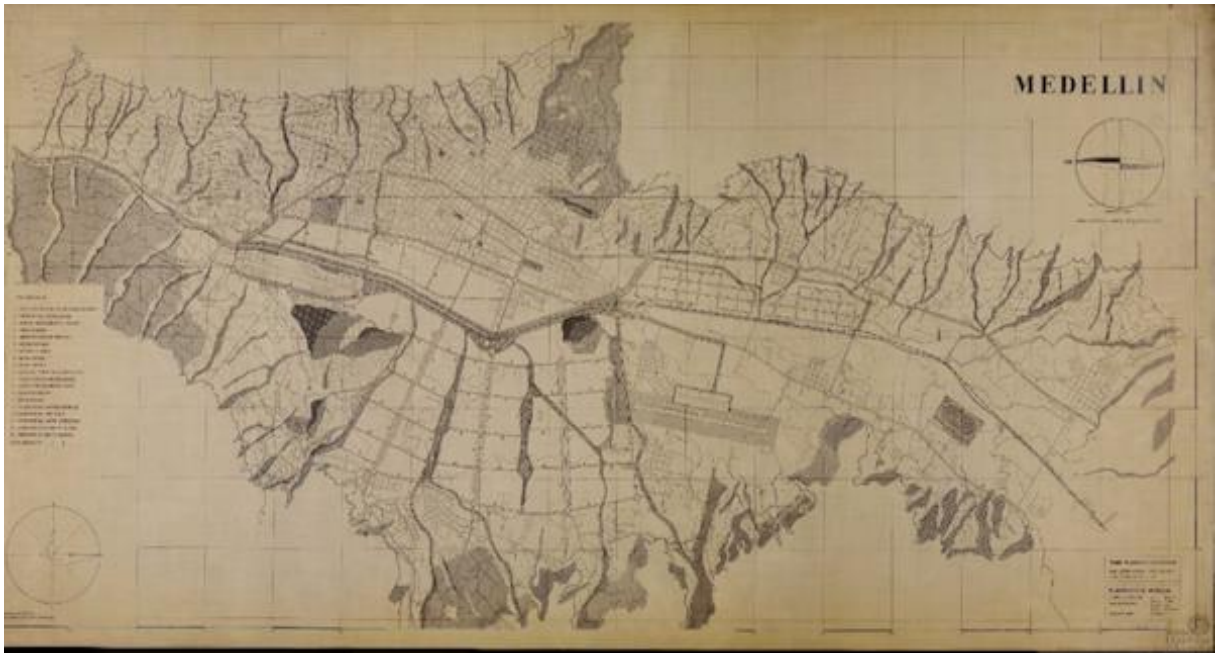


Figure 18: Part of the 1950's *Plan Piloto* by Wiener and Sert. Source: Estrada Gil, 2012.

4.4.2. The effect of the Green Belt on SoVI and political perception

Examining Figures 6 and 7 it is possible noticing how Comuna 8, the location where the pilot project of the Green Belt, the Jardin Circunvalar, has been constructed, saw no changes in the overall Social Vulnerability Index (SoVI) over the period 2013-2017. Looking at the individual indicators maps (Figures 8, 9, 10, 11), instead, Comuna 8 saw a decrease in unemployment rate, contributory health system participation and female-headed household, while illiteracy rate and food insecurity increased. The other indicators remained stable over the period under analysis. It is hard to correlate these variations in social vulnerability to the implementation of the Jardin Circunvalar, especially for the proximity of the two years under analysis.

Figure 19 shows the hazard map included in Medellin's 2014 POT, in combination with the SUB-POT establishing the Green Belt project. The map shows how the north-eastern part of the city, where the Jardin Circunvalar has been implemented, is severely threatened by natural hazards, in particular landslides. It is interesting to see how this lines up with the requests of Comuna 8's community plans in regards to the project, where risk mitigation and risk management were one of the most requested measures, as also with one of the stated objectives of the project ("reduce the risk of landslides", as seen in Section 4.4.1.1).

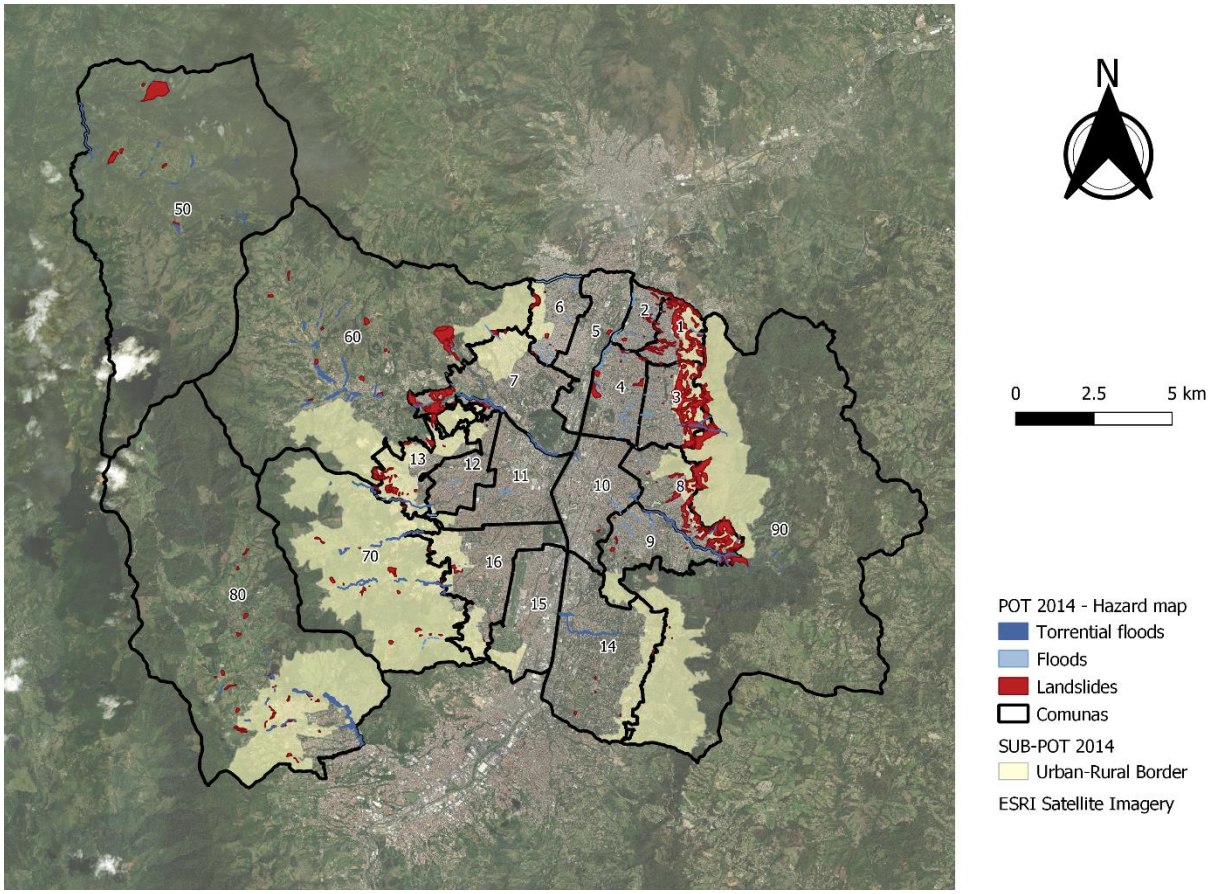


Figure 19: Hazard map and Urban-Rural Border plan containing the Green Belt project (and Jardin Circunvalar, in Comuna 8), from Medellin's 2014 POT. Source: the author.

Contrasted outcomes on this particular topic, however, have been seen during the interviews. While EDU's employee (Interviewee-4) affirmed:

"During a meeting with the community leaders, we reached an agreement on what the needs were",

a community member (Interviewee-13) stated:

"With the final project we felt cheated, it was not what we wanted".

Given these quotes, as also the previous ones included in Section 4.4.1.1, it is intriguing looking at Figure 20, showing the variation in Political Perception over the period 2013-2017. Comuna 8, as also the neighbouring ones, stands out with its impressive reduction in terms of trust and satisfaction with political institutions, as opposed for example to the wealthiest Comunas 12 and 14 (La America and El Poblado) which maintained high values for both 2013 and 2017. Although hard to validate, as mentioned in regards to the SoVI results, this may be caused by the questionable and highly debated effect of Jardin Circunvalar's construction, and it is an aspect that needs to be mentioned.

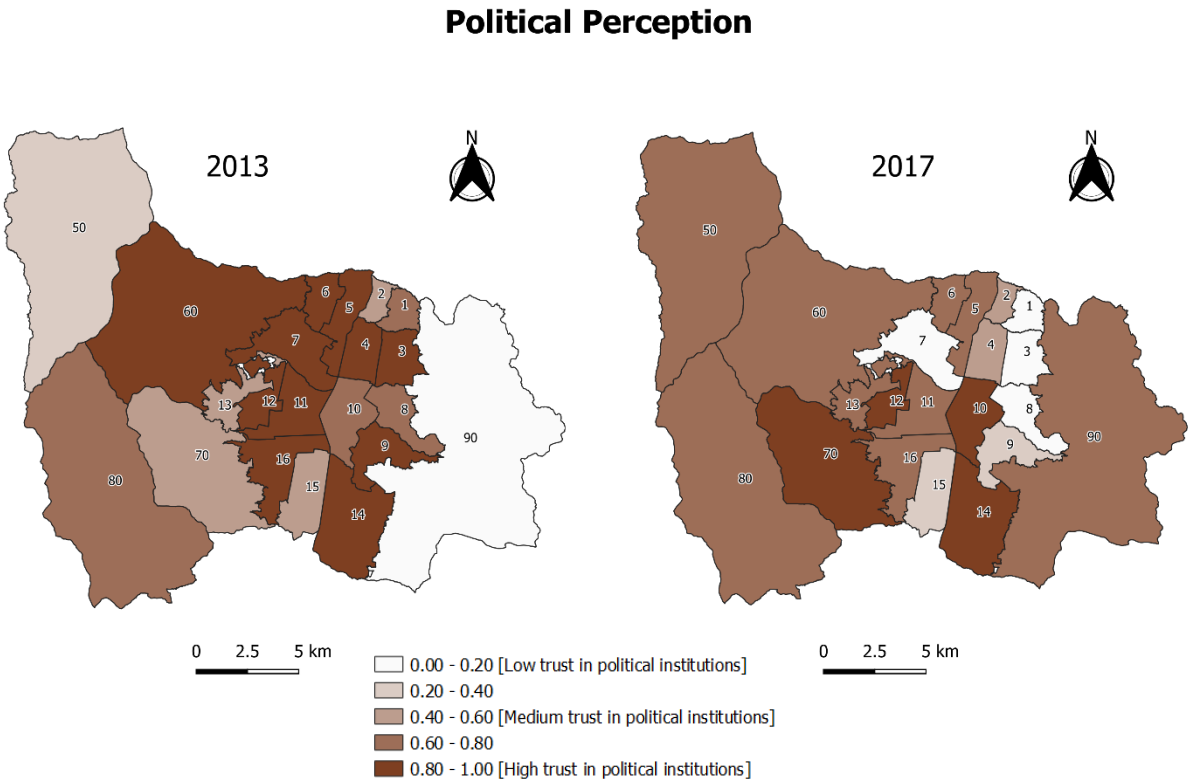


Figure 20: Distribution of the Political Perception indicator over Medellin's Comunas for years 2013 and 2017. Source: the author.

5. DISCUSSION

'No tienen pantalones y quieren cinturones'
Ciudad Comuna, 2014

This chapter presents a deeper look into the obtained results, linking them with the key concepts that drove the whole study and answering the research questions.

5.1. Social vulnerability assessment

Results from the social vulnerability assessment in Medellin show minimal variations between the two years under analysis, 2013 and 2017. This has been most probably caused by the proximity of the two years under analysis, and it needs to be mentioned that the availability of a more exhaustive dataset would have helped, although the years examined coincided with the implementation of the Green Belt project. It is also worth mentioning how the replacement of the missing values in the dataset, substituted using the approach followed by Cutter & Finch (2008), may have had an impact on the cumulative SoVI indexes, flattening everything out on medium values.

The maps of the single indicators can stimulate important reflections. Patterns of inequality among the urban landscape of Medellin are clear, since some of the *Comunas* are afflicted by the worst results for many of the selected variables. The indicator that seems to have undergone the biggest changes over time is the Dependency Ratio. The '*Corregimientos'*, the larger neighbourhoods that are defined as a mix of urban and rural areas given the geographic location over the high slopes at the boundaries of the valley surrounding the city of Medellin, saw the most dramatic reduction over time. The reasons for these changes cannot be identified, and they may include some imperfections in the database. However, it is worth mentioning that being bigger than the other neighbourhoods, changes in these areas may have an impact on the visual perception on the overall map. Given that all the '*Corregimientos'* saw a decrease in Dependency Ratio, it is has been decided to maintain the indicator in the overall analysis, also considering that a variation of this entity may have really happened. *Comunas* 1,2, and 8 appear to have the highest values in Dependency Ratio in both 2013 and 2017.

More in general, social vulnerability indexes are hard to validate, as choices deeply influence the results. Indexes are good tools for directing policy interventions, as they are relatively easy to communicate and interpret but, if not used correctly, they can be highly misleading (Saisana, Saltelli, & Tarantola, 2005). It must be said, though, that an index is a per se simplistic tool, as it tries to depict a complex reality only through some indicators. However, simplifying is needed to show evidence, give key messages and stimulate actions. It is for this reason that is crucial to reason the choices, and to explain all the steps taken, to allow the possibility of improving the robustness and validity of indexes results (Saisana et al., 2005; Tate, 2012). In relation to the case of Medellin, decision-makers and planning departments of the Municipality and the Metropolitan Area are already familiar with this type of analysis (Alcaldia de Medellin, 2014; Departamento Administrativo de Gestión del Riesgo de Desastres (DAGRD) & Universidad EAFIT, 2016; UN-HABITAT, 2010; Interviewee-9, 2020; Medellin Como Vamos, 2018), increasing the pertinence and applicability of such an assessment. Social vulnerability assessments, in such a way accomplished, can shed a light on the underlying drivers of vulnerability provoking *transformative* climate adaptation measures specifically targeting them. This would therefore lead to increasing the intrinsic justice and equity of climate adaptation.

Furthermore, a sensitivity analysis would have been fundamental for giving more relevance to the outcome of the SoVI, but the time and effort required to carry it out have been used for a qualitative analysis of implemented climate adaptive interventions, an urgent research gap in the scientific literature.

5.2. *Process-Output-Outcome* investigation

From the results obtained through an in-depth examination of available media, community-produced documentaries, newspaper articles, urban development plans, climate adaptation plans, existing literature and interviews transcriptions, many conclusions can be drawn.

In relation to the *process*, it can be understood how citizens were very much involved, but much less considered. Although taking part in the redaction of the urban development plan and the climate adaptation plan, and in the early stages of the Green Belt project design, their inputs have been pretty much ignored. As a key interviewee from the Medellin's municipality planning department (Interviewee-9) affirmed, participation at the community level is happening, but with unsuccessful results. The relationship between citizens and institutions has been deteriorating over the years, mainly due to the lack of visible improvements and of consideration of their inputs perceived by the community, as it can also be seen from the Political Perception indicator results (Figure 20).

Both *procedural* and *distributive* justice have seen negative responses, since vulnerable portions of the population lacked the political power to influence the decision-making processes. Furthermore, findings from the fieldwork confirmed how low-income residents have been discriminatorily relocated to non-hazard-proof areas, have lost their social infrastructure and have been deprived of their practices and culture of nature in order to create "new environmental privileges for upper-class locals and visitors", as seen in Anguelovski et al. (2018).

The lack of meaningful citizen participation had as a consequence the scarce social acceptability of the Green Belt project, affecting, therefore, its *legitimacy*. According to Adger et al. (2005), lack of legitimacy may result in the impossibility of fully implementing interventions. This may have happened in Medellin, where only one part out of the fourteen planned of the Green Belt project has been completed, inevitably also due to contextual economic and political constraints.

For what concerns the *credibility* of policies and plans, climate adaptation is rarely mentioned in Medellin's city plans, while the climate adaptation plan developed by AMVA is a significant step forward. However, it is not legally binding so the implementation of the suggested measures, although ambitious in terms of reducing social vulnerabilities and guaranteeing human rights, (e.g. dignified housing, livelihoods improvement, food security, education, health) is naively treated and gets lost in multi-level governance, overlapping responsibilities between different institutional levels, conflicts of interests of different cities, departments and administrations, and more in general a lack of strong political will. This shows the weakness in vertical interplays for policy measures and between governmental departments, already identified by scholars several times (among others Greiving & Fleischhauer, 2012; Van Asselt & Renn, 2011). As extensively seen already in scientific literature, in fact, governments prefer to prioritize short-term immediate necessities instead of programmes targeting an uncertain phenomenon as climate adaptation (among others Ford et al., 2011; specifically for Medellin see Pérez-Muñoz, 2016; Pérez-Muñoz, Brand, & Agudelo, 2017).

The lack of climate adaptation in the past agenda of Medellin's municipality needs to change, especially given the high sensitivity particularly of the dwellers living on the steep slopes of the city, which are often the ones living in non-flood-proof buildings, the most threatened by landslides, and the most socially

vulnerable. Urban planning and disaster risk management that have traditionally been "*del contragolpe*" in Medellin (as stated by two different interviewees: Interviewee-5 and Interviewee-9), namely only acting when reacting to dramatic events, need to incorporate climate adaptation in a targeted and coordinated way, in order to avoid future further dramatic experiences. In this sense the great tradition of Medellin in regards to civic society organization and public participation (Urán, 2010) can play a great role. The city has a fervent net of active actors, like NGOs, university and community associations, that are already collaborating together in very fruitful ways (e.g. community plans and activities/projects with academia). The city needs to recognize this and should produce solutions not only -for- but -with- the communities, tailored to their needs in order to reach climate adaptation, increase social justice and reduce social vulnerabilities (Shi et al., 2016).

Past administrations of the city appear to have taken other paths, preferring more technocratic and top-down approaches, mostly for economic reasons and for recovering the city's image of the most violent city in the world. In this context, different administrations started to attract international support and funds through big and popular flagship projects (e.g. metrocable, escalators, Green Belt) which raises many questions, like: *Is there any other way? At what expense?* The audacity showed by the city especially with the first version of the Green Belt, that included even a monorail, could be used instead for driving out of poverty the dwellers of informal settlements, providing them with adequate housing and basic services lacking at the moment. The currently implemented neoliberal and appealing -"mediatic"- solutions may bring, alongside international awards, debatable and inequitable benefits. Is the sacrifice of vulnerable portions of the populations as *collateral damages* for economic gains acceptable?

It needs further attention and more sensitivity the question of how the creation of jobs for the community in the development of the Green Belt project may have affected the evaluation of the latter by community members that had benefits. As already seen in other contexts and with different implications (for example Greco & Bagnardi, 2018) people without a job may happily welcome individual opportunities that in end produce negative consequences for themselves or for the community as a whole. A job is always better than having none, whether or not it has repercussions on the personal or general interest in the longer term.

Finally, monitoring and evaluating the impact of climate adaptation measures is lacking and it is difficult to implement, as shown with the results from this research, where the minimal variations in terms of social vulnerability during the period 2013-2017 made impossible their attribution to the implemented climate adaptive interventions. However, the social vulnerability assessment and the QuIP have shown a good potential in contributing to the needs for more evaluation and monitoring to identify the success (or the lack of it) of the climate adaptive interventions in Medellin. This combined approach, especially with a stronger and innovative connection between the mostly quantitative maps and the differently-gathered qualitative data, can be crucial in communicating the urgency of transformative, just and equitable climate adaptation actions and eventually show people not only as numbers but as what they really are: stories.

5.3. Post-COVID reflections

Although not directly related to the focus of this thesis, it is impossible not to mention some points of contact between this research and the COVID-19 pandemic. The almost unimaginable series of events that the whole world has experienced and is currently experiencing show how climate change is only one of the stressors affecting and exacerbating social inequalities. Ethnic minorities and deprived areas' dwellers, in fact, are suffering higher infection rates and deaths (Barr, Kommenda, McIntyre, & Voce, 2020; BBC, 2020; Bouie, 2020; Centers for Diseases Control and Prevention, 2020), and Medellin makes

no exception. Although the city has been praised for its response to the pandemic (The Economist, 2020b), Comuna 8 is the neighbourhood with the most COVID-19 cases (Estrada Ramirez, 2020).

The impacts of COVID-19 on already striking social inequalities are evident, and they further justify stressing the need for a shift towards a more just society. Transformative climate adaptation addressing root causes of social vulnerability and human rights is a necessity, since they are often not addressed by technocratic infrastructural developments. *How to wash your hands when there is no water provision? How to apply social distancing when living in inadequate housing?*

6. CONCLUSIONS AND RECOMMENDATIONS

This research had the objective of improving social justice and equity of climate adaptation through social vulnerability assessments, with the specific study area identified in Medellin, Colombia. The study was tackled with a combination of both quantitative and qualitative methods, especially focusing on *process*, *output* and *outcome* of climate adaptation planning.

A quantitative SoVI has been created for the years 2013 and 2017, which showed minor variations in social vulnerability over space and time over the city of Medellin. The main reasons for this have been identified in the proximity of the two years under analysis and the not exhaustive available dataset.

A qualitative analysis of a wide range of primary (interviews) and secondary data (plans, media, documentaries, literature) demonstrated how citizens were included in the decision-making processes, but not really considered and reflected in plans and projects, which contributed to decreasing their *legitimacy*, as well as the political trust in public institutions. The latter appeared to be a very interesting result that would be worth investigating more. AMVA's climate adaptation plan is an ambitious and important plan, that gets however lost in multi-level governance, overlapping responsibilities and failure of vertical interplays between different policies and different institutions. Medellin's administration, as today, lacks a delineated and clear strategy for climate adaptation. The only intervention clearly stated to be (also) for climate adaptation in the most recent official urban planning documents is the Green Belt, actually ideated in 1950 when climate change was far from being recognized as a global issue. However, only one part of the project has been completed, the Jardin Circunvalar, out of the fourteen originally planned, that had in turn debatable and inequitable outcomes. Citizens directly affected by the project reported a general state of dissatisfaction, mainly because of the lack of provision of public services, dignified housing and disaster risk management that emerged as main necessities of the area, that were promised at the beginning of the project, but that were never delivered.

Finally, the combination of the results obtained by both the quantitative and the qualitative approaches should have uncovered the effect of climate adaptive interventions on social vulnerability in Medellin. This has not completely reached, mainly due to the minimal changes in social vulnerability between 2013 and 2017 that precluded the attribution challenge. The combination of SoVI and QuIP, however, showed great potential for stimulating and driving more just and equitable adaptation measures. In fact, creative combinations of typically quantitative (and "cold") results, with typically qualitative ones would enhance the communicability of the urgency of such interventions.

Based on these final conclusions, it is recommended to carry out a sensitivity analysis for the social vulnerability assessment, that would better validate the obtained results. Furthermore, after the fieldwork it emerged how constructing the SoVI together with the local stakeholders, choosing the suitable indicators and focusing on the local peculiarities and necessities, would give outcomes particularly interesting for the local context under observation. This practice would also help in identifying specific and contextual root causes of social vulnerabilities, catalysing much needed transformative and egalitarian climate adaptation measures, as well as achieving meaningful citizens' participation.

The lack of an exhaustive and satisfying dataset showed how censuses and surveys may be "obsolete", underlining the need for more precise methods to "count people", necessary for more oculate planning especially in contexts dealing with migration and informality, where disaster risk is amplified. In regards to

this, big data, remote sensing and artificial intelligence have great potential for doing so (The Economist, 2020a; Thomson et al., 2020), and it is a field of study that will gain relevance in the future.

Lastly, more research is needed in regards to the relation between climate change and social sciences. As explained in the text, monitoring and evaluating the impact of climate adaptive measures is one of the most pressing issues, but not only. For example, exploring the links between climate change and migration, or behavioural sciences or its psychological effects on the human population is currently lacking among scholars and has a great relevance for the future of our society.

LIST OF REFERENCES

100 Resilient Cities. (2016). *Resilient Medellin - A Strategy For Our Future*. Medellin: Rockefeller Foundation.

Adger, W. N., Arnell, N. W., & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change*, *15*(2), 77–86. https://doi.org/10.1016/j.gloenvcha.2004.12.005

Adger, W. N., Paavola, J., Huq, S., & Mace, M. J. (2006). *Fairness in adaptation to climate change*. Cambridge, Massachusetts: MIT Press.

Aguiar, F. C., Bentz, J., Silva, J. M. N., Duarte Santos, F., Penha-Lopes, G., Fonseca, A. L., & Swart, R. (2018). Adaptation to climate change at local level in Europe: An overview. *Environmental Science and Policy*, *86*, 38–63. https://doi.org/10.1016/j.envsci.2018.04.010

Alcaldia de Medellin. (2014a). *Acuerdo 48 de 2014: "Por medio del cual se adopta la revisión y ajuste de largo plazo del Plan de Ordenamiento Territorial del Municipio de Medellín y se dictan otras disposiciones complementarias."* Medellin.

Alcaldia de Medellin. (2014b). Circulares Encuesta Calidad de Vida. Retrieved March 16, 2020, from https://www.medellin.gov.co/irj/portal/medellin?NavigationTarget=navurl://f0ea9f10392febab26306c5be3d1bba5

Alcaldia de Medellin. (2016). *Medellin cuenta con vos: Plan de Desarrollo - Anteproyecto*. Medellin.

Alcaldia de Medellin [@AlcaldiadeMed]. (2020). ¡Estamos comprometidos con el cambio climático! Hoy desde el pacto ambiental C40, coalición conformada por 96 ciudades que buscan luchar contra el cambio climático, trabajaremos en la formulación de un Plan de Acción Climático en línea con el Acuerdo de P. Retrieved from https://twitter.com/AlcaldiadeMed/status/1220831497445421056

Anguelovski, I., Irazábal-Zurita, C., & Connolly, J. J. T. (2018). GRABBED URBAN LANDSCAPES : Socio-spatial Tensions in Green Infrastructure Planning in Medellín. *International Journal of Urban and Regional Research*, 133–156. https://doi.org/10.1111/1468-2427.12725

Anguelovski, I., Shi, L., Chu, E., Gallagher, D., Goh, K., Lamb, Z., … Teicher, H. (2016). Equity Impacts of Urban Land Use Planning for Climate Adaptation. *Journal of Planning Education and Research*, *36*(3), 333–348. https://doi.org/10.1177/0739456X16645166

Antwi-Agyei, P., Dougill, A. J., Stringer, L. C., & Codjoe, S. N. A. (2018). Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. *Climate Risk Management*, *19*(November 2017), 83–93. https://doi.org/10.1016/j.crm.2017.11.003

Área Metropolitana del Valle de Aburrá. (2018). *Plan de Acción ante el Cambio y la Variabilidad Climática del Área Metropolitana del Valle de Aburrá 2019 - 2030*. Medellin.

Arnstein, S. R. (1969). A Ladder Of Citizen Participation. *Journal of the American Planning Association*, *35*(4), 216–224. https://doi.org/10.1080/01944366908977225

Atteridge, A., Remling, E., Carmen, M., Editor, D., & Hulme, M. (2018). Is adaptation reducing vulnerability or redistributing it ? *WIREs Clim Change*, *9*(January/February). https://doi.org/10.1002/wcc.500

Bakker, S., & Brandwijk, Y. (2016). Adding Public Green Space While Healing Old Wounds. Retrieved October 14, 2019, from https://www.citylab.com/design/2016/04/medellin-metropolitan-greenbelt-public-space/478692/

Barnett, J., & O'Neill, S. (2010). Maladaptation. *Global Environmental Change*, *20*(2), 211–213. https://doi.org/10.1016/j.gloenvcha.2009.11.004

Barr, C., Kommenda, N., McIntyre, N., & Voce, A. (2020, April 22). Ethnic minorities dying of Covid-19 at higher rate, analysis shows. *The Guardian*. Retrieved from https://www.theguardian.com/world/2020/apr/22/racial-inequality-in-britain-found-a-risk-factor-for-covid-19

Bauman, Z. (2011). *Collateral Damage: Social Inequalities in a Global Age*. Cambridge: Polity Press.

BBC. (2020). Coronavirus: Call for testing over "Covid wealth divide." Retrieved May 29, 1BC, from https://www.bbc.com/news/uk-wales-52513528

Begg, C. (2018). Power, responsibility and justice: a review of local stakeholder participation in European flood risk management. *Local Environment:The International Journal of Justice and Sustainability*, *23*(4), 383–397. https://doi.org/10.1080/13549839.2017.1422119

Benzie, M. (2014). Social justice and adaptation in the UK. *Ecology and Society*, *19*(1). https://doi.org/10.5751/ES-06252-190139

Bergvall, M., & Dah, E. (2015). *A green belt of synergies. A study on the implementation of a contemporary Green Belt*. Swedish University of Agricultural Sciences. Faculty of Natural Resources and Agricultural Sciences. Uppsala.

Bosworth, J. (2019, November 25). 2019 has been a difficult year in Latin America — 2020 may only get worse. *Business Insider*. Retrieved from https://www.businessinsider.com/political-instability-protests-in-latin-america-may-intensify-in-2020-2019-11?international=true&r=US&IR=T

Bouie, J. (2020). Why Coronavirus Is Killing African-Americans More Than Others. *The New York Times*. Retrieved from https://www.nytimes.com/2020/04/14/opinion/sunday/coronavirus-racism-african-americans.html

Breil, M., Downing, C., Kazmierczak, A., Mäkinen, K., Romanovska, L., Terämä, E., & Swart, R. (2018). *Social vulnerability to climate change in European cities – state of play in policy and practice* (European Topic Centre Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA) Technical paper 2018/1). https://doi.org/https://doi.org/10.25424/CMCC/SOCVUL_EUROPCITIES

Bryman, A. (2012). *Social Research Methods*. New York: Oxford University Press.

Cannon, T. (1994). Vulnerability analysis and the explanation of "natural" disasters. In *Disasters Development and Environment* (Vol. 37, pp. 13–30). Chichester: John Wiley. Retrieved from http://leeclarke.com/courses/disasters/cannon_vulnerability_analysis.pdf

Centers for Diseases Control and Prevention. (2020). COVID-19 in Racial and Ethnic Minority Groups. Retrieved June 25, 2020, from https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/racial-ethnic-minorities.html

Chelleri, L., Waters, J. J., Olazabal, M., & Minucci, G. (2015). Resilience trade-offs: addressing multiple scales and temporal aspects of urban resilience. *Environment and Urbanization*, *27*(1), 181–198. https://doi.org/10.1177/0956247814550780

Chen, W., Cutter, S. L., Emrich, C. T., & Shi, P. (2013). Measuring social vulnerability to natural hazards in the Yangtze River Delta region, China. *International Journal of Disaster Risk Science*, *4*(4), 169–181. https://doi.org/10.1007/s13753-013-0018-6

Chu, E., Anguelovski, I., & Carmin, J. A. (2016). Inclusive approaches to urban climate adaptation planning and implementation in the Global South. *Climate Policy*, *16*(3), 372–392. https://doi.org/10.1080/14693062.2015.1019822

Ciudad Comuna. (2012). Por la vida y la dignidad. Comunidades en Movilizacion. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=KK2az-zbOB0

Ciudad Comuna. (2013). Cinturon verde generando desigualdad. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=dKQ3QwXqoNw

Ciudad Comuna. (2014). El Jardin de Dudas. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=20U_2FMrxE8&t=1231s

Ciudad Comuna. (2019a). Concertacion y Resultados del Proceso. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=oF3E0rUKZPc

Ciudad Comuna. (2019b). Gestion del Riesgo e Impactos en Laderas. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=4BB6Ju1U5sA

Ciudad Comuna. (2019c). Percepcion y Monitoreo del Riesgo. Retrieved March 3, 2020, from https://www.youtube.com/watch?v=08YC0cfPmGc

Copestake, J., Morsink, M., & Remnant, F. (2019). *Attributing Development Impact: the Qualitative Impact Protocol case book*. Rugby, UK: Practical Action Publishing.

Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. *PNAS*, *105*(7), 2301–2306.

Demos & Pi. (2019). *Rapporto tra gli Italiani e lo Stato - 2019*. Vicenza.

Departamento Administrativo de Gestión del Riesgo de Desastres (DAGRD), & Universidad EAFIT. (2016). *PLAN MUNICIPAL DE GESTIÓN DEL RIESGO DE DESASTRES MEDELLÍN 2015 – 2030. COMPONENTE I*. Medellin: Alcaldía de Medellín y Universidad EAFIT. Retrieved from http://salgar-antioquia.gov.co/apc-aa-files/32373762643634663436653161653634/plan-municipal-de-gestin-del-riesgo-de-desastres-salgar_final.pdf

EDU. (2014). Jardín Circunvalar de Medellín es reconocido como buena práctica para enfrentar el cambio climático en Colombia. Retrieved January 15, 2020, from https://cinturonverde.wordpress.com/2015/05/29/jardin-circunvalar-de-medellin-es-reconocido-como-buena-practica-para-enfrentar-el-cambio-climatico-en-colombia

EDU. (2015). Jardín Circunvalar de Medellín: ¿En que consiste el proyecto? Retrieved April 14, 2020, from https://cinturonverde.wordpress.com/about/

EDU. (2016). Medellín gana premio equivalente al " Nobel de urbanismo": El Colombiano. Retrieved February 23, 2020, from https://cinturonverde.wordpress.com/2016/03/18/medellin-gana-premio-equivalente-al-nobel-de-urbanismo-el-colombiano/

EEA. (2016). *Urban adaptation to climate change in Europe 2016. Transforming cities in a changing climate*. https://doi.org/10.2800/41895

Ellis, C. (2014). *Small scale / Global ambition. Strategies of architectural production and global urban competitiveness in Medellin, Colombia*. Columbia University.

Estrada Gil, L. M. (2012). *El parque barrial en la planeación y configuración urbana de Medellín*. Universidad

Nacional de Colombia, Sede Medellin. Retrieved from http://www.bdigital.unal.edu.co/6618/

Estrada Ramirez, S. (2020). Coronavirus: Villa Hermosa es el nuevo foco de contagios en Medellín. Retrieved June 30, 1BC, from https://caracol.com.co/emisora/2020/06/29/medellin/1593454184_884775.html

Faivre, N., Sgobbi, A., Happaerts, S., Raynal, J., & Schmidt, L. (2018). Translating the Sendai Framework into action: The EU approach to ecosystem-based disaster risk reduction. *International Journal of Disaster Risk Reduction*, *32*(December 2017), 4–10. https://doi.org/10.1016/j.ijdrr.2017.12.015

FAO (Food and Agriculture Organization of the United Nations). (2008). *Climate Change and Food Security: A Framework Document*. Rome.

Flatø, M., Muttarak, R., & Pelser, A. (2017). Women, Weather, and Woes: The Triangular Dynamics of Female-Headed Households, Economic Vulnerability, and Climate Variability in South Africa. *World Development*, *90*, 41–62. https://doi.org/10.1016/j.worlddev.2016.08.015

Ford, J. D., Berrang-Ford, L., Bunce, A., McKay, C., Irwin, M., & Pearce, T. (2015). The status of climate change adaptation in Africa and Asia. *Regional Environmental Change*, *15*(5), 801–814. https://doi.org/10.1007/s10113-014-0648-2

Ford, J. D., Berrang-Ford, L., & Paterson, J. (2011). A systematic review of observed climate change adaptation in developed nations. *Climatic Change*, *106*(2), 327–336. https://doi.org/10.1007/s10584-011-0045-5

Frankenberg, E., Sikoki, B., Sumantri, C., Suriastini, W., & Thomas, D. (2013). Education, vulnerability, and resilience after a natural disaster. *Ecology and Society*, *18*(2). https://doi.org/10.5751/ES-05377-180216

Fraser, N. (2008). From redistribution to recognition? Dilemmas of justice in a 'post-Socialist' age. In K. Olson (Ed.), *Adding Insult to Injury: Nancy Fraser Debates Her Critics*. London: Verso Press.

Garcia Ferrari, S., Smith, H., Coupe, F., & Rivera, H. (2018). City profile: Medellin. *Cities*, *74*(January), 354–364. https://doi.org/10.1016/j.cities.2017.12.011

Glassman, A. L., Escobar, M.-L., Giuffrida, A., & Giedion, U. (2009). *From Few to Many. Ten Years of Health Insurance Expansions in Colombia.* (A. L. Glassman, M.-L. Escobar, A. Giuffrida, & U. Giedion, Eds.). Washington, DC: Inter-American Development Bank; The Brookings Institution.

Greco, L., & Bagnardi, F. (2018). In the name of science and technology: The post-political environmental debate and the Taranto Steel Plant (Italy). *Environmental Values*, *27*(5), 489–512. https://doi.org/10.3197/096327118X15321668325939

Greiving, S., & Fleischhauer, M. (2012). National Climate Change Adaptation Strategies of European States from a Spatial Planning and Development Perspective. *European Planning Studies*, *20*(1), 27–48. https://doi.org/10.1080/09654313.2011.638493

Grisez Kweit, M., & Kweit, R. W. (2007). Participation, Perception of Participation, and Citizen Support. *American Politics Research*, *35*(3), 407–425. https://doi.org/10.1177/1532673X06296206

Grupo de Investigacion Ambiente Habitat y Sostenibilidad, Mesa de Vivienda Comuna 8, & Corporacion Montanoa. (2019). *Plan Comunitario de Conocimiento y Reduccion del Riesgo de Desastres, Barrio El Pacifico Comuna 8* (Vol. 53). Medellin: Colegio Mayor de Antioquia. https://doi.org/10.1017/CBO9781107415324.004

Gundersen, B. C., & Ziliak, J. P. (2015). Food Insecurity And Health Outcomes. *Health Affairs*, *34*(11), 1830–1839. https://doi.org/10.1377/hlthaff.2015.0645

Hernandez Palacio, F. (2012). Sprawl and Fragmentation. The Case of Medellin Region in Colombia. *TeMa, Journal of Land Use, Mobility and Environment*, *5*(1), 101–120.

Hoffmann, R., & Blecha, D. (2020). Education and disaster vulnerability in Southeast Asia: Evidence and policy implications. *Sustainability (Switzerland)*, *12*(4), 1–17. https://doi.org/10.3390/su12041401

Huynh, L. T. M., & Stringer, L. C. (2018). Multi-scale assessment of social vulnerability to climate change: An empirical study in coastal Vietnam. *Climate Risk Management*, *20*(June 2017), 165–180. https://doi.org/10.1016/j.crm.2018.02.003

IPCC. (2013). Summary for Policymakers. In T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, … P. M. Midgley (Eds.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

IPCC. (2014a). Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]*. (pp. 117–140). Geneva, Switzerland.

IPCC. (2014b). Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. *Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of TheII Ntergovernmental Panel on Climate Change.*, (1–32), 2019.

Irazábal-Zurita, C., Barrows, L., Bu, L., Calvin, E., Krassner, A., Quinn, N., … Buchholz, T. A. N. (2013). *GROWTH MANAGEMENT IN MEDELLÍN, COLOMBIA*. Medellin and Bogotá.

Kashem, S. Bin, Wilson, B., & Van Zandt, S. (2016). Planning for Climate Adaptation: Evaluating the Changing Patterns of Social Vulnerability and Adaptation Challenges in Three Coastal Cities. *Journal of Planning Education and Research*, *36*(3), 304–318. https://doi.org/10.1177/0739456X16645167

Katic, K. (2017). *Social Vulnerability Assessment Tools for Climate Change and DRR Programming*. (D. Tomanovic, Ed.). United Nations Development Programme. Retrieved from https://www.adaptation-undp.org/sites/default/files/resources/social_vulnerability05102017_0.pdf

Kenton, W. (2019). Reading into Dependency Ratio. Retrieved December 14, 2019, from https://www.investopedia.com/terms/d/dependencyratio.asp

Klasen, S., Lechtenfeld, T., & Povel, F. (2011). *What about the Women? Female Headship, Poverty and Vulnerability in Thailand and Vietnam* ('Poverty, Equity and Growth in Developing and Transition Countries: Statistical Methods and Empirical Analysis' No. 76). Goettingen.

Lawrence, R. J. (2002). Inequalities in urban areas: Innovative approaches to complex issues. *Scandinavian Journal of Public Health*, *30*(59_suppl), 34–40. https://doi.org/10.1177/14034948020300030601

Leeuw, F., & Vaessen, J. (2009). Address the attribution problem. In *Impact Evaluations and Development. NONIE Guidance on Impact Evaluations* (pp. 21–34). Washington: NONIE - The Network of Networks on Impact Evaluation. World Bank.

Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-ford, L., Maillet, M., Araos, M., … Austin, S. E. (2017). What does the Paris Agreement mean for adaptation? *Climate Policy*, *17*(7), 825–831.

https://doi.org/10.1080/14693062.2016.1248889

Magnan, A. (2014). Avoiding maladaptation to climate change: towards guiding principles. *Surveys and Perspectives Integrating Environment and Society*, *7*(1). Retrieved from https://journals.openedition.org/sapiens/1680%0A

Magnan, A., Schipper, E., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., … Ziervogel, G. (2016). Addressing the risk of maladaptation to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *7*(5), 646–665. https://doi.org/10.1002/wcc.409

Marzi, S., Mysiak, J., Essenfelder, A. H., Amadio, M., Giove, S., & Fekete, A. (2019). Constructing a comprehensive disaster resilience index: The case of Italy. *Plos One*, *14*(9), e0221585. https://doi.org/10.1371/journal.pone.0221585

Mavhura, E., Manyena, B., & Collins, A. E. (2017). An approach for measuring social vulnerability in context: The case of flood hazards in Muzarabani district, Zimbabwe. *Geoforum*, *86*(October), 103–117. https://doi.org/10.1016/j.geoforum.2017.09.008

Medellin Como Vamos. (2018). *A contribution to the quality private sector from the quality of life*. Medellin: Medellin Como Vamos.

Mesa Interbarriales De Desconectados. (2013). Comuna 8 votó por las propuestas comunitarias para el proyecto Cinturon Verde. Retrieved February 16, 2020, from https://mesainterbarrialdedesconectados.blogspot.com/2013/05/comuna-8-voto-por-las-propuestas.html

Mikulewicz, M. (2018). Politicizing vulnerability and adaptation: on the need to democratize local responses to climate impacts in developing countries. *Climate and Development*, *10*(1), 18–34. https://doi.org/10.1080/17565529.2017.1304887

Movimiento Laderas. (2018). *Escuela territorial de barrios de ladera*. Medellin: Corporacion Con-Vivaos, Mesa de Vivienda de la Comuna 8, Montanoa-A. Retrieved from https://issuu.com/movimientoladeras/docs/cartilla_etbl_issuu

Movimiento Laderas. (2020). *Propuestas para el plan de desarrollo de Medellin 2020 - 2023*. Medellin. Retrieved from https://issuu.com/movimientoladeras/docs/bolet_n_plan_de_desarrollo_2020-2023

Ncube-Phiri, S., Mundavanhu, C., & Mucherera, B. (2014). The complexity of maladaptation strategies to disasters: The case of Muzarabani, Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *6*(1), 1–11. https://doi.org/10.4102/jamba.v6i1.145

Olazabal, M., Galarraga, I., Ford, J., Sainz De Murieta, E., & Lesnikowski, A. (2019). Are local climate adaptation policies credible ? A conceptual and operational assessment framework. *International Journal of Urban Sustainable Development*, *11*(3), 277–296. https://doi.org/10.1080/19463138.2019.1583234

Overland, I., & Sovacool, B. K. (2020). The misallocation of climate research funding. *Energy Research & Social Science*, *62*(November 2019), 1–13. https://doi.org/10.1016/j.erss.2019.101349

Pacione, M. (2001). *Urban Geography. A Global Perspective. Urban Geography*. London and New York: Routledge.

Pérez-Muñoz, C. (2016). *Análisis de vulnerabilidad y planes de adaptación urbana para la reducción de los efectos del cambio climatico en Medellín*. Universidad Nacional de Colombia, Medellin. Retrieved from http://www.bdigital.unal.edu.co/55086/

Pérez-Muñoz, C., Brand, P. C., & Agudelo, L. C. (2017). Planes de acción de adaptación urbana y análisis de vulnerabilidad para Medellín: una propuesta para reducir los efectos del cambio climático desde la planificación territorial. *Gestión y Ambiente*, *20*(2), 155–166.

Perfetti del Corral, M. V. (1995). *Las transformaciones de la estructura urbana de Medellín. La colonia, el ensanche y el plan regulador*. ESCUELA TÉCNICA SUPERIOR DE ARQUITECTURA DE MADRID. Retrieved from http://oa.upm.es/13745/1/transformacionesurbanasmedellin.pdf

Phillips, T. (2019, December 31). Latin America's tumultuous year turns expectations on their head. *The Guardian*. Retrieved from https://www.theguardian.com/world/2019/dec/30/latin-america-tumultuous-year-2019

Pietrapertosa, F., Salvia, M., De Gregorio Hurtado, S., D'Alonzo, V., Church, J. M., Geneletti, D., … Reckien, D. (2018). Urban climate change mitigation and adaptation planning: Are Italian cities ready? *Cities*, (November), 1–13. https://doi.org/10.1016/j.cities.2018.11.009

Preston, I., Banks, N., Hargreaves, K., Kazmierczak, A., Lucas, K., Mayne, R., … Street, R. (2014). *CLIMATE CHANGE AND SOCIAL JUSTICE: AN EVIDENCE REVIEW*.

Radinger, T., Echazarra, A., Guerrero, G., & Valenzuela, J. P. (2018). School education in Colombia. In *OECD Reviews of School Resources: Colombia 2018* (pp. 35–79). Paris: OECD Publishing. https://doi.org/https://doi.org/10.1787/9789264303751-en

Rawls, J. (1971). *A Theory of Justice*. Cambridge, MA: Harvard University Press.

Reckien, D. (2018). What is in an index? Construction method, data metric, and weighting scheme determine the outcome of composite social vulnerability indices in New York City. *Regional Environmental Change*, *18*(5), 1439–1451. https://doi.org/10.1007/s10113-017-1273-7

Reckien, D., Lwasa, S., Satterthwaite, D., McEvoy, D., Creutzig, F., Montgomery, M., … Khan, I. (2018). Equity, Environmental Justice, and Urban Climate Change. In C. Rosenszweig, W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, & S. Ali Ibrahim (Eds.), *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network* (pp. 173–224). New York: Cambridge University Press.

Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., De Gregorio-Hurtado, S., … Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, *191*, 207–219. https://doi.org/10.1016/j.jclepro.2018.03.220

Ribot, J. (2010). Vulnerability does not just Fall from the Sky: Toward Multi-scale Pro-poor Climate Policy. In *Social Dimensions of Cimate Change: Equity and Vulnerability in a Warming World* (pp. 47–74).

Ribot, J. (2011). Vulnerability before adaptation: Toward transformative climate action. *Global Environmental Change*, *21*(4), 1160–1162. https://doi.org/10.1016/j.gloenvcha.2011.07.008

Saisana, M., Saltelli, A., & Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of the Royal Statistical Society, Series A (Statistics in Society)*, *168*(2), 307–323.

Sanchez Mojica, B. E. (2013). A City Torn Apart: Forced Displacement in Medellín. *International Law*, *22*(January-June), 179–210. Retrieved from http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S1692-81562013000100007&lng=en&tlng=en.

Sassen, S. (1991). *The Global City: New York, London, Tokyo*. Princeton, NJ: Princeton University Press. Retrieved from https://www.jstor.org/stable/j.ctt2jc93q

Schnitter Castellanos, P. (2004). Wiener and Sert's pilot plan for Medellín. Contract and presentation. Colombian Urban Planning and its vicissitudes (p. 12). 11th Conference of the International Planning History Society. Barcelona. Retrieved from http://www.etsav.upc.es/personals/iphs2004/pdf/194_p.pdf

Sen, A. (1992). *Inequality Re-Examined*. Oxford: Calendon Press.

Sherman, M. H., & Ford, J. (2014). Stakeholder engagement in adaptation interventions: An evaluation of projects in developing nations. *Climate Policy*, *14*(3), 417–441. https://doi.org/10.1080/14693062.2014.859501

Shi, L., Chu, E., Anguelovski, I., Aylett, A., Debats, J., Goh, K., … Van Deveer, S. D. (2016). Roadmap towards justice in urban climate adaptation research. *Nature Climate Change*, *6*(2), 131–137. https://doi.org/10.1038/nclimate2841

Shifter, M. (2020, January 21). The Rebellion Against the Elites in Latin America. *New York Times*. Retrieved from https://www.nytimes.com/2020/01/21/opinion/international-world/latin-america-elites-protests.html

Shirley, W. L., Cutter, S. L., & Boruff, B. J. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, *84*(2), 242–261.

Smith, H., Coupe, F., Medero, G. M., Acosta, J. H. C., Garcia-Ferrari, S., Montoya, C., … Rivera, H. (2018). *Resilience or Resistance? Negotiated Mitigation of Landslide Risks in Informal Settlements in Medellin*. Medellin.

Sotomayor, L. (2015). Equitable planning through territories of exception: the contours of Medellin's urban development projects. *International Development Planning Review*, *37*(4), 373–397. https://doi.org/10.3828/idpr.2015.23

Tate, E. (2012). Social vulnerability indices: A comparative assessment using uncertainty and sensitivity analysis. *Natural Hazards*, *63*(2), 325–347. https://doi.org/10.1007/s11069-012-0152-2

The Economist. (2020a). America's census looks out of date in the age of big data. Retrieved February 4, 2020, from https://www.economist.com/international/2020/01/20/americas-census-looks-out-of-date-in-the-age-of-big-data

The Economist. (2020b, June). Medellin's medical marvel. Retrieved June 15, 2020, from https://www.economist.com/the-americas/2020/06/04/how-colombias-second-largest-city-is-controlling-the-pandemic

Thomas, K., Hardy, R. D., Lazrus, H., Mendez, M., Orlove, B., Rivera-Collazo, I., … Winthrop, R. (2019). Explaining differential vulnerability to climate change: A social science review. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(2), 1–18. https://doi.org/10.1002/wcc.565

Thomas, V., & Lopez, R. (2015). *Global Increase in Climate-Related Disasters*. *ADB Economics Working Paper Series* (Vol. 466).

Thomson, D. R., Kuffer, M., Boo, G., Hati, B., Grippa, T., Elsey, H., … Sliuzas, R. (2020). Need for an Integrated Deprived Area "Slum" Mapping System (IDEAMAPS) in Low- and Middle-Income Countries (LMICs). *Social Sciences*, *9*(80), 17. https://doi.org/doi:10.3390/socsci9050080

UN-HABITAT. (2010). *Encuesta de Calidad de Vida Medellín 2008*. Medellin.

UN. (2016). *Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction* (Vol. A/71/644).

United Nations. (2017). Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313), Annex (6 July 2017), *11371*(July), 25. Retrieved from http://ggim.un.org/documents/A_RES_71_313.pdf

United Nations International Office for Disaster Risk Reduction (UNISDR). (2009). *Terminology on Disaster Risk Reduction*. Geneva, Switzerland: United Nations International Strategy for Disaster Risk Reduction.

Urán, O. (2010). Medellin: Participatory Creativity in a Conflictive City. In *Participation and democracy in the twenty-first century city* (pp. 127–153).

Van Asselt, M. B. A., & Renn, O. (2011). Risk governance. *Journal of Risk Research*, *14*(4), 431–449. https://doi.org/10.1080/13669877.2011.553730

Velásquez, C. (2013). *Diagnóstico y propuestas comunitarias para el mejoramiento integral del barrio, El Faro, comuna 8 Medellín*. Medellín. https://doi.org/10.21500/16578031.75

Vlugt, M. (2018). *Escaping from the crisis: A qualitative assessment of integration amongst the Venezuelan migrant population of Medellín, Colombia.* University of Utrecht.

Yoon, D. K. (2012). Assessment of social vulnerability to natural disasters: A comparative study. *Natural Hazards*, *63*(2), 823–843. https://doi.org/10.1007/s11069-012-0189-2