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A Qualitative Comparative Analysis of local climate action across municipalities in Southern and Eastern Europe

Master Thesis – Integrated Natural Resource Management (M.Sc.)

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Summary

Cities and local administrations are increasingly showing their ambitions to tackle climate change. They are crucial actors to implement the Paris Agreement and strive for a sustainable future. Scientific research has established a vast body of literature about urban climate action in metropolitan areas and innovative cities. In this thesis I explore the activities of small- and medium-sized municipalities to increase the understanding on how they implement climate action and especially what conditions might support them in their efforts. The objective is to create awareness for local climate action in Eastern and Southern European countries and smaller cities, as these have not been in the spotlight of research yet. To find common patterns of enabling conditions for local climate action fuzzy-set Qualitative Comparative Analysis is a helpful method to find combined solution pathways. 25 municipalities from the countries of Czech Republic, Greece, Poland, Portugal and Romania are combined as a dataset and analysed for their local climate actions and possible conditions supporting them. These municipalities are diverse in their size, distribution and sociodemographic situation as well as their current climate activities. Results show that the size of a municipality is not the sole limiting factor but that local parties or joining transnational networks can facilitate the implementation of climate action on the local level. The interplay of several conditions like the national climate policy, local parties supporting climate action or transnational networks combined are enabling municipalities to prioritize activities for climate action. Therefore, the finding suggests a well-aligned multi-level climate governance system can facilitate better climate action on the local level.

List of abbreviations

BMU	Federal Ministry for Environment, Nature Conservation and Nuclear Safety Germany (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit)
C40	Cities Climate Leadership Group
CCPI	Climate Change Performance Index
CEE	Central and Eastern European countries (refers to Visegrad states, Baltics and part of Balkan countries – formerly Eastern bloc members)
CEMR	Council of European Municipalities and Regions
CoM	Covenant of Mayors
CO_2	Carbon dioxide
COP	Conference of the Parties (UN Climate Change conferences)
CoR	Committee of the Regions
EC	European Commission
EEA	European Environmental Agency
ETS	Emissions Trading System
EU	European Union
EUKI	European Climate Initiative
ESR	Effort Sharing Regulation
FfF	Fridays for Future
fsQCA	Fuzzy-set QCA
GGCA	Galvanizing the groundswell of climate action
GHG	Greenhouse gas emissions (climate gases like carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and ozone)
GNI	Gross national income
ICLEI	Local Governments for Sustainability (formerly: International Council for Local Environmental Initiatives)
INUS	Insufficient, but necessary part of an unnecessary but sufficient condition
IPCC	Intergovernmental Panel on Climate Change
NECP	National energy and climate plan
NDC	National Determined Contribution
NGO	Nongovernmental organization

NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PiS	Law and Justice Party Poland (*Prawo i Sprawiedliwość)*
PRI	Proportional Reduction in Inconsistency
QCA	Qualitative Comparative Analysis
RoN	Relevance of Necessity
RWP	Right-wing-populist (party)
SDG	Sustainable development goal(s)
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom
US	United States

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1. Introduction

Climate change is one of the major challenges for humankind in the 21st century. Both the impacts of a changing climate above 2°C and solutions for low-emission pathways are well established. The proclaimed goal of the European Union (EU) is to reach climate neutrality, meaning net-zero greenhouse gas (GHG) emissions by 2050 (European Commission 2018). Although measures and tools are at hand theoretically, implementation of adequate mechanisms are missing. National goals for 2030 will probably not be reached in terms of emission reduction, as climate policies and regulations are not ambitious enough. Counterbalancing this trend of national governments, cities and to some extent also regions are taking on to pledge and implement ambitious climate policies and local climate action. The thesis will analyse such climate action on the local level in Eastern and Southern Europe and explore conditions, under which also smaller cities and municipalities can contribute to climate change mitigation.

1.1. Background

The Paris Agreement of 2015 was an important milestone in global climate policy and raised high hopes for a sustainable future. Until December 2019, 187 nations have ratified the Agreement to stay "well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C" (UNFCCC 2015). Already four years later, mechanisms like National Determined Contributions (NDCs), commitments and pledges seem not to be effective. Despite the increased awareness and official actions, global emissions are still rising. Cities bring new hope as they prove themselves as strong actors who are increasingly pledging ambitious emission targets. However, besides the big innovation hubs like Copenhagen, Berlin or New York, also small- and medium-sized cities wish to contribute to the mitigation process.

After the Rio Conference in 1992, so called transnational climate networks between local entities have been growing tremendously (Lee 2019). Among them the most prominent are C40, ICLEI or the Covenant of Mayors (CoM). The networks tend to foster collaboration, networking and learning between cities, but usually only the sustainability pioneers benefit from the networks. Especially C40 cities are a network of very active and bigger cities. Smaller towns especially in economically weaker

countries, seem to be neglected (Finn und McCormick 2011; Heikkinen et al. 2018; Shefer 2018; Watts 2017).

1.2. Problem statement

Cities are part of the solution and the problem at the same time. Up to 80 percent of energy is demanded from cities, a boom in building construction as well as congested streets and increased individual consumption majorly contribute to GHG emissions (OECD 2010). At the same time cities, especially large metropolitan areas are pressured to solve local impacts of climate change like urban heat island effect, bad air quality and health hazards. The peculiar situation of local level climate actions followed by a rise of transnational municipal networks in contrast to unambitious mitigation commitments at national level triggers questions on alternative solution for a wicked problem like climate change mitigation: How is the local level aligned with national commitments? What if national commitments are low? Why does the local level engage in climate policy, although not obliged to participate in this collective action problem, where they could just free-ride? How are smaller cities responding to climate action and how can they be supported in their engagement?

1.3. State of the art – why are cities important for climate change mitigation?

The literature on climate change in cities and local climate action is increasing steadily. While I will outline the most important scientific debates here, a deeper analysis of current literature is presented in *Chapter 2*.

Already the Brundtland report 1987 and the Rio conference in 1992 mention cities as an important arena to address the issue of global warming and limit climate change. Since then, many scholars (Bulkeley and Betsill 2005; Bulkeley and Castán Broto 2013; Cole 2015; Jordan et al. 2018; Ostrom 2009; Reckien et al. 2018; Rosenzweig et al. 2010) have pointed out the importance of none-state actors such as cities and regions, while national governments hardly recognize the potential of multi-level climate alignment for their NDCs (Hsu et al. 2019; 2019). A literature review by Lamb et al. (2019) has identified more than 4,000 case studies on local climate change mitigation and concluded that more structural scientific assessments are necessary to grasp the potential of urban local bodies. They call for a more systemized way to construct effective and evidence-based urban climate policies by leaving no city behind. Especially when small and medium-sized cities are underrepresented in case studies,

this gap needs to be closed, followed by a process of capacity building for those local entities beside the major metropolitan areas (Lamb et al. 2019).

The ideas of a polycentric governance system augment the climate governance debate to a more diverse view on the role of cities. Bulkeley and Betsill's book "Cities and Climate Change" (2003), Hughes et al. (2018) contribution on multi-level climate governance "Climate Change in Cities" or "Governing Climate Change" by Jordan et al. (2018) only represent parts of the debate on how to best integrate the local level to a global commons problem. Acuto and Parnell (2016) introduce the idea of *leaving no city behind* and institutionalizing local authorities within the existing climate governance regime as "IPCC for cities" (ebd.).

This already points to the brisk scientific debate that has emerged over the last years. Cities are seen as key actors and literature tries to identify why, how and under what circumstances they create meaningful climate policies and what could be further steps to manifest those actions for the future. A first take away from science debates is that the real challenge of the climate crisis is not a technical one – because in theory, we know what to do and not to do, but manifests itself to become the global social question of the 21st century.

1.4. Research objective

The challenges of solving a global climate crisis have been explored. It is crucial now to determine working mechanisms and new forms of cooperation to foster climate change mitigation. The objective of this thesis is to follow a "leave no city behind" approach (Acuto and Parnell 2016) and especially address small- and medium sized municipalities in countries which have seen some kind of crisis or change of political system, namely the five European countries Czech Republic, Greece, Poland, Portugal and Romania. While first thoughts might be that climate change mitigation at the local level is not a priority for municipalities, there are examples that show the contrary and bear hope, that efforts are taken up by local actors to foster mitigation efforts inside the society. I would like to shed light on the activities of smaller cities to understand, how they implement climate action and especially what factors might support them in their efforts and which ones hinder them.

Often, small cities not only lack financial, but also human resources and might not be known for being especially innovative and sustainable. They are less connected to

global networks (as well as their citizens are rather locals than jetsetters). Furthermore, their national governments might not have elaborated climate change policies or emission reduction schemes in place. To my current knowledge, no research (in English) has been done to analyse this group of cities, which also is due to a research bias and selectivity in only looking at pioneers and well-documented cases.

Homsy (2018) focused on small cities and "unlikely pioneers" - municipalities that would not appear to be active in climate change mitigation from a regular statistical perspective, but proven to be pioneers among their fellow municipalities. He pointed out the importance of citizen action, strong leadership and setting up a narrative of positive elements of climate mitigation measures such as saving money from electricity. I would like to build on this positive narrative and include small- and medium-sized municipalities in the greater picture to value their efforts and find solutions to reach many more municipalities.

With a complex problem like climate change mitigation it has been established that there is not one way of achieving goals, but different mechanisms, adapted to the local reality, might work effectively. I chose to look at four structural conditions (size, national climate policy, participation in transnational network and local parties in council), which might influence how they implement climate action and which level of experience they have. Therefore, my research questions are:

- *How is the status of municipalities in Southern and Eastern Europe in terms of climate action?*
- *What are enabling conditions for successful local climate action?*

Concrete propositions are introduced in *Chapter 4*, when the setting and dataset is explained. The research objective is to get a deeper understanding of enabling mechanisms to employ for these smaller cities and develop well-aligned policies in a multi-level climate governance framework in these countries. Secondly, also scientific focus should shift from the pioneering cities towards the smaller but still ambitious entities, which need more support as they might lack financial resources or knowledge capacity to contribute to a just and sustainable future.

To do this, I chose Qualitative Comparative Analysis (QCA) as the research method because it provides good mechanisms to research about multiple factors and establish more than one solution to lead to an outcome. It is a good tool and research technique to establish patterns from a mid-size dataset and find common drivers without neglecting case relevant data, both qualitative and quantitative. Elaborating a dataset of 25 municipalities can be a first step to broaden the scope of current scientific debates about local climate action and design further research into this direction.

1.5. Summary and structure of the thesis

Cities have become key actors in climate policy. Climate action is not explicitly reserved for bigger cities, but also implemented in small- and medium-sized municipalities. Those might need more and different support than innovative urban learning labs. Finding a supportive framework for those municipalities can help to take everyone on board for a just and sustainable future.

To embed the analysis for those municipalities across European countries, in *Chapter 2* the concepts of Polycentricity and Multi-level Governance are specified as well as terms like *municipality* differentiated from *city*. Since the last decade, climate action at the local level has become a popular research topic. A literature analysis provides the relevant scientific context, including biases and gaps in research.

More details on the five countries of analysis – Czech Republic, Greece, Poland, Portugal and Romania- are provided in *Chapter 3*, followed by a description of the dataset of 25 municipalities. The dataset shows a diverse set of municipalities ranging in size, distribution but also socioeconomic factors like unemployment rates or parties. The level of experience with climate action varies from some pioneers to motivated beginners.

The method of QCA was chosen due to its novel approach of conjunctural causation and equifinality. I found several advantages of doing a QCA in this context:

- First, it is a method which can bridge qualitative and quantitative work. QCA provides space to examine combinations of conditions, rather than pure correlations, which might be important for local climate action. It works especially well for mid-sized N (Schneider und Wagemann 2010a).

- A further advantage is the iterative character of QCA. While I will gather data information in a first desk-based literature and official document analysis, these findings might be revised in a later interview as outdated for example. “[C]onditions do not compete against each other in a race for explaining more of the variation in an outcome” (Schneider und Wagemann 2010a, 382). This aspect makes QCA especially interesting for the analysis of multi-level and polycentric approaches, where no one silver bullet is the solution, but different aspects can lead to a satisfying result (Cole 2015). The term fuzzy-set to QCA implies a non-binary element setting.

It is explained in *Chapter 4* as well as the concrete data collection and calibration process to build a dataset with informative conditions.

The further steps of the analytical moment of the QCA reveal the truth table and the solution formula after the minimization process in *Chapter 5*. Results show that the size of a municipality is not the sole limiting factor but that local parties or joining transnational networks can facilitate the implementation of climate action.

These and further results as well as the limits of the analysis are discussed and evaluated in *Chapter 6*. Research and policy should draw more attention to small- and medium-sized municipalities to take them on board and support their actions.

2. Setting the scene: current debates and issues of local climate action

This chapter provides a crisp overview of the most important terms, the theoretical concepts of polycentricity and multi-level climate governance, and the scientific discussion about the role of local authorities in climate politics. Although it is widely recognized that the local level plays an important role in combating climate change, it is considered a non-state actor in international climate negotiations.

2.1. Objectives of the chapter

Setting the scene and defining relevant terms is at the core of this chapter. Knowing scientific debates and bringing the analysis in the broader context is important for a refined research question and comparable analysis. More precisely, the aims are to:

- **Clarify important terms** like *local climate action* and the different perspectives of *city*, *town* and *municipality* to better understand the context of the analysis. When dealing with complex phenomena in human-environmental interactions, a fine-grained understanding is necessary to be able to compare with existing research.

- **Lay down the concepts** of *polycentricity* and *multi-level governance* and explore the relation between those two. The idea of power sharing between different levels of governance is important for both concepts, but the degree of sovereignty and responsibility on the local level is more important for polycentricity. On the other hand, in multi-level governance, smooth vertical and horizontal alignment is the focus.

- **Embed the analysis in the scientific context** and provide a good understanding of the available knowledge. Scientific interest for local climate action and possible ways to combat climate change beyond national or international agreements is rising. The literature review contributes insights into current debates and the state of the art of local climate action research.

2.2. Clarification of terms

Many terms are frequently used in local climate action research, though few common definitions exist. Different understandings of one term co-exist and are often interchanged inadvertently. To avoid misunderstandings and provide a workable and comparable thesis, the most common terms are explained.

Local climate action

The term local climate action is used frequently to describe responses to climate change. Before I define the local, let me begin by analysing the later part of the term. Clearly action is required in order to respond to climate change, and often this action is outlined by multi-national agreements such as the Paris Agreement and the Sustainable Development Goals (SDG). The goal of the Paris Agreement is to limit global warming to 1.5°C or maximum 2°C (IPCC 2018). The 17 SDGs provide the framework to reach this goal, combining climate change action with measures for social equity and the eradication of global poverty.

Specifically, SDG 13 is focused on climate action: "stepped-up efforts to reduce greenhouse gas emissions and strengthen resilience and adaptive capacity to climate-induced impacts" (UNDP 2020). The targets for SDG 13 include strengthening resilience efforts, integrating measures against climate change into national policies, improving education and awareness about climate change and implementing the Paris Agreement (Sustainable Development Goals Knowledge Platform 2020). Indeed, since the Paris Agreement was signed many countries have pledged to achieve the 1.5°C goal.

While SDG 13 mostly addresses national governments, nonstate actors increasingly are included in climate action. For example, the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) deems every individual capable of contributing to climate action activities (BMU 2020). To stress the engagement of non-state actors, the group "Galvanizing the groundswell of climate action" (GGCA) was formed at the COP 20 in Lima in 2014 to widen the frame for climate diplomacy (Bäckstrand et al. 2017). The climate groundswell defines climate action as "any policy, measure, or program that reduces greenhouse gases, builds resilience to climate change, or supports and finances those goals" (GGCA 2020). This group explicitly stressed the wide scale of actors who can contribute to climate action; "ranging from cities

committing to more efficient building standards, companies putting a price on carbon in their investment decisions, or a coalition of companies and farmers' groups" (ibid.).

Subnational and local actors have implemented climate actions for decades, but awareness of their importance in the climate diplomacy sphere has only been recognized in the last few years. The 20th Conference of the Parties (COP) in Lima offered a unique opportunity to re-structure the international climate regime (Hale 2016). The Intergovernmental Panel on Climate Change (IPCC) has even named urban areas as one of the four critical systems that can accelerate the necessary steps to reach the 1.5°C goal (Bazaz et al. 2018).

The question remains, however, of who exactly should be involved in climate action, as every human being and organization in inextricably tied to the climate and natural systems. Over the years, cities have increasingly taken the responsibility to implement urban climate action, which encompasses mitigation, adaptation, sustainable mobility strategies and urban planning activities. However, the term "city" is rarely specified, which poses a challenge when differentiating between small cities and big cities – when is a city a city? The next section defines the "city," "urban area," "local government" and "municipality" in the context of local climate action.

Perspectives on the "city"

In the literature about climate action the term "city" is commonly used (Bulkeley and Betsill 2003; Bulkeley and Castán Broto 2013; Finn and McCormick 2011; Heikkinen, Ylä-Anttila, and Juhola 2018; Homsy 2018a; Hughes, Chu, and Mason 2018), though it is often very vaguely defined. Different perspectives exist and finding one agreed-upon definition is difficult.

Throughout Europe, different methods of defining a city exist: from population size and density, to medieval city rights and national policy funds for urban centres (Dijkstra and Poelman 2012). As a common European definition, the OECD and European Commission (EC) commonly define a city as "an urban centre of at least 50,000 inhabitants" (Dijkstra and Poelman 2012, 2). Further, cities usually contain an urban centre, a population density of 1,500 inhabitants/km² and municipalities inside the urban centre are part of the city (ibid.). Furthermore, the definition might also include a commuting zone, if many people live outside the pre-defined city zone but commute to

work inside the city on a daily basis. This understanding of a city as a larger human settlement is quite intuitive, however, it does not depict functions of local administrations as a city can encompass multiple local governments.

Following the argument of size and density, the next smaller category is a town, which was defined by the ESPON project TOWN as a human settlement between 5,000-50,000 inhabitants (ESPON 2014). The functional aspect that is again missing here is the administrative unit, which is not specified. Using the term "municipality" is then the political scientists' perspective of thinking in administrative entities, which both a town and city can have. According to the Cambridge dictionary, a municipality is "a city or town with its own local government, or the local government itself" (Cambridge dictionary, "municipality").

The term municipality is therefore used in this thesis to describe local government entities. It is the most fitting term because the dataset (explained in detail in *Chapters 3* and *4*) contains settlements from 7,000-120,000 inhabitants, which means that both towns and cities are included using the spatial definition above. The focus, however, lies in the political entity of a local government and how it implements climate action at the local level – not considering businesses or organizations. For the literature analysis I still use "city" because it is the most commonly used term in papers and articles. Most papers analyse bigger urban entities which are actually defined as cities in this context. But my analysis focuses on small- and medium-sized municipalities, which makes a distinction necessary.

2.3. Scientific concepts for local climate action

With an increasing understanding of the complexity and interdependencies of our world, finding appropriate solutions becomes more difficult. Climate change and related global warming is one of the most pressing collective action problems that requires immediate solutions. The question of how to govern climate change and assign responsibilities is hotly debated. Whereas multi-level governance suggests aligning different levels of government for joint coordinated and collaborative climate action, the concept of polycentricity abstains from a "one-size-fits-all" approach and favours solutions tailored to specific circumstances. These two concepts are explained now in detail.

A polycentric concept for local climate action

It is helpful to consider the climate as a common-pool resource, which are goods like the atmosphere, soil and water bodies that are (mostly) shared, challenging to make exclusive and difficult to manage (Ostrom 2009). On the other hand, climate change is a global public "bad," or a problem of collective action conventionally referred to in game theoretical terms like the "tragedy of the commons" (Hardin 1968) or the prisoner's dilemma, where people have a tendency to free-ride and lack motivation to cooperate. For a long time, climate governance was centred around the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, which was taken as a norm all signatory nation states had to follow and implement in a top-down style (Jordan et al. 2018). The term monocentric governance describes the situation where the state has control and decision-making power, usually on the national level (Termeer, Dewulf, and van Lieshout 2010).

Vincent Ostrom and the Bloomington School provided a new approach to address such problems using polycentric governance. At the core, the concept of polycentricity proposes multiple decision-making centres, which interact with each other and have a high degree of autonomy (Carlisle and Gruby 2019). Another central proposition of polycentricity is trust among actors, which increases the willingness to cooperate (Ostrom 2009). Trust and responsibility for action "can be more effectively undertaken in small- to medium-scale governance units" (Ostrom 2009, 39) so that the local government level is a central actor in polycentricity.

> *"Thinking polycentrically implies not accepting simple blueprints, but digging into details of institutional design and human behaviour" (Thiel, Blomquist, and Garrick 2019, 3).*

This line of thinking was influenced also by Elinor Ostrom´s idea of "going beyond panaceas" (Ostrom 2007). The term polycentric stems from the field of botany and found its way to political science and political economy with Ostrom, Tiebout, and Warren (1961), who explained metropolitan areas as "many centres of decision-making which are formally independent of each other" (ibid., 831). In a wider sense, polycentricity not only encompasses governmental actors but also private persons, organisations or companies. It is widely applied in water governance and natural resource management (Cole 2015; Pahl-Wostl and Knieper 2014).

The concept of polycentricity was developed as a descriptive tool, but over time evolved in a normative and positive theory and can be used as an analytical framework. Interest of how institutions work together and how individual actors play a role in the outcome motivate scholars to use the concept of polycentric governance (Thiel 2016). In research, polycentric governance as a term is often used when talking specifically about governance systems which "lack any uniquely designated final authority" (Stephan, Marshall, and McGinnis 2019, 26).

Elinor Ostrom´s approach was one that started at the bottom and she believed that it gradually would expand, which Jordan et al. (2018) see happening with more integration of non-state and subnational actors in international climate negotiations. It has since gained much attention and further research to what extent "government services are best provided at the lowest level of government" (Cole 2015) is sprouting. Mutual trust and learning are essential elements of a long-lasting approach. As Cole (2015) in a pre-Trump and pre-Brexit time verifies the hypothesis of polycentricity with the US-China Climate Change Working Group, these findings seem to be from a different era today. Nonetheless, through a variety of local actors and transnational networks, polycentric structures are visible today, although the aspect of hierarchy might need a new revision.

Discussion about overarching rules and which instance is responsible for them remain unsettled, as are the concepts of polycentricity. Unfortunately, Elinor Ostrom passed away before she could finish in-depth research on polycentric emission targets and their potential (Jordan et al. 2018). Fortunately, several critical junctures have enabled the evolution of a more polycentric climate governance system since Ostrom´s paper. The advantages of a polycentric governance system are that they allow for experimentation and learning, as well as a higher degree of direct participation and better accountability. Dominating actors and unclear responsibility can, however, weaken a polycentric system (Jordan et al. 2018).

Multi-level governance as support for local climate action

Multi-level governance is an action-oriented approach to share power in a more structured way, both vertically and horizontally. It is more complementary than contradictory to polycentric governance. Ostrom explicitly mentioned the interdependencies of multiple actors and government levels (Ostrom 2009), although

the distinction between a polycentric system and multi-level governance is a rather pragmatic one. Whereas the perspective of polycentricity stems from a normative theory approach, multi-level governance is promoted by a hands-on mentality to align different levels and actors onto one goal. From a geographical viewpoint, multi-level governance is especially popular in the context of the European Union whereas polycentric governance has its origin in the United States. Also multi-level governance rejects a top-down approach of governing, but the emphasis is less on the autonomy of actors than on joint coordination and a focus on government bodies (Wurzel, Liefferink, and Torney 2019).

Joint understandings and goals are important because "multilevel governance emphasizes the threefold displacement of state power and control" (Termeer, Dewulf, and van Lieshout 2010) between national, international and local government authorities as well as between civil society. The concept of multi-level governance stresses the interdependence of the various government (and also non-governmental) levels to reach the common goal of limiting global warming. Viewing the emergence of a polycentric climate governance system a bit more sceptically, scholars argue for more coordinated and collaborative climate action and clear responsibilities across all involved actors. This can enable upscaling of successful processes and lead to standardization, which in the polycentric setting is contradictory (Wurzel, Liefferink, and Torney 2019).

Multi-level climate governance therefore can be described as "the synergistic interplay between different levels of government, as well as between a variety of non-state actors, in governing climate action" (Bellali et al. 2018, 19). The window of opportunity was taken by local leaders – cities as well as companies – to increase their influence in the international climate regime and expand their presence during the COP 21. We can see a shift "away from the regulatory role towards one of enabling others to act" (Bulkeley and Betsill 2005, 56).

It is a common understanding now that the emission gap between current (national) policies and the 2°C goal can be closed if climate action is well-coordinated between different levels and sectors (Adriázola, Dellas, and Tänzler 2018; Hale 2016; IPCC 2018). The close interplay between national, regional and local governance level is interdependent, especially regarding financial capacity (Homsy and Warner 2012). Municipalities do not manoeuvre in an empty space but within the policy framework of

regional, national or European regulations. Competencies in infrastructure, mobility, housing or environment are shared or split between local, regional and national authorities. Municipalities cannot tackle issues of climate change on their own, as can the national level not achieve its goals without the engagement of regions and municipalities.

Further, working horizontally municipalities have the opportunity to learn and exchange experiences within a range of transnational climate networks. They also need to coordinate locally with e.g. water and power utility providers. This all leads to a multidimensional, intertwined system of climate governance (Hughes, Chu, and Mason 2018). As the number of engaged municipalities, networks of cities, companies and citizen movements is increasingly becoming confusing, scholars argue for a more structured process (Termeer, Dewulf, and van Lieshout 2010; Thiel, Blomquist, and Garrick 2019). One concern is purely one of structuring a coherent policy processes, but the more interesting question is the one of power and power sharing between levels and actors. It is expected that the influence of non-state actors in the UNFCCC will increase (Hale 2016).

Lee (2018) acknowledges the importance of multilevel governance systems. Especially for cross-geographical issues like renewable energy production, binding regulations and subsidies from (inter)national frameworks lead the way. The European Union is an important policy actor in this regard. Since the late 1980s the EU has been regulating GHG emissions and climate policies (Kemmerzell 2018). The 2008 Climate and Energy package, for example, was a significant step for a more sustainable European continent and included the establishment of the transnational network CoM. (Kemmerzell 2018).

There are several benefits when different levels are combined. Beyond compliance to regulations or showing good will, subsidy schemes are usually a good incentive to set up a specific project. Climate mitigation and adaptation usually is costly, so fiscal co-benefits and co-financing is at the core for higher governance levels to motivate local municipalities to join their mission (Kemmerzell 2018). The limited space of action from local governments often is disregarded but might be widened through experimenting with innovative solutions to climate change and integrating different actors (Bulkeley and Castán Broto 2013; Wolfram et al. 2018).

As municipalities have a strong vertical and horizontal link and are the entity closest to citizen, their role is vital in establishing well-working multi-level climate governance, this concept and the scholars working on both polycentricity and multi-level governance offer new ways of thinking beyond a monocentric, top-down approach.

2.4. State of the art – local climate action in literature

As has been stressed before, the local level plays an important role in climate action. Among the scientific community, there is a "new-found enthusiasm for the potential for urban responses to climate change" (Bulkeley and Castán Broto 2013). The available literature on urban climate action is increasing rapidly. Although climate change is a global challenge and negotiated internationally, i.e. with the Paris Agreement, cities are fostering their responsibilities for a sustainable future. They are said to be "crucial actors in climate change mitigation and adaptation" (Reckien et al. 2018).

The power and institutionalization of cities in climate change is increasing steadily. For example, in 2017 US-President Donald Trump announced a withdraw from the Paris Agreement, but many US cities responded by pledging their commitment to a 1.5° C goal, in what is called "America´s pledge" (Chow 2019). In spite of, or even because of the federal withdrawal from the Paris Agreement and a trend of reduced climate action by other cities, states, companies and organizations, these cities doubled up on their climate commitments (Bloomberg Philanthropies 2019). "[C]ities represent a beacon of hope for carbon reduction in politically tumultuous times" (Watts 2017).

The OECD sees cities as key actors to reduce climatic change as they "have significant opportunities to lead by example" (OECD 2010). Municipalities can function as the bridge between government and its citizen. They are the entity with close contact and knowledge of local perspectives, challenges and possible solutions. Local level activities for climate mitigation include switching the municipal car park to hybrid or electric vehicles, retrofitting of buildings, energy management activities, investing in sustainable energy production but also citizen engagement and information campaigns. It seems thus reasonable to expect cities to lead the change.

Urban areas globally currently host 50 percent of the world´s population and this urbanization trend is only increasing (ibid.). Most of the energy is consumed in urban settlements around the globe and accounts for a growing number of greenhouse gas emissions – estimates go as high as 71% of energy related emissions in urban areas

(Rosenzweig et al. 2010). On the other hand, urban areas are at times more vulnerable to climate change. Heat waves hit cities harder than rural areas and compacted soil and concrete aggravates flooding (OECD 2010). Therefore, efficient solutions for a low carbon city have to be found in order to limit the impacts of climate change (OECD 2010).

The existence of national level policies influences how local governments tackle climate change on the local level. Where national plans for adaption exist, it is more likely that such plans are also constructed at the local level (Heidrich et al. 2016). Conversely, where national policies are weak, networks to support the local government are more attractive for committed local leaders (Kemmerzell 2018).

As climate policy started with mitigation, many actors at the local level have implemented – or are currently working on- mitigation plans and to a lesser extent on adaptation (Araos et al. 2016; Heidrich et al. 2016; Hennessey et al. 2017; Kona et al. 2018; Lamb et al. 2019). While at first, this seems counter-intuitive because adaptation has a higher direct impact on the local level, mitigation measures often bring co-benefits like cost-reduction and reduced public spending (Hennessey et al. 2017). The Paris Agreement, the European Union or the national governments depend on the local level to implement appropriate actions to reduce emissions to aim for less than 2°C (Adriázola, Dellas, and Tänzler 2018). In turn, local governments need fitting instruments and national regulations to implement such actions.

If vertical alignment is not reaching out to the local level, the chances of effective climate action decrease (Hsu et al. 2019). Bulkeley and Betsill (2005) acknowledged the roles of local authorities as they have an incentive to improve liveability in their city. An important but undervalued co-benefit of climate policy is the impact for people´s well-being and health. Green spaces, good air quality and places for outdoor activity significantly improve the lives of citizens (Hiscock et al. 2017). Educated, internationally oriented and economically strong cities join climate networks more often (Lee 2018). This, in turn, implicates that those cities joining are already active in climate policy.

Nonetheless, Finn and McCormick (2011) found a lack of holistic approaches in climate action plans across major US cities. Combining climate policy with economic and social aspects is essential for the success of such plans. A more holistic view on local level

politics looks at the cross-cutting coalitions between state and non-state actors which can facilitate the sustainability transformation in a more polycentric setting (ibid.).

Many voluntary programmes have been set up to support committed local governments to pursue environmental and climate policy. However, the involvement of local governments seems not to be a relevant factor for a programme to be successful (van der Heijden 2018). Rather than that, institutional capacities and the structure of a local government influence how ambitious local climate action is. Surprisingly, the financial situation in the municipality only plays a secondary role. More important is the access to other sources, funds or grants (Homsy 2018b) or the allocation of budgets (Bae and Feiock 2012).

The role of mayors matters a great extent as to whether or not there is participation in transnational networks, study visits or consultations with foreign experts in East-and Central Europe (Baldersheim, Bucek, and Swianiewicz 2002). Already in 1997, only a couple of years after the end of the Cold War, mayors of Poland, Czech Republic and Slovakia drove European integration on the local level (Baldersheim, Bucek, and Swianiewicz 2002). If mayors are personally committed to climate action, they are likely to have a substantial impact even in a small municipality (Homsy 2018b).

There is a distinguishable difference between metropolitan cities and medium-sized municipalities in how they govern, especially when it comes to climate change (Homsy 2018b). Local democracy might be higher in smaller municipalities because communication between authorities and citizens is closer and more personal ties exist, but larger municipalities have more capacities. Especially for climate policy, the latter one is decisive (Gendzwill and Swianiewicz 2016). The communication of mitigation activities is determined by size and the motives behind climate action, which are as previously stated often financial co-benefits (Homsy 2018b).

Although many municipalities joined climate networks or have some goals to reduce energy consumption, implementation of the proposed plans remains a challenge (Heikkinen, Ylä-Anttila, and Juhola 2018; Kamenders, Rosa, and Kass 2017). Having a plan for emissions reduction like a Sustainable Energy Action Plan (SEAP) does not necessarily result in fewer emissions compared to municipalities without such plans (Azevedo, Horta, and Leal 2017). Lack of experienced technical staff, access to relevant tools or facilitation services are some of the main reasons why the implementation is

weak (Kamenders, Rosa, and Kass 2017). This points to a scientific challenge of how to properly analyse the local level engagement on paper vs reality – and much more in-depth analysis to find relevant factors of good local climate policy is still needed.

Besides national climate policies, transnational networks like C40, ICLEI (Local Governments for sustainability) and the Covenant (CoM) are a common practise on the local level to engage further in climate action (Lee 2018). The scientific interest in network participation of local actors has seen tremendous growth (e.g. Baldersheim, Bucek, and Swianiewicz (2002), Busch (2015), Roger, Hale, and Andonova (2016), Kamenders, Rosa, and Kass (2017), Heikkinen, Ylä-Anttila, and Juhola (2018), Kona et al. (2018), Melica et al. (2018), Lee (2018), Lee (2019) and more). Local authorities often use the power of networks to foster climate policy in the local agenda and get support (Heidrich et al. 2016; Reckien et al. 2018). Networks, sometimes referred to as transnational municipal networks, are described as "institutionalised spaces where local governments from different countries come together as equitable partners in an exchange on climate change related issues" (Busch 2015). Transnational networks of municipalities play a "growing role" (Kemmerzell 2018) for local climate action, but vertical integration is closely related to engagement in horizontal exchange.

Key ideas for transnational networks are a voluntary membership and focus on measures of implementation rather than lobbying and interest communication (ibid.). Furthermore, transnational networks can provide different functions for municipalities: As a platform networks facilitate horizontal knowledge and information exchange, e.g. through good-practise workshops. Some networks also provide consultancies and tools for municipalities on how to reach their reduction goals. Especially the Covenant can be seen as a network with an additional commitment function because signatories have to state their emission reduction goal with at least 20 percent until 2020. A smaller part of transnational networks actively pursue advocacy for municipalities at higher policy levels like the EU or international level (ibid.). Networks do not solely replace national policies but they complement each other (Roger, Hale, and Andonova 2016). Bridging the local with the international level, networks can facilitate vertical communication and alignment for better multi-level governance (Lee 2018). Access to funding and investment options to secure stable network participation are an important trigger for municipalities.

The "Covenant of Mayors serves as ancilliary factor for cities which are both active in multilevel governance structures and climate protection, even before becoming a member of the covenant" (Kemmerzell 2018).

The Covenant is somehow an exceptional institution as it was established by the European Union to reach EU goals at the local level. The network counts more than 9,000 signatories in September 2019 in 59 countries (CoM Website 2019). By becoming a signatory, the municipality commits formally to a GHG reduction goal of 20 percent by 2020 and at least 40 percent by 2030, which is in alignment with reduction targets of the EU. The CoM is an important network for small municipalities below 10,000 inhabitants. Those small municipalities often rely on the regional administrative level or other actors to get support with the baseline review and setting up strategy documents.

Membership requires a to develop a SEAP or now increasingly a SECAP (Sustainable Energy and Climate Action Plan) for 2030, which should be monitored every two years (Lee 2018). Participation does not initiate climate policy but fosters it in the administrative level. Lee (2018) found a positive correlation between network membership and employment in the municipality. However, in his later study in 2019 he found that mostly pioneers benefit from networks as they gain much attention and prestige (Lee 2019).

2.5. Biases and gaps of current literature on local climate action

The analysis has shown substantial interest in local climate action, urban networks as well as theoretical concepts of polycentricity and multilevel governance. However, the focus of current studies leaves several gaps to be filled.

A) Most of the studies conducted are looking at large cities

"Just 12% of the world's urban population lives in mega-cities, compared to 43% in small cities—yet both groups are treated almost equally in research, studied respectively in 23% and 19% of cases" (Lamb et al. 2019).

Studies on climate policy at the local level have brought insights into planning processes, reasons to join climate networks and raised multilevel governance challenges. However, current research does not grasp the disparity between large and

small cities and focusses on pioneers in local climate policy. The literature review by Lamb et al. (2019) analysed more than 4,000 case studies and papers, but from the municipalities analysed in this thesis, only one municipality has been subject to research so far. In all other countries, mainly bigger cities have been analysed according to their climate policies. As Lee (2018) points out, capital cities or economic hubs tend to be stronger in climate governance. They are more likely to join networks and have a highly educated population, who is well informed about the consequences of climate change. Put simply, their starting point is far different than smaller cities.

Small and medium-sized municipalities do have very different challenges than metropolitan areas: financial and human resources are limited, socioeconomic situation might be tense and citizens might therefore have a different focus of how local policy should be shaped (Homsy 2018b; Homsy and Warner 2012; Rosenzweig et al. 2010). Melica et al. (2018) focused as one of the few researchers on small municipalities below 10,000 inhabitants and stressed the need for multi-level governance cooperation when setting up a SECAP. Small municipalities can become and are willing to be more sustainable with support from the regional level (Melica et al. 2018).

B) More case studies on urban climate action are conducted in Western Europe

While Lamb et al. (2019) found 179 case studies from German cities, only nine were from Czechia and Romania, 21 from Poland, 25 from Greece and 50 from Portugal were included in the literature review dataset. There is a visible cut between Western Europe (France, Belgium, UK, Spain, Italy etc.) and Eastern Europe (Poland, Hungary, Romania, Bulgaria etc.). For local climate action, Kern (2019) stresses the need to research not only good examples like Copenhagen or Freiburg, but also contributions from smaller cities as well as cities lagging behind and how to support them.

From a global perspective, this bias is even more shifted to the Global North (Europe, North America and Oceania). This is disproportionate to the populations of African and Asian countries. Again case studies in small and medium-sized cities in these regions are almost non-existent although in those regions population growth is fastest and climate change impacts will probably be severe (Lamb et al. 2019). The idea of "leaving no one behind" is not yet reflected in current scientific literature about local climate action.

C) Data availability restricts comparative research

Araos et al. (2016), Kemmerzell (2018), Reckien et al. (2018) and Lee (2019) use data provided by official statistical offices like Eurostat and public documents available in English. To date, there is no EUROSTAT database for smaller entities below the NUTS III level. Apart from primary data collection via interviews and case studies, availability of data about local climate action is limited. The websites of networks provide insights to their members, but often are not regularly updated. Statistical offices from the respective countries or regions might provide information, often only in the national language, which can lead to a language barrier or loss of information during translation. Furthermore, if data is available, current papers mostly look at the planning side rather than monitoring of actual implementation (Homsy 2018a; Kona et al. 2018; Reckien et al. 2018; van der Heijden 2018). The data on how and which climate actions are implemented is even harder to access.

D) Comparative analysis needed to structure current local climate action

Although scientific interest for local climate action has been high during the last years, there have not been attempts to systemize knowledge from case studies. Lamb et al. (2019) propose creating a typology of actions to advance the learning process and develop new ways of thinking. van der Heijden et al. (2018) stress the "need for rigorous, critical, and systematic studies on the role of cities". QCA was introduced as one solution to a more holistic understanding (Kemmerzell 2018; Lamb et al. 2019; van der Heijden 2019).

2.6. Summary – what we know and don´t know from the literature

This chapter has set the scene on the state of research about local climate action, which helps in understanding the current debate. Terms like local climate action, polycentricity and multi-level governance were clarified, as well as the difference between city and municipality. Recent papers and issues of local climate action such as activities, networks and current scientific gaps have been identified. In order to gain a more holistic understanding of the myriad enabling and hindering conditions for climate action at the local level, I followed the scientific suggestions from Kemmerzell (2018), Homsy (2018b) and Lamb et al. (2019), who propose a fuzzy-set QCA and the study of

“unlikely pioneers” – less advanced, smaller municipalities (Homsy 2018b). The cases studied and their contexts are outlined next.

3. Case description

To make sense of the analysis, which is explained in detail in chapters four, five and six, it is necessary to embed it in the overarching context and provide a proper description of the cases. 25 municipalities were selected as they are all part of a project financed by the European Climate Initiative (EUKI) and show a level of willingness to create meaningful local climate actions. They are spread across five countries (Czech Republic, Greece, Poland, Portugal and Romania). Due to data privacy concerns the municipalities will remain anonymous. As I am interested in finding supportive conditions for local climate action, individual municipal analysis will not be the priority.

3.1. Objectives of the chapter

This chapter provides the necessary context of current climate policies and politics to understand the QCA explained in the following chapters. The goal of this chapter is to:

- **Describe relevant policies on a European and national level**. As the concept of multi-level governance suggests, the different governance levels are interdependent from each other. Therefore, it is crucial to gain an understanding of those relevant levels. European regulations determine to some extent how national governments manoeuvre in climate policy but also national governments influence European climate targets.

- **Point out different stances of national climate policies and current emission reduction ambitions.** Identifying the various perspectives of national governments on climate action reveals a first idea of the framework in which municipalities are implementing local climate actions.

- **Characterize the dataset in its most important descriptive features** and relevant information to make sense of the analysis. The description of characteristics provides the relevant knowledge of the data set for a more in-depth qualitative comparative analysis. In a QCA, although individual cases are not at the centre, a good understanding of the cases at stake leads to a greater power of explanations,

but also enables the reader to draw more sophisticated solutions. In the best case, it provides a more tailored approach for practical policy advice.

3.2. European climate policy – new hope or new facade?

Comparing municipalities from different European member states has several advantages and is a common practice to further develop cohesion policies inside the European Union. To gain a perspective of the local contexts a short overview of European level climate policy is provided. At the European level, climate policy has a relatively long history. Since the 1990s environmental and climate policies have been on the table in Brussels or Strasbourg. To limit global temperature to below 2°C was discussed in the EU environmental council in 1996 (Delbeke and Vis 2016). With the ratification of the *Kyoto Protocol* in 2002, the EU created a diverse set of climate policies, but it also was and remains entangled between multilateralism and global decisions at the UN level.

Looking at current debates and stalemate situations (such as migration policy), environmental and climate legislation is based on the concept of qualified majority, which provides more room for manoeuvre (Delbeke and Vis 2016). European GHG emissions decreased by 19 percent in all sectors (except transport) until 2014. With the *Emission Trading System* (ETS) the European Union has developed a core instrument for emission reduction as "the world's first major, and biggest, carbon market" (Schaller and Carius 2019, 4). Since 2005, the ETS covers emissions from the energy sector as well as energy-intensive industries. Non-ETS sectors are agriculture, transport, and also local level building and small sources of GHG emissions. For the high emissions from agriculture and buildings the *Efforts Sharing Regulation* (ESR) was adopted in 2017 as well as a further regulation on land use, land use change and forestry (Schaller and Carius 2019).

In 2007 the European Council committed to reducing 20 percent of GHG by 2020 independently, which was formally agreed upon as the *energy and climate package* in 2009 with the 20-20-20 goals by 2020: 20 percent reduction of GHG emission, 20 percent reduction of energy consumption and 20 percent of renewable energy (ibid.). The targets should be reached cost-effectively and are distributed to the member states considering their GDP. The *low carbon economy roadmap 2050* was introduced in 2011

as a long-term climate strategy on the European level with interim targets like 40 percent GHG reduction by 2030 and 60 percent by 2040.

A continuous tension exists between European climate and energy policy. While climate policies are being implemented quite successfully and accepted to be developed at the European level, energy policy in great parts remains in the hands of the national governments. The Energy Efficiency Directive 2012 offered a bundle of measures for increasing energy efficiency in buildings, supplying sustainable heat or energy and guided national governments for better energy policies. For 2030, this course slightly will be changed. The bouquet of policies on the European level seems to be increasing, but national forces are increasingly limiting the Unions achievements.

The European Environmental Agency (EEA) reported for 2017 a decrease of policies and measures in member states (2018), with the highest number of policies was seen in the momentum before the Paris Agreement in 2014. The role of the European Union in climate and energy policy is significant because 74 percent of national climate mitigation policies align with EU policies (European Environmental Agency 2018). European member states reported more than 1,500 policies and measures for climate change mitigation, where the majority is dealing with energy efficiency. Regarding the countries of analysis, Romania and Czech Republic reported more measures than the EU average of 54, but Poland, Portugal and Greece have less policies for climate mitigation. Sectors of relevance for climate mitigation policies are dominantly energy consumption, transport and energy supply. Poland and Portugal however have implemented more policies on transport than energy consumption (ibid). For the Paris Agreement, national governments are obliged to articulate NDCs. All member states of the European Union as well as the European Union itself are parties to the Paris Agreement.

On top of that, member states also designed *National Energy and Climate Plans* (NECP) for the energy union which should be finalized by the end of 2019 under regulation 2018/1999. Latter ones provide some room for vertical alignment of targets as Gancheva, Kepesidi, and O'Brien (2019) explain. NECPs goals do not specifically require integrating regional or local authorities but indirectly have an impact on them and can become more effective if those actors are part of the plan. The Committee of the Regions (CoR) could function as a mediator role between different levels and provide best practices and mainstreaming across Europe. Some member states NECPs

already entail local level involvement, mainly for energy communities, energy efficiency or energy poverty. Member states that have already moved forward with local authority integration are Greece, Poland, Germany, Belgium, Romania, Czechia, Bulgaria, Italy and Portugal (Gancheva, Kepesidi, and O'Brien 2019) – this includes (in various forms) all countries of the thesis.

Climate policy at the European level today has decisive momentum. The European parliament, just like most member state parliaments, has taken note and been affected by the global wave of right-wing populism. A study by Schaller and Carius (2019) analyzed that right-wing populist parties (RWP) across European countries are rather disengaged in climate policy or even deny the existence of anthropogenic influence on the earths system.

This position is also heavily reflected in the voting behavior of the European parliament and is proposed to get more conflicted with a higher share of RWPs in the 2019 elected EU parliament (ibid.). Schaller and Carius warn that the "increasing share of climate-sceptics in European countries could side-line any ambitious climate policy proposals" (Schaller and Carius 2019, 44). Therefore, the increased disagreement on important future topics like climate, energy but also migration is a stress test for the EU. A new glimmer of hope is newly- elected Commission President Ursula von der Leyen's plan for a *European Green Deal*, which she introduced at the COP 25 in Madrid recently:

> *"Our goal is to be the first climate neutral continent by 2050. If we want to achieve that goal, we have to act now, we have to implement our policies now." (Leyen 2019).*

The European Green Deal is currently under discussion and planned as a European Climate law with the objective of a climate-neutral Europe by 2050. For effective climate action and achieving the 1.5°C target, however, more collaboration is required. The following sections will briefly introduce the national contexts of five countries and to what extent the vertical levels of policies are aligned.

3.3. National frameworks

As a single actor, the nation state alone cannot solve a wicked problem like climate change. It is, however, the entity that until now has been most involved in international climate governance and is leaned on the most when plans fail.

"No state can implement meaningful climate action without its cities. No city can effectively tackle climate change without a proper framework set by the state" (Capizzi et al. 2017)

The municipalities looked at in this research project are in five different European countries, which offers a comparison between national level ambitions. It is especially interesting since the countries are quite distinct from each other, not only in terms of geographic location, climatic conditions or dominating industries, but also in their strategies to tackle climate change. They are in the list of eligible countries for the EU Cohesion Fund, as their "gross national income (GNI) per capita is less than 90% of the EU average" (Kolodziejski and Azavedo 2019, 1).

The EU Cohesion Policy aims at a more social and economic homogenous EU and supports regions and cities in job creation, economic competitiveness and environmental and climate goals. The Cohesion Fund and adjoining policies help to implement economic and environmental measures in alignment to the EU (Getimis 2007). Commonly, the five countries have gone through a transformation process (a break from the Soviet Union) or had serious financial problems after the economic crisis of 2008/09 (Portugal and Greece). Therefore, it is safe to assume that Czech Republic, Greece, Poland, Portugal and Romania have had to deal with many other political issues apart from climate change.

Looking at national GHG emissions, an already diverse picture can be drawn. All selected countries together account for a 2.16 percent of global total GHG emissions. By comparison, the EU as a whole has a share of 12.08 percent of total emissions (UNFCCC 2016). Poland represents almost half the GHG emissions of all five countries with 1.06 percent, while Portugal is the lowest with only 0.18 percent (ibid.). Since 2018, member states are required to design NECPs and explain steps for emission reduction from 2021 to 2030 and outline a long-term strategy. An overview of the NECPs and proposed goals is provided in table 1.

Country	GHG goal (non-ETS)	Reneawable Energy goal 2030	Energy efficiency	Integrative aspect
Czech Republic	14% compared to 2005	20,8% → improve to 23%	Low level of ambition	Just and fair transition not covered so far
Greece	14% compared to 2005	31% → improve more concrete strategies to achieve the goal	Insufficiently ambitious	No adaptation section, plan not detailed enough
Poland	7% compared to 2005	21% → improve to 25%	Modest level of ambition	More detailed description of just & fair transition,
Portugal	17% compared to 2005	47% → well above the goal	Modest to low level of ambition	Good interaction between climate and circular economy plans
Romania	2% compared to 2005	27.9% → improve to 34%	Very low level of ambition	Interactions with air quality, bioenergy etc.

Table 1: Relevant data on climate and energy goals of NECPs (own compilation based on EU Commission assessment)

In the assessment the European Commission deplores that the gap between national plans and European targets still is significant. Only a third of NECPs submitted are ambitious enough, among these Portugal. Others are asked to readjust their national strategies (European Commission 2019a).

Czech Republic

The Czech Republic is the smallest of the five countries with 10,6 million inhabitants and most of the population lives in towns below 20,000 inhabitants– a consequence of the "process of suburbanization" (OECD 2018, 18). This leads to a high fragmentation of local government and a high share of municipalities (more than 6,000). This limits local capacity to administer municipalities effectively in Czech Republic (OECD 2018). It is characteristic to have a unitary-decentralized administrative system with a "strong local government" (Spaczek and Nemec 2018). Since Czech Republic joined the EU in 2004, "local governance has experienced a systemic change and appears to be more horizontal and multilevel" (Lysek and Ryšavý 2018, 12). The process of

Europeanization with the principles of EU cohesion policy and structural funds has impacted Czech municipalities for more intermunicipal cooperation (Lysek and Ryšavý 2018). However, being a signatory to the Covenant of Mayors is not common for Czech municipalities.

The country had impressive economic growth during the last years and is among the heavily industrialized regions in Europe, which also couples with a high energy intensity and reliance on coal and nuclear power (Alessandrini et al. 2017). Although the share of renewable energy is increasing, Czech Republic is not yet on the forefront of a carbon-free economy. The targets for the Kyoto-Protocol were fulfilled and goals for 2020 should also be reached (ibid.). Coal is the main source of energy, but incrementally is being replaced with nuclear power. Since August 2019, a coal commission discusses a possible phase-out of coal power plants (Europe beyond Coal 2019).

Although there is general capacity to tackle global issues, "central and subnational authorities have not been proactive on environmental policy" (OECD 2018, 17). In 2017, the *Climate Protection Policy of the Czech Republic* replaced a previous policy to align with the Paris Agreement. The targets in its policy are a reduction of 32 Mt-eq. (million metric tonnes of gas equivalent) for 2020, for 2030 to reduce up to 44 Mt-eq. in comparison with 2005. In the reference year, Czech Republic emitted 146 Mt -eq. (Ministry of the Environment of the Czech Republic 2017). The assessment of the NECP advised for a number of re-adjustments e.g. to raise the target of renewable energy to 23 percent, which was given with 20.8 percent in the draft NECP. Several detailed elaborations e.g. investments for research and development, increasing energy efficiency or strengthening regional cooperation for energy (European Commission 2019b). The OECD made similar suggestions for additional measures taken to achieve global climate and environmental goals (OECD 2018).

So far, these suggested policy amendments have not been made. The Czech Republic joined Poland, Hungary and Estonia to block the long-term climate neutrality strategy 2050 discussed in June 2019 by the European Commission (Tefer 2019). Since the new Commission with President von der Leyen is acting, the *Green Deal* is again debated with the same demands for climate-neutrality, this time offering transition funds for heavily fossil-dependent countries to convince member states like Czech Republic to agree (Guarascio 2019).

In summary, climate policy in Czech Republic is formally in alignment with the Paris Agreement but lacks ambition. As efforts for climate neutrality are blocked at the European level, those ambitious actions will be hard to realize at the national level in Czech Republic. As the EU has influenced and empowered the local level, time will tell if a more regionalized Czech Republic will alter ambitious national climate policy.

Greece

With more than 2,000 islands and a peninsula, Greece is remarkably distinct to most other member states. The fragmentation of the territory has led "to considerable intra- and inter-regional disparities" (Getimis 2007, 44). Centre-periphery connections for a long time have been rather centralized. Since the founding of the Third Hellenic Republic in 1974 until the economic crisis in 2008/09, a trend towards decentralization and a relatively stable party system are characteristic. The crisis of 2008/09 not only meant financial challenges but also brought government reforms and new political parties to the table. Two reforms on local governments decreased the number of municipalities and altered responsibilities of the local governments: *Kapodistrias* in 1997 and *Kallikrates* after the crisis in 2010.

After the *Kallikrates* reform, municipalities had enhanced competencies like environmental planning, social policy and education as well as trade and tourism (Ioannis 2016). Increased regionalization is therefore clearly visible but was tough for the crisis-ridden country. Although the reform was motivated by domestic strategies, the EU welcomed the step towards more decentralization and empowered municipal organizations during the time of reform. Now smaller municipalities benefit from increased access to European funds (Oikonomou 2019). Furthermore, the political parties were shaken up by the crisis. The traditional two-party system does not exist anymore, rather a dispersed parliament with currently seven parties is the new reality. During the last ten years, Greece has gone through six national parliament elections and several changes of prime ministers (ibid.).

A look at environmental and climate policy suggests that these turbulent years have left traces on policy planning and implementation. The Climate Change Performance Index (CCPI) 2019 ranks Greece as very low in climate policy, because it lacks a long-term emission reduction strategy (Burck et al. 2018). On the other side, Prime Minister

Kyriakos Mitsotakis announced a phase-out of coal power plants for electricity production in 2028, although one more plant is currently constructed (Europe beyond Coal 2019). As a national adaptation strategy already exists, Greece is trying to lower the impacts on agriculture, forestry and urban areas, which will suffer from increased heat and dry days as well as forest fires (Giannakopoulos et al. 2011).

Public opinion might have influenced recent efforts for better climate policy. Concern about climate change impacts is high, with 81 percent of Greeks supporting the implementation of measures against climate change (Paravantes 2019). Its draft NECP is fairly well developed with GHG emission reduction in line with EU targets, which is 14 percent less than the reference year 2005. It lacks some accuracy in how to implement various policies like regional cooperation and air quality (European Commission 2019c). The draft NECP recognized the link to local climate actions and their importance for the national assessment mentioning urban mobility projects (Sailler 2019).

Ten years after the crisis, Greece is still affected by political and fiscal instability, nevertheless it seems that – although slowly - steps are being taken to mitigate and adapt to changing climatic conditions. Public concern might further demand fitting climate and energy policies in the near future, not only at the national level, but also from Greece's reformed local governments.

Poland

Polish environmental and climate governance has had some troublesome years since accession talks with the European Union began. It is one of the largest European countries based on territory and population. As a major producer of hard coal, Poland is known to frequently block European efforts in climate policy like the *2009 roadmap for 2050* or *European strategy for climate neutrality 2050* (Marcinkiewicz and Tosun 2015).

Politically, "Poland has joined the ranks of countries experiencing democratic backsliding" (Tworzecki 2018, 97) with the right-wing populist Law and Justice Party (PiS) winning elections since 2015. The country provides a puzzling case for political scientists because despite steady economic growth, low unemployment rates, and general satisfaction with a parliamentary democracy, the Polish people voted a majority

of PiS politicians into parliament in 2015 and seem to be rather satisfied since it won majority again in the 2019 elections. Systemic changes to the constitution and the judiciary or restricting media and NGOs were some projects on how to transform the political system in Poland in only a couple of years and with broad public acceptance (Tworzecki 2018). One explanation identified by Tworzecki (2018) is a perceived unfairness that leads to an anti-establishment and anti-system voting behaviour. Regionalism has been promoted and further strengthened among the 16 regions, 380 powiats (counties) and 2,479 municipalities (CEMR 2016).

In Poland, as in several other of the Eastern European countries, climate policies enter political agendas through external actors like the European Union. It can get stable salience on the countries internal agenda if public demand aligns with those external proposed plans (Marcinkiewicz and Tosun 2015). Because public demand for climate policy is very low in Poland, it is not seen as a high priority for politicians and nearly all parties in parliament are against highly ambitious GHG reduction goals. It is associated with energy insecurity and a turn-away from Poland´s big coal industry (ibid.). Recently, problems of air pollution raised greater awareness for climate isues. In late 2019 a new ministry of climate was established but the absence of major changes in climate policy continues (Olszewski 2019).

Strengthening transnational energy cooperation on different levels is a path for more ambitious climate policy. Furthermore, "*municipalities and local-level administrations show much greater support for a transition based on RES than the Polish government does"* (Tews 2015, 283). This suggests that a policy change from the bottom might be more plausible than a change from national level. The local authorities already feel the impacts of climate change and suffer from poor air quality. Energy independence and co-benefits like saving money through energy efficiency are important drivers.

Municipalities are advised to create a Low Carbon Economy Plan, which should tackle air quality (Kunikowski 2018). The national government just readjusted its *Energy Policy Poland 2030 to 2040* with new goals. The amount of coal in the energy supply should decrease from 80 percent to 56-60 percent in 2030, while renewables should increase to 23 percent – and further to 32 percent in 2040. Poland´s plan to balance a decrease in coal and increase in renewables is to construct a nuclear power plant for energy security (Evans and Easton 2019). The NECP was generally well-developed

although national targets in renewables stay behind EU targets and should be revised again (European Commission 2019d).

Poland remains a difficult member state for European climate and energy policy. The European Union targets are a main point of calibration for Poland. It has manifested a national sympathy for its coal industry. Internally however, local administrations are working to increase energy efficiency and are keen to increase the share of renewables to gain energy autonomy in their region. This leaves room to manoeuvre and implement climate policies at the local level.

Portugal

Portugal is a coastal country on Europe´s western Atlantic border. It is a unitary state that is sub-divided into two major regions and fragmented in 3,400 municipalities for 10,4 million inhabitants (CEMR 2016). Similar to Greece, Portugal was hit hard by the financial crisis and had a high government deficit with increasing levels of debt, which led to austerity measures in the years following the crisis (Andreas, Burns, and Touza 2019). With lots of effort directed to change financial policy, Portugal is recovering with a projected growth rate of 2 percent annually and doubled annual exports. According to a YouGov survey in September 2019, the Portuguese are rather optimistic for the future, but are concerned about corruption inside the country and the chance of a new crisis (Dennison and Franco 2019).

Nation-wide elections were held in October 2019 and revealed a very stable outcome with the re-election of Prime Minister Antonio Costa from the socialist party. He leads a minority government with the Left bloc. While Greece, Spain and Italy have faced a dire political time of instabilities, Portugal moves along with a stable left-wing government and quite satisfied citizens. Portugal so far has not seen a strong right-wing populist movement (ibid.).

Frequently hit by heat waves and forest fires, the country has been active in climate change adaptation but also released the ambitious mitigation plan *Roadmap to climate neutrality 2050*. This long-term strategy aims to phase-out of coal by 2030, increases engagement with regional and local governments, and addresses a socially just transition. In his inaugural speech after re-election, Prime Minister Antonio Costa even corrected the coal phase-out to 2023 (País ao Minuto 2019). Portugal´s NECP is one of

the few submitted to the EC which fulfil the criteria to achieve European goals. By 2030, renewables should be supplying 47 percent of the energy mix. The CCPI in 2019 ranked Portugal 17 (out of 57 countries) because of its efforts in national and international climate policy (Burck et al. 2018). Vertical integration remains a perpetual challenge in climate policy.

> *"[T]he coordination of climate change policies in Portugal has traditionally been done by ministries and government agencies, with scarce involvement of other stakeholders" (Campos et al. 2017).*

Portugal has set sail for ambitious climate policies in the recent years. If implementation is just as ambitious, the country will be a pioneer in climate policy, despite or even in order to effectively overcome austerity. Enabling regional and local actors to be a part of the road to carbon neutrality will determine its success.

Romania

Romania is a member state of the EU since 2007. It is a unitary state with 41 counties and is further sub-divided into 3,181 local administrations of which 103 are cities (*municipii*) (CEMR 2016). The executive power is shared between the Prime Minister, currently Ludovic Orban, and the President, Klaus Iohannis. Presidential elections were held in November 2019 after the social democratic government was accused of corruption. President Iohannis won against the social democratic candidate "confirming the pro-European trajectory" and guaranteed some stability (The Guardian 2019).

Although Romania has seen strong economic growth during the last few years, high poverty rates and unequal socioeconomic development are major challenges (Worldbank 2019). The main sectors of employment are industry and services, although wages and working conditions are worse than EU averages. Emigration to other European countries pays a major contribution to the low unemployment rate in Romania (Steluța Georgeta 2015).

Efforts in climate and energy policy are driven by EU policies and directives. When the *National climate change strategy 2013-2020* was criticized as unambitious and based on incomplete analysis, a reversed strategy for 2016-2030 was published and re-adjusted in 2018 by the newly elected government. Cornerstones of the strategy include the construction of one nuclear and one lignite power plant.

Romania´s energy production is characterized by a high share of hydro power. Among the EU member states, Romania is relatively energy independent but still seeks to increase regional autonomy in energy production (Aceleanu et al. 2017). Energy poverty is decreasing steadily, however still around eleven percent of Romanian households cannot keep their homes adequately warm during the winter period (EU Energy Poverty Observatory 2019). Although there is a high natural potential for wind, solar and biomass energy to complement existing hydro power plants, poor investment strategies and low governance capacity hinder sustainable energy development (Aceleanu et al. 2017).

In the draft NECP, Romania planned a renewable energy share of 27.9 percent, which is below the required figure of 34 percent. Emission reduction in the non-ETS sectors are set at two percent compared to 2005 and is compliant with European goals. Energy efficiency efforts meanwhile have a low ambition. The NECP assessment of Agora Energiewende (2019) finds fault because of a lack of integrated approaches and missing detailed analyses of future predictions in energy consumption. On the other side, Romania´s NECP is among the few which recognize the importance of cities for climate and energy actions and explicitly mention smart city concepts in Bucharest and Cluj-Napoca (Sailler 2019). Furthermore, it recognized the CoM as a relevant transnational network facilitating energy policy and energy efficiency (Sailler 2019). The CCPI ranks Romania at 20, mainly because of the low share of energy usage. In terms of its climate policy, Romania is considered a laggard (Burck et al. 2018).

Among Romanian municipalities the signatory to the CoM is prevalent, which shows local level willingness for climate ambitions, especially when linked to co-benefits. Local authorities in Romania are experienced in fund acquisitions to realize local projects. Therefore, many closely follow up on European level directives and opportunities (Interview with Romanian municipal representative).

Romania´s climate action on national and local level remain driven by European directives and “realistic steps have not been taken to address the causes for the general lack of vision and capacity of coherent long-term planning” (Dudău and Cătuți 2019, 343).

The five different countries have shortly been presented now, outlying their overall situation as well as energy and climate policies. The countries are diverse in their ambitions, goals and strategies. Now I will introduce the municipalities within these countries that will be analysed.

3.4. Characteristics of municipalities

The importance of local activities such as developing sustainable strategies and joining transnational climate networks has been portraited in *Chapter 2*. I have identified a scientific bias for big cities in Western countries and a gap in research to look at smaller local entities, especially in non-pioneer countries. The set of municipalities I selected for the thesis is therefore a relevant and meaningful completion to enhance the understanding of local climate action and supportive conditions. Most of the municipalities have not been on the scientific radar so far.

The 25 municipalities are a set of diverse cases in size, socioeconomic factors and level of climate ambition. While some of them have been working with climate strategies for multiple years, others are in the stage of developing their first local climate plan. This provides a good basis for a QCA, but also needs some deeper understanding. In the following the most important characteristics are described.

The municipalities are very different in size. The smallest municipality has around 7,000 inhabitants, while the largest has more than 120,000. However, the majority has less than 80,000 inhabitants and it not one of the biggest cities in the respective country. There are country-specific distributions, which need to be considered. Municipalities in the Czech Republic are all below 30,000 inhabitants, while bigger cities are rather located in Portugal and Romania.

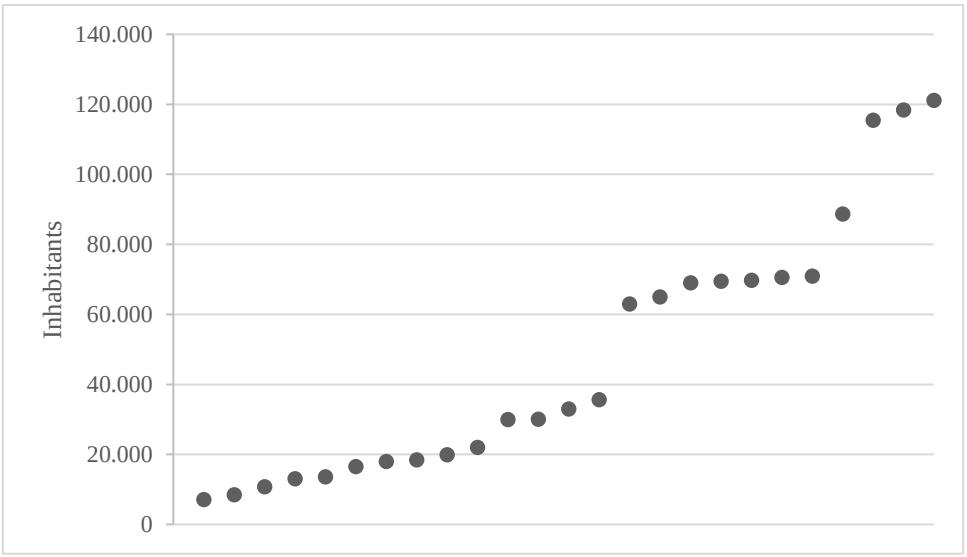


Figure 1: Distribution of the 25 municipalities according to inhabitants

Different socioeconomic conditions in the countries are also reflected on the local level. Unemployment rates are very low in municipalities of the Czech Republic, one of Europe´s industry hot spots, while many Greek municipalities have to deal with double-digit unemployment rates – clearly visible as the highest five dots in figure 2.

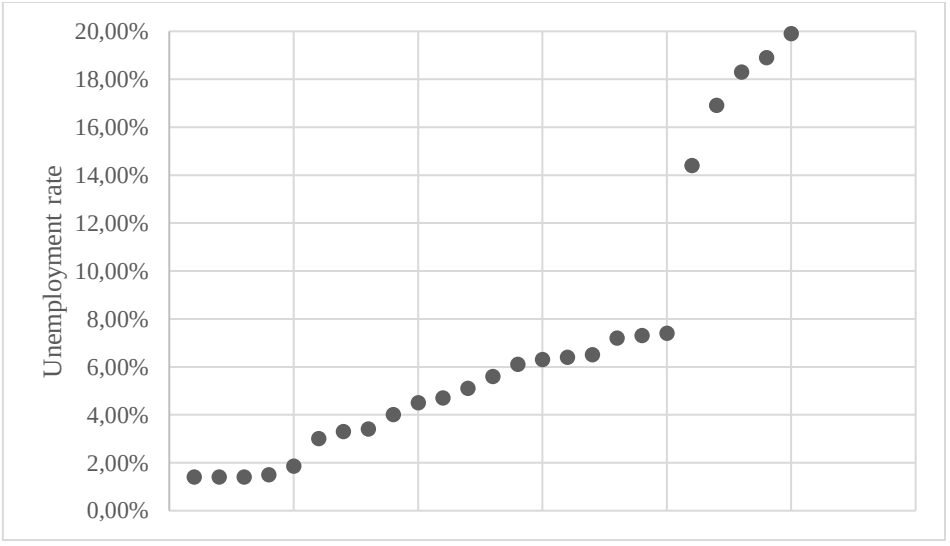


Figure 2: Unemployment rates according to EUROSTAT in NUTS 3 of the municipalities in 2018

Horizontal networks are also capturing smaller municipalities. Here, only the CoM is analysed as the most prominent and well-established network of European and

increasingly global municipalities. Eleven municipalities are signatories and submitted a SEAP for 2020, three have signed and are currently drafting a SECAP and further five municipalities are taking first steps to join the CoM. Again, national tendencies can be detected, as such networks are more common in Portugal and Romania and less in Czech Republic. Polish municipalities are also part of the Polish Energy Cities network as well as the Romanian municipalities to the Romanian branch. Portuguese municipalities previously have participated in an adaptation project. Horizontal networks therefore are used to some extent, but as the table of CoM signatory reveals, none of the municipalities have submitted plans for 2030 (SECAPS) and stay in the framework of European strategies.

municipality code	Covenant of Mayors signatory process
PRA	no
ROZ	no
CIE	no
ZAM	no
SYR	no
FAR	no
ANS	interested
LOU	interested
KAL	interested
MIL	planning to join
PRE	planning to join
PIS	CoM without SEAP
BUZ	CoM without SEAP
JAS	CoM without SEAP
SZT	SEAP 2020
BIE	SEAP 2020
RAM	SEAP 2020
DEV	SEAP 2020
ZAL	SEAP 2020
ALI	SEAP 2020
VIA	SEAP 2020
SET	SEAP 2020
DOR	SEAP 2020
AGD	SEAP 2020
COR	SEAP 2020 and adapt

Table 2: Overview of CoM process – from non-signatory to member with SEAP for 2020 (as of CoM Website September 2019)

Most scientific papers base the focus on local strategy documents for climate and energy policies. They capture the goals and long-term commitments of local entities. The municipalities of this analysis show quite a diversity of strategy documents and the processes behind. In seven municipalities no strategy document was found via the website. In another four cities, strategy documents were found with some indications of emission reduction and environmental concerns in the broader sense. Ten municipalities do have dedicated sustainable strategies either an integrated city plan or sectoral strategies for mobility and energy efficiency. The remaining four have adaptation plans or dedicated a chapter of the city strategy to climate and energy. The capacity for well-developed climate and energy strategies can be increased via network participation, which often provide guidelines and local support but also through national and European pressure on local entities. As in Poland, municipalities are required to establish Low Economy Plans.

Although ideas like a climate emergency declaration or a strategy for climate neutrality in 2050 are being discussed in the public, none of the municipalities currently plans to instate such documents. The level of implementation of these strategies remains unclear so far and regional events or elections can change the policy agenda.

The research on political parties in relation to climate change is only just emerging. As Schaller and Carius (2019) and Lockwood (2018) analysed at European and national level, right-wing populists do not prioritize climate and energy policies and are more inclined to block ambitious efforts. Assuming this is similar at the local level, I collected information about parties in the local councils –for Poland on the county level (*powiat*). Parties among the municipalities are spread broadly on a left-right spectrum. From communists to right-wing populists all parties are represented in some or another local council. In the table 3 below are the parties with most seats at the local level. The column "other" summarizes local or regional parties as well as agrarians, which are common in Poland. In most cases the mayor is from the majorities party as well, only one municipality had an independent candidate. When local parties are in majority in the local council, I scanned through articles of local newspapers to get an idea of their election campaign and priorities.

Socialists	Green/ecologists	Social democrats	Liberals	Conservative	RW-Populist	Other
3	2	3	7	3	2	5

Table 3: Main party in local council according to last elections (with data from national websites)

Mayors and internal administrative staff also influence agenda-setting, though they need to be adequately trained and motivated to take up issues of climate change and energy management, which often are not mandatory tasks for local administrations. The local council however also has the ability to shape local policies and push sustainable decisions.

Several scholars (e.g. Reckien et al. 2018) have pointed out the difficulty of grasping the actual implementation of sustainable strategies at the local level. As part of the project, municipalities do, however, define concrete priority areas each year, which are attainable goals in this time frame. This short-term working priority areas offer a unique reference point to see how far along in a sustainability process the municipalities are at the moment and what exactly they are working on. In 2019, some developed SEAPs while others worked on smart city concepts, communication processes with the public or local industry collaborations.

If a local climate plan is not mandatory, like in the countries of analysis, municipalities usually first look for sustainable projects that offer co-benefits like energy efficiency, refurbishment of buildings and energy management. Furthermore, they might be eager to engage in energy communities and produce local, autonomous energy through wind, solar or biomass plants. In municipalities where air quality is an issue, sustainable mobility plans are a solution for better life quality for their citizens. Citizen participation, sustainable projects in schools and integrated city planning are then measures that do not directly have a (financial) benefit for the municipality but still might earn prestige. Ambitious municipalities are implementing sustainable tourism projects or setting up a circular economy system as well as developing integrated solutions combining both climate change mitigation and adaption.

This first insight to the set of municipalities already gives some perspective that even though they are not among the largest cities in their countries, they are implementing local climate actions. Their frameworks of action are diverse, as are the socioeconomic conditions. This points in a direction that a “one size fits all” approach cannot support

the local level adequately, rather a bouquet of supportive conditions might facilitate local climate action.

3.5. Summary

The most important European, national and local features of climate policy and specific municipal characteristics have been laid down in this chapter. European goals are important anchor points for national and local climate policies. In this chapter I have furthermore shown the diversity of stances for ambitions in climate and energy topics. While countries like Poland and Czech Republic are blocking efforts for climate neutrality in fear of their economic and social status, Portugal has already introduced such a roadmap itself. Local level activities however do not purely reflect national tendencies.

4. Methodology

The methodological framework is explained in the following chapter. Grounded in the idea of comparative analysis as a useful approach to solve current and future wicked problems of climate change and policy, QCA is used both as a research approach and as an analysis tool in this study. In this chapter I explain the methodological process of designing such a fuzzy-set QCA (fsQCA). Starting with a general introduction to QCA, the operationalization, then data collection and finally calibration are explained to guarantee a high degree of transparency.

4.1. Objectives of this chapter

Before the analytical moment is explained and results are discussed, essential aspects of a QCA in general and the methodological process in specific for this analysis need to be specified. Therefore, for the following chapter, the aims are to:

- **Lay down the most important aspects of QCA**. Developed 30 years ago, QCA is still considered a novel methodology, though it has found its way into many scientific fields. General information about the approach and methodological process ensure an increased understanding. QCA has a risk of being misinterpreted if not properly explained, as the idea of a set of combinations is unlike e.g. a regression analysis or a case study approach.

- **Explain the process of operationalization, data collection and calibration**. Transparency is a key component of a good QCA because the results should be replicable and comparable. Therefore, the data collection and selection process as well as calibration of conditions are explained.

- **Formulate hypotheses based on literature and case knowledge**. At the end of the chapter, four hypotheses and further expectations are formulated in line with the research question.

4.2. Qualitative Comparative Analysis

A number of studies on local climate action have found QCA a useful method to find common challenges and drivers of local climate action (Hennessey et al. 2017; Kemmerzell 2018; Lamb et al. 2019; van der Heijden 2018; 2019). Purdon (2014) argued for more comparative analysis in climate change policy, especially small and medium- N studies for good policy recommendations and criticised the unstructured body of literature about single case studies.

With QCA one can set up "enabling typologies to be tested and brought to a higher level of explanatory and comparative power" (Lamb et al. 2019, 284). They further call for a systematic comparison of small and medium-sized cities (in their categorization cities < 1 million in habitants) because of a persisting scientific gap. Therefore, using QCA in my thesis seems pertinent and relevant. It aims at understanding those cases of municipalities being active in climate policy.

I follow this argumentation because QCA's advantage is to combine different conditions and modify cases as configurations to establish typologies and test theories. It can have a policy advising function if important combined conditions are applied as a working strategy (van der Heijden 2019). When quantitative data is not available, comparative methods are better suited to find answers to pressing issues. Convergence towards causal relationships is needed in the next generation of climate change research (Purdon 2014).

QCA was introduced by Charles Ragin as "a powerful method to analyze causal relationships between a set of conditions and an outcome" (Pahl-Wostl and Knieper 2014, 141). Case study research is defined qualitatively, considered to be thick and in-depth while large statistical analyses are quantitative and provide evidential factors. Ragin aims to combine those two is QCA as "a middle ground between the two strategies of depth and breadth" (Ragin 2000, 14). It has a "double nature" (Schneider and Wagemann 2010a) as either a way of analysing data or a qualitative research practise.

The double nature aspect allows one to understand cases holistically and analyse outcomes based on a set of conditions, which can be derived from literature or theoretical hypotheses. Still a young, novel method, or some might rather define it an approach or technique, QCA is constantly modified or redefined depending on the purpose of the research and up to this point has gone through some updates e.g. from

crisp-set to fuzzy-set QCA (Schneider and Wagemann 2010a) and more fine-grained calibrations for qualitative data (Block and Vis 2018).

Despite harsh critiques deeming it as a "wholly ineffective" method that serves only to "obfuscate matters" (Lucas and Szatrowski 2014, 3), many scholars of comparative analysis value QCA as an innovative approach to reach plausible causal relationships and develop new theories (Mahoney 2008). The manifold articles (Mello 2017; Pahl-Wostl and Knieper 2014; Peters et al. 2017; Purdon 2014; van der Heijden 2019), workshops and websites (www.compasss.org) for QCA hint to more and more acceptance and use of this novel method in the social sciences.

One distinctive feature of QCA is its multi-purpose use for researchers. As a research approach, it helps to analyse data and build up cases as configurations before the actual analytical moment (Schneider and Wagemann 2010b) and during or after this moment, the analysis is defined using necessary and sufficient condition, coherence and coverage, which align more to quantitative work (ibid.).

QCA is a set-theoretic method using Boolean algebra to explore patterns of similarity or causal relationships. Combining case-focused research with research on conditions, "QCA allows for operationalizing cases as configurations of conditions" (van der Heijden 2019). Systematic comparison can be coupled with in-depth case analysis. The logic behind QCA is very distinctive from regression analysis, where only one solution is sought after. In QCA many paths can lead to the outcome, which is called equifinality. This also reflects complex reality better. QCA is preferably applied for a medium-N data set (Schneider and Wagemann 2010a).

Because the method is still very young, Thomann and Maggetti (2017) argue for viewing it as an approach to do research rather than a technique. Coming from the qualitative social sciences, QCA can be an iterative process with equifinality (Schneider and Wagemann 2010a). Therefore it starts before the actual analysis and considers case selection, conditions definition and commonly, and recalibrations (Schneider and Wagemann 2010a). Secondly, QCA as an analytical technique can be used to "find empirical patterns in the data" (Schneider and Wagemann 2010a). For this, many applications and software packages with e.g. Tosmana, STATA or R exist. I decided to use R for a fuzzy-set QCA because it is the most comprehensive at the time of writing this thesis, and has a neat handbook provided by Duşa (2019).

While the method can be used inductively to explore new insights and define hypotheses, QCA can also be a suitable tool for deductive approaches (Thomann and Maggetti 2017). This thesis, although incorporating existing knowledge, is constructed as a step towards a new theory including a “leave no city behind” (Lamb et al. 2019) approach to find specific hypotheses for small and medium-sized municipalities. The iterative process and basis of existing literature however suggests that QCA also finds a good mid-way between inductive and deductive approaches. Generating a new theory with hypotheses for small and medium-sized municipalities in climate governance is out of scope for this Master´s thesis but might be a future project for research.

Core principles of QCA are **equifinality**, **conjunctural causation** and **causal asymmetry**, which provide information beyond statistical methods or case studies. This is important to understand the processes and results of a QCA. With this method **sufficient** and **necessary conditions** need to be determined. A sufficient condition X is one, that leads to the outcome Y and is somehow important for its presence. There cannot be cases where the outcome Y exists without this condition X. Otherwise it would not be sufficient. This can be written as:

$$X \rightarrow Y$$

Necessary conditions X follow a reverse logic. When outcome Y is present, X must also be present. If there is equifinality, meaning different paths lead to outcome Y, then a necessary condition X must be present in every path. This can be written as:

$$X \leftarrow Y$$

A capital letter like X, A or B in Boolean Algebra signifies the presence of a condition, small letters like x, a or b the absence. With Venn diagrams the logic of sufficiency and necessary conditions is visualised like the following figure 3:

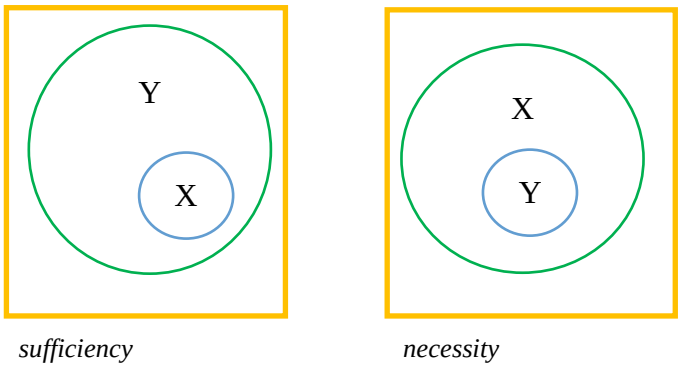


Figure 3: Venn diagrams of sufficiency and necessity

A more complex situation could be:

$$AB + c \rightarrow Y$$

(Schneider and Wagemann 2007; 2010a). Here, equifinality is present. Not one path AB leads to the outcome, but also c can be the reason that Y appears. The plus sign in Boolean Algebra symbolises OR.

By contrast, causal complexity, also called conjunctural causation, means that the outcome is explained by a combination of conditions rather than by conditions individually (Schneider and Wagemann 2007). An INUS condition means "*insufficient but necessary part of a condition which is itself unnecessary but sufficient for the result*" (Schneider and Wagemann 2010a). This term describes a condition inside a combination of two or more conditions that is in itself not sufficient, but necessary for the combination. Furthermore, the combination is only sufficient but not necessary. This already gives some taste of the causal complexity. A further QCA specific logic is asymmetric causality. The presence of X cannot be inverted to the phenomenon of the simple absence of x but must be tested separately (Schneider and Wagemann 2010a).

Once conditions are identified and cases are constructed as configurations, a truth table is set up. In a truth table, rows can be sets of case configurations, which is a clear distinction from quantitative statistical methods. The analysis of the truth table can be conducted with different tools: bottom-up, Quine -McClusky Algorithm (following the logic of minimization) or Mill´s methods (either method of difference or method of similarity) (Schneider and Wagemann 2007).

While the early applications focus on the crisp-set version, fuzzy-set was introduced in the early 2000s by Ragin to overcome issues of membership in a binary setting. Ragin described fuzzy-sets as "interpretive algebra, a language that is half-verbal-conceptual and half-mathematical-analytical" (Ragin 2000). Cases in social sciences are often vague and fuzzy-set theory helps to systematically structure such research (Smithson and Verkuilen 2006). With fsQCA degrees of membership between the values of 0 and 1 can be calibrated (Schneider and Wagemann 2007).

The scaling of values and thereby degrees of memberships inside sets can vary. For this analysis I use a 4-step model. The truth table in an fsQCA can be used to formulate ideal types, following the logic of Lazarsfeld or Weber (Schneider and Wagemann 2007). Especially for fsQCA, Ragin designed three pillars to argue for cross-case analysis with the first pillar being diversity. To bridge case-oriented and variable oriented work diversity "transcends these two opposing principles of generality and complexity" (Ragin 2000). Diversity-oriented research formulates types to find similarities between cases and therefore follows a middle-range generalization.

The second pillar of fuzzy-set social science is to understand cases as configurations. Ragin takes Lazarsfeld´s approach of "property space" for the configurational technique in fsQCA (and also csQCA). And as a third pillar, Ragin (2000) stresses the iterative nature and back-and-forth between theory and evidence as a strength of fuzzy-sets. Furthermore, the methods that fuzzy-set QCA can be used are not ready-made but require researchers to gain substantial information. Ragin describes fsQCA as "tools of discovery" (Ragin 2000). The method is more demanding for researchers because ideas and concepts of social science have to be pinned down precisely while allowing interpretation.

Another development in QCA has been the introduction of *coverage* and *consistency* in response to criticism that the method is too deterministic. The coverage explains in numeric terms how much of the outcome is explained by each path of combinations of conditions whereas the consistency measures to what extent empirical data is necessary or sufficient (Schneider and Wagemann 2007; 2010a). As many QCA scholars have stressed, to work accurately with QCA and provide transparent configurational information, the steps of a fsQCA should be in alignment with the "Standards of Good Practice" set up by Schneider and Wagemann (2010b).

4.3. Operationalization

The "Standards of Good Practice" by Schneider and Wagemann (2010b) describe important aspects for successful QCA research. They provide an important guideline for a fuzzy-set QCA. Their aspects were considered closely before, during and after the analysis.

Schneider and Wagemann (2010b) name five possible goals of QCA. The goals addressed in the thesis are twofold. First, to gather systematic data out of qualitative materials and form a coherent dataset of municipalities from Czech Republic, Greece, Poland, Portugal and Romania. Data from those countries and especially from smaller cities and municipalities is rare in current research. The second goal is to test existing theories from literature and develop new ideas for climate mitigation in smaller municipalities. While an extensive multi-method approach is out of scope of this research, elements of an (unsystematic) literature review and qualitative case study interviews were conducted prior to the QCA and were necessary to build up a proper analysis.

All 25 municipalities are members of a European project on strengthening local climate action. One municipality resigned during the time of data collection but was still included in the dataset. I familiarized myself with municipalities and the overall context while working as a project assistant. Familiarity with those cases not only helped to get in contact with municipal representatives but also increased my understanding of local processes. However, no internal data of the project was used for the analysis. While selection was plausible due to my familiarity with those municipalities and the project, it also provides a new angle to local climate action research, as the municipalities are small to medium-sized in terms of their population and are of five different countries which have not yet been in the centre of scientific attention. The 25 cases are diverse in their attributes like size, socioeconomic factors and experience in climate action, which makes them an interesting and workable dataset for a QCA.

4.4. Data collection

Data collection was mainly done on a desk-based approach. It included national statistic offices websites, EUROSTAT data, municipal websites as well as publicly available project information. Municipalities are kept anonymous to protect the progress of the

project and the municipal representatives in their current work on climate action, which sometimes is seen contradictory. I use a three-letter individual code to distinguish them.

Data collection is a sensitive topic for the analysis. Usually, data availability and quality are major challenges. Here, I could benefit from in-depth knowledge of the project. Only public availably data was used to establish the dataset and initially included many more conditions than used in the analysis. While prior studies like Reckien et al. (2018) could benefit from EUROSTAT data for the bigger cities across Europe, for small and medium-sized cities or municipalities there is no European database currently available. This limited availability of data determined what kind of information about the municipalities was available and could be analysed.

Prior to the collection of data and final selection of conditions, I conducted four scoping interviews with municipal representatives (Annex A) and attended two conferences, where issues of local climate action where discussed. The seven conditions are a mix of qualitative and quantitative data. Most of the conditions were selected out of the previous literature review and the scoping interviews. Not all aspects that were mentioned in the interviews could be addressed. Although there was a discussion about the Fridays for Future (FfF) movement, there was very little data on any strikes or FfF groups in the municipalities. Another aspect which was mentioned with opposite views was financial capacity or budgeting, but due to lack of comparative data and data security reasons this topic was excluded. The dataset provides general information about the municipalities, so that for the QCA, specified conditions could be selected which are most relevant. Based on the literature analysis and interviews, the final dataset includes seven conditions and the outcome PRIO.

PRIO was chosen as the outcome for specific reasons. First, as analysed in *Chapter 2* there is little knowledge in the scientific community about actual implementation and success of climate action measures on a broader scale. Some case studies can provide details on implementation, but most larger analyses use strategy documents and plans as an outcome. PRIO describes the specific priority in year 2019 that the municipality is actively working on and gains coaching as well as advisory services as part of the project. This is more action oriented than simply looking at strategy documents – which exist also for a part of the dataset. As the municipalities made this information public, it is a good and also unique way to find out what is currently the focus of those small

municipalities. It also provides an idea of how advanced a municipality is in climate action, as there is a typical way of approaching it.

Climate action priorities usually start with setting up planning documents and signing on to the CoM. Energy management or retrofitting of public buildings are also popular first steps because they provide co-benefits of municipal budget savings and might be necessary anyway for very old buildings. Such measures are also not too burdening for public finances. Having a representative town hall is mostly accepted by citizens. A next step is to optimize municipal waste management, but usually, waste is a mandatory issue for the municipality to deal with. Making it more sustainable or installing a biogas plant is a good step for better climate action and might also come with financial co-benefits.

More ambitious priorities of a municipality are sustainable mobility planning and infrastructure projects, which usually are costly and might also involve public communication and awareness measures. Stretching climate action to schools is also a common step of climate active municipalities who have had some good experiences before. Adaptation projects and nature-based solutions, citizen awareness programs or sustainable tourism do not offer direct benefits for the municipality and therefore are ranked as highly ambitious climate action measures. As PRIO offers insights into the steps of municipalities, this opportunity was taken and PRIO set as the outcome.

Out of the seven total conditions which were initially collected, and following the literature analysis and interviews, a more limited number of four conditions was selected. Since the research question is about enabling conditions and the guiding framework of municipalities, conditions that explain possible enabling factors were chosen for the QCA:

- INH: the size of a municipality measured in population,
- NAT: the national climate policy setting,
- COM: participation in the CoM network and
- PAR: majority parties in the local council.

The selection of these four conditions should depict the enabling framework of municipalities. The argument of “size matters” is a very common one and also determined the whole research as the focus is on small and medium-sized municipalities. Furthermore, NAT was taken as it represents a very influential condition of the vertical political framework and COM as a representative of the horizontal

framework. To also take into account local political directions, the parties in the local council, who also represent local public opinion, where included as a fourth condition. The full set of conditions is explained in table 4.

Condition	Abbreviation	Assumption and relation to outcome
Inhabitants	INH	The bigger a municipality, the more likely it is to have a climate action plan and emission reduction goals. (Homsy 2018a; 2018b)
Connected – Distance to next bigger city	CON	The closer a municipality is located to a bigger city (< =250.00 inhabitants) the more ambitious it is.
National climate governance	NAT	If the national government is implementing ambitious climate policies this affects the local level. Municipalities can be supported when upper levels commit to climate mitigation targets. (Bulkeley/Betsill 2005,(OECD 2010) (Heidrich et al. 2016; Homsy and Warner 2012)
Covenant of Mayors signatory	COM	The participation in the transnational municipal network is voluntary and suggests that municipalities who sign up are implementing sustainable local policies. (Heidrich et al. 2016; Reckien et al. 2018)
Parties in the local council	*PAR*	Right-wing populist (RWP) and conservative parties are likely to act adversely towards climate action at the local level. (Schaller and Carius 2019)
Unemployment rate (at NUTS II level)	*UNEM*	If the region faces low employment the focus of the municipality is likely to be on social and employment policies rather than climate & energy. (Homsy 2018b)
Strategy Document	*DOCS*	If an official strategy document exists, the municipality is likely doing more in terms of local climate action. Official strategy documents can be sectoral sustainability strategies or integrated plans. SEAPs were not counted as strategy documents as they are already included in the CoM variable. (OECD 2010(Reckien et al. 2018))
Priority working area in 2019 (Outcome: Priority)	PRIO (later named OUTCOME)	The more a municipality is involved with climate action, the more ambitious it is. Involvement or ambition is considered to rise from measures with high co-benefits like energy efficiency to more financially intensive or long-term projects.

Table 4: Overview of collected conditions

4.5. Calibration

Calibration is an important step in a fsQCA. It is the "process of using empirical information on cases for assigning set membership to them" (Schneider and Wagemann 2012, 32). The goal of calibration is to group and separate the cases according to their membership in certain sets. Conditions and the outcome are seen as the available sets in a QCA. Important anchor points for the calibration process are 0.00 (full non-membership) 0.5 (the cross-over point) and 1.00 (full membership). But in the actual calibration, the 0.5 value is problematic and should be avoided because of their inherent ambiguity (Schneider and Wagemann 2012). The data collected for the analysis was both qualitative and quantitative, which resulted in the calibration outside of the analysis with the programme R.

I used a four-step degree of membership:

- 0 (completely outside the set),
- 0.33 (more out than inside the set),
- 0.67 (more in than out) and
- 1(completely inside the set).

The process of calibration takes recourse to theoretical knowledge from the literature review as well as the scoping interviews and my own knowledge of working on the project.

INH is a quantitative condition, so that membership was allocated according to the quartiles. The condition NAT is calibrated with the consideration of several factors: national CO_2 emissions, ranking in the CCPI, coal-phase out strategy and the proposed goals for GHG reduction and share of renewable energy by 2030. The country details were presented in *Chapter 3*. The participation in a transnational network was measured with the Covenant as one of the most important and established networks in Europe. To assign the four-step membership scale, the cases where differentiated between non-signatories, non-signatories with interest to join (in preparation to join), signatories without a SEAP and signatories with SEAP or even SECAP.

Fourth, calibration of PAR followed the assumption that similar tendencies are present in local councils as are on national and European parliaments. As right-wing populist parties tend to block efforts in climate policy and green parties strive for ambitious climate policy, this political continuum was taken as the point of reference. Therefore,

the majority party or parties were calibrated along this continuum. If local parties were in the majority of the local council, further research on their programs and political agenda was conducted via local newspapers and election campaign pamphlets. I then assigned the local parties to the ideological background they were closest to. Table 5 shows the detailed cross-over points for the conditions and the outcome.

Condition	**Assumed causal direction**	**Calibration explanation**
INH (Inhabitants)	The bigger a municipality, the more likely it is to have a climate action plan and emission reduction goals. (Homsy 2018a; 2018b)	0 → 0 <= 18.000 0.33 → 18.001 <= 35.000 0.67 → 35.001 <= 70.000 1 → 70.001 <= 150.000
NAT (National climate governance)	If the national government is implementing ambitious climate policies this effects also the local level as a multi-governance aspect. Municipalities can be facilitaties when upper levels commit to climate mitigation targets. The indicator for national climate governance is a combined analysis of multiple factors and is listed separately in table *c* (Bulkeley/Betsill 2005,(OECD 2010) (Heidrich et al. 2016; Homsy and Warner 2012)	0 → high CO2 emissions, low CCPI, no coal phase out planned, no ambitious goals for GHG reduction or renewable energy 0.33 → relatively high CO2 emissions, low CCPI, coal-phase out in discussion, low levels of GHG reduction and renewable energy 0.67 → moderate CO2 emissions, medium CCPI, coal phase out, GHG reduction and renewable energy aligned with European goals 1 → low CO2 emissions, good CCPI, coal phase-out decided, ambitious GHG reduction and renewable energy goals above European requirements
COM (Covenant of Mayors signatory)	The participation in the transnational municipal network is voluntary and suggests that municipalities who sign up are implementing sustainable local policies. (Heidrich et al. 2016; Reckien et al. 2018)	0 → no signatory 0.33 → interested to join 0.67 → signatory without SEAP 1 → signatory with at least SEAP 2020

PAR (Parties in the local council (*for Poland: "Powiat" level))	Right-wing populist (RWP) and conservative parties are likely to adverse climate action on local level. Source: (Schaller and Carius 2019)	0 → RWP or conservative-right party in majority 0.33 → RWP in council, but not majority 0.67 → liberals, social democrats or socialist parties 1 → ecological, green parties in council
PRIO (Outcome: Priority)	If priority for the year 2019 is set as ambitious, the municipality is very active in mitigation. Here, however, 0 does not describe that a municipality is not active or ambitious, rather that it is rather new to climate action activities.	0 → setting up a planning document, internal capacity building, getting funding. 0.33 → energy efficiency and refurbishment, waste management, energy communities, street lighting 0.67 → mobility, urban planning, air quality, adaptation, communication 1→ smart city, nature-based solutions, tourism, industry collaboration, specified projects

Table 5: Overview of calibration with cross-over points

When all conditions are calibrated, a data matrix provides an overview of the individual cases and the outcome. The data matrix (table 6) shows all four calibrated conditions and the outcome. With it, the next step is to check for necessity and sufficiency and produce a truth table, which is executed in *Chapter 5*.

CODE	INH	NAT	COM	PAR	PRIO
AGD	1	0.67	1	0.67	0.67
ALI	0.67	0.33	1	0.67	1
ANS	0	1	0.33	0.67	0.33
BIE	0.33	0	1	0.67	1
BUZ	1	0.33	0.67	0.67	0
CIE	0.33	0	0	0.33	0.67
COR	0.33	1	1	1	0.67
DEV	0.67	0.33	1	0.67	0.67
DOR	0	0.67	1	0.33	0
FAR	0.33	0.67	0	0.67	0
JAS	0.67	0	0.67	0	0.33
KAL	0.67	0.67	0.33	0.33	0.33
LOU	1	1	0.33	0.67	0.67
MIL	0	0.33	0.33	0.67	1
PIS	0.33	0.33	0.67	0.33	0.67
PRA	0	0.33	0	0.33	0.33
PRE	0	0.33	0.33	0.67	0.67
RAM	1	0.33	1	1	0.33
ROZ	0	0.33	0	0	0.33
SET	1	1	1	0.67	1
SYR	0.33	0.67	0	0.67	0.33
SZT	0	0	1	0.33	0.33
VIA	1	1	1	0.67	1
ZAL	0.67	0.33	1	0.67	0.33
ZAM	0.67	0	0	0	0

Table 6: Data matrix with calibrated fuzzy-set values

4.6. Hypothesis formulation

Given all of the information up to this point in the research process, some hypotheses concerning the concrete conditions emerged. In line with the research question, I looked for enabling conditions to implement ambitious local climate action in smaller municipalities across European countries. The assumptions and criteria for selection have been mentioned in table 5 (4.5). QCA aims at conjunctural causation so that the combinations of conditions are focussed on. I expect none of the conditions to be individually necessary nor sufficient for the outcome. My hypotheses for possible solution formula of the fsQCA are the following:

A) Small municipalities cannot enable ambitious local climate action on their own. Even if national or horizontal support exists.
Formula: **inh*NAT + inh*COM → prio**

B) Small municipalities can set ambitious actions if they have a strong supportive framework, both horizontally and vertically.
Formula: **inh*NAT*COM → PRIO**

C) If the national government is not supporting ambitious climate action but the local level is motivated to take steps in climate action, horizontal networks are supporters
Formula: **nat*COM*PAR → PRIO**

D) The influence of right-wing populists or conservative parties in the local council is stronger than national ambitions. Even if national climate policy is ambitious or the municipality already joined the CoM, climate action locally is not prioritized
Formula: **NAT*par + COM*par→ prio**

With the knowledge so far, I expect a low level of necessary junctural conditions because the 25 municipalities are quite diverse and in different countries. Sufficient INUS combinations, however, should be present. In terms of the distribution among the countries studied, I assume that ambitious municipalities are present more frequently in Portugal rather than in Poland or Czech Republic due to national government reactions on climate policy.

4.7. Summary

This chapter provided an introduction to QCA as a research approach. QCA is a useful approach for conducting a medium-N research and focussing on conjunctural causation rather than relying on single conditions. This is an attempt to capture the complexity of local climate action.

I explained the steps of the research with the dataset up to the point of the calibrated data matrix to make the following analytical moment as comprehensible as possible. Several tables show steps of the process. The four conditions INH, NAT, COM and PAR were chosen to be tested for the outcome PRIO. To not lose sight of the mission of the thesis and research question, hypotheses for possible solutions of the fsQCA were proposed.

5. Results

After the general introduction of QCA, the conditions and calibration were laid down. The next step that follows now is the "analytical moment" (Schneider and Wagemann 2010b) itself that produces the results and is explained step by step in the following chapter. The aim of the analytical moment is to identify common structures or patterns i.e. the solution formula that leads to the outcome. For those steps the software and programming language R was used because it provides packages *QCA* and *SetMethods* as well as *venn* which are very useful for the analysis. The script for this analysis is attached in Annex F.

5.1. Objectives of this chapter

The analytical moment includes the step from a raw data matrix to finding a solution formula. Therefore, in this chapter the focus is to:

- **Explain the steps of the analytical moment,** which are the analysis of necessity, analysis of sufficiency, the construction of a truth table with a minimization process. Those steps are made transparent to understand the result.

- **Provide the truth table of the QCA**, which is a central feature of any QCA and allows for a different perspective away from case-centred to conjunctural conditions.

- **Find and describe the solution formula**. Out of the truth table, a solution formula can be derived via the minimization process, which entails important information about how conditions are working together and when the outcome is visible.

5.2. Analysis of necessity

Before a truth table can be constructed, which checks for sufficiency, the individual necessity is tested for the outcome. If none of the conditions are individually necessary, also combinations of conditions cannot be necessary.

> *"Generally speaking, a condition X is necessary if, whenever the outcome Y is present, the condition is also present" (Schneider and Wagemann 2012, 69).*

In other words, no case shall have outcome Y if a condition X is necessary and all those cases where Y is not present can be excluded for the analysis of necessity. Finding necessary conditions in a QCA is rather rare.

The important parameters of fit are consistency and coverage and to a lesser extent also the relevance of necessity (RoN). Latter one checks for the trivialness of each condition for the outcome. The higher the score, the more relevant a condition is for the outcome. All parameters have values between. Consistency is an important parameter of fit for necessity. It checks the degree of deviation of the outcome subset from the respective condition. For fsQCA consistency is "the degree to which each case's membership in X is equal to or greater than their membership in Y" (Schneider and Wagemann 2012, 141). For fsQCA, consistency is calculated with the formula:

$$Consistency_{Neccesary\ conditions\ (X_i \geq Y_i)} = \frac{\sum_{i=1}^{I} \min(X_i, Y_i)}{\sum_{i=1}^{1} Y_i}$$

As the range of the consistency value (and respectively the other parameters as well) ranges from 0 to 1, the threshold for consistency should be as high as ≥ 0.9.

Secondly, coverage mathematically is an equivalent, as the formula is:

$$Coverage_{Neccesary\ conditions\ (X_i \leq Y_i)} = \frac{\sum_{i=1}^{I} \min(X_i, Y_i)}{\sum_{i=1}^{1} X_i}$$

Coverage "expresses how much smaller the outcome set Y is in relation to set X" (Schneider and Wagemann 2012, 144) or put differently: is a measure of relevance of a necessary condition. Checking for coverage only makes sense when the condition already passed the threshold for consistency. Then, the coverage threshold is ≥ 0.5.

Ideally, necessary conditions should have a high consistency value as well as a high coverage to be meaningful.

In the software R the function *QCAfit* calculates necessity with the three parameters consistency, coverage, and RoN. The four conditions INH, NAT COM and PAR as well as their complements where tested for being individually necessary for the outcome PRIO.

```
> QCAfit(mun[, -the_outcome_column], mun$OUTCOME, necessity = TRUE)
```

The result shows no necessary condition. No condition fulfils the threshold criteria of consistency ≥ 0.9, although the coverage figures are above ≥ 0.5 except for ~COM. But as states above, if consistency does not apply, coverage does not matter anymore. The RoN scores here range between 0.67 and 0.78, which suggest that the conditions are not trivial, but rather relevant. This also supports the chosen conditions as empirically relevant factors for the outcome. XY plots are a common method to display relations like necessity and sufficiency for fsQCA. The XY plots for the analysis of necessity are displayed in Annex D.

	Consistency	**Coverage**	**RoN**
INH	0.60	0.64	0.75
NAT	0.63	0.68	0.78
COM	0.76	0.66	0.67
PAR	0.76	0.72	0.76
~INH	0.60	0.59	0.69
~NAT	0.63	0.60	0.69
~COM	0.39	0.48	0.73
~PAR	0.55	0.60	0.74

Table 7: Results of the analysis of necessity with the R function QCAfit

If there are no individual conditions which fulfil the threshold criteria, it is not meaningful to analyse combinations of conditions for necessity. As proof, the function *superSubset* with the inclusion cut of 0.9 and the RoN.cut of 0.6 reveals no relevant unions.

```
> superSubset(mun, outcome = "OUTCOME", incl.cut = 0.9, ron.cut =
0.6)

Fehler: There are no combinations with ron.cut = 0.6
```

5.3. Analysis of sufficiency

Duşa (2019) describes the analysis of sufficiency as the "main purpose of the QCA methodology" (125). The two steps, analysis of sufficiency and analysis of necessity, are in a mirror-image relation and complement each other. However, the analysis of sufficiency is much more elaborate as it produces the truth table and leads the steps to the minimization process. Sufficiency is explained as the all-time presence of condition X whenever Y is present as well. Furthermore, as Y is a superset of X, the condition cannot be present when ~Y. The logical conclusion of this set relation is that Y is much bigger and explained by more factors than X, which often is an empirical reality. In fuzzy-sets mathematically, condition X always has to have a smaller value than Y to be sufficient for it. Seen as a XY plot, all points of X should be above the diagonal line of the graph (see figure 4). Situations as presented in figure 4 are exemplary cases.

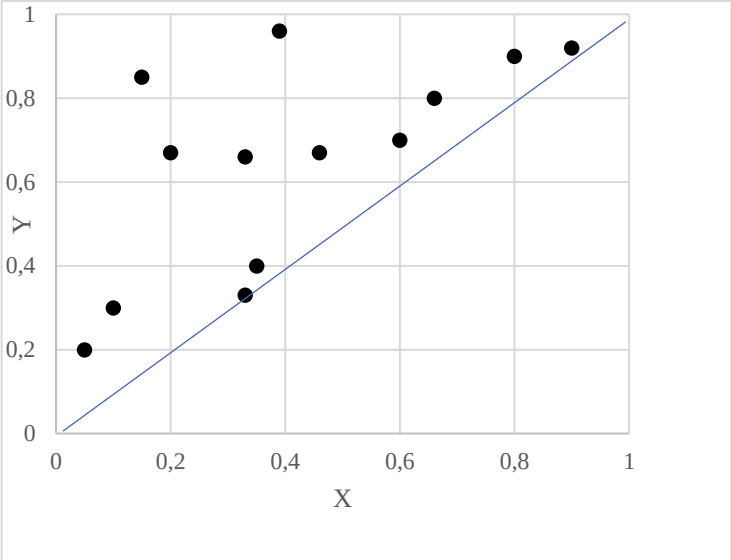


Figure 4: Graphical representation of perfect fuzzy sufficiency (example with own random data)

In empirical data, some cases might be below the diagonal line and therefore lower the sufficiency score, which is measured with consistency (sometimes also referred to as inclusion).

Assuming a perfect subset relation between X and Y, the consistency value checks the deviation of empirical data from this perfect relation and is expressed with the formula:

$$Consistency_{Sufficient\ conditions\ (X_i \leq Y_i)} = \frac{\sum_{i=1}^{1} \min(X_i, Y_i)}{\sum_{i=1}^{1} X_i}$$

Another familiar parameter of fit for sufficiency is coverage. This parameter indicates how much of Y is explained with X. It is seen as a "relation in size between the subset (X) and the superset (Y)" (Schneider and Wagemann 2012, 129). Coverage is somewhat similar in its meaning to R^2 in statistical modelling (Duşa 2019; Legewie 2013). The formula for coverage again is complementary to consistency but the same as consistency of necessary conditions:

$$Coverage_{Sufficient\ conditions\ (X_i \leq Y_i)} = \frac{\sum_{i=1}^{1} \min(X_i, Y_i)}{\sum_{i=1}^{1} Y_i}$$

The suggested threshold for consistency for sufficient conditions is ≥ 0.75, but for coverage, there is no standard threshold. However, coverage should be at least 0.5 for the condition to be somehow relevant. This can be adjusted to specific situations.

In R the *QCAfit* function can also programme results for analysis of sufficiency for individual conditions. It also includes the parameter PRI (proportional reduction in inconsistency), which helps in cases where X is sufficient both for Y and ~Y.

```
> QCAfit(mun[, -the_outcome_column], mun$OUTCOME, necessity = FALSE)
```

The results in table 8 show, that there are no individual sufficient conditions with consistency ≥0.75, so that the PRI value was not a necessary parameter here. Consistency as well as coverage are ranging between 0.60 and 0.76 and indicate some medium important value. Although individually they are not sufficient, it now seems plausible that combinations might be.

	Consistency	**Coverage**	**PRI**
INH	0.64	0.60	0.48
NAT	0.68	0.63	0.50
COM	0.66	0.76	0.53
PAR	0.72	0.76	0.58
~INH	0.59	0.60	0.39
~NAT	0.60	0.63	0.41
~COM	0.48	0.39	0.24
~PAR	0.60	0.55	0.33

Table 8: Results of the analysis of sufficiency with the R function QCAfit

The core of the fsQCA is constructing a truth table, which explores the sufficiency of combinations of conditions. At this step, conditions are represented as configurations, which is a fundamental logic of the QCA truth table. The analysis before used a bottom-up approach to finding sufficient conditions, whereas the truth table looks from top-down, which is easier to perform the logical minimization later on (Schneider and Wagemann 2012). Each row of a truth table represents the possible combinations of conditions, which leads to the formula 2^k, where k are the conditions. In this case it

means k= 4 conditions, so that the truth table has 16 possible combinations and rows – which also implies that there are 16 possible cases.

For the analysis, the truth table is constructed with the function *truthTable*, which uses an updated procedure to calculate fsQCA to vector corners. The inclusion score was set at 0.75, as is the standard sufficiency threshold. The truth table below shows in total 13 out of 16 possible cases are empirically evident. Three possible rows are not shown in the truth table, because they do not appear in the data I used. Those are called *logical remainders*. While in crisp-set QCA, logical remainders are "simply those rows without enough cases in them" (Schneider and Wagemann 2012, 152) for fuzzy-sets it is more difficult to determine logical remainders, because all cases have a membership score in all paths. Conventionally, one would consider a path a logical remainder if no case has membership score in it higher than 0.5.

The first seven rows or paths of the truth table below have the outcome assigned with 1, indicating that those rows are sufficient. Out of 16 possible conjunctions, 13 are empirically observed, which means that 3 rows are *logical remainders* (rows 1, 3 and 15) and the analysis therefore shows *limited diversity*. Logical remainders in fuzzy-sets are defined as "a truth table row that does not contain enough cases with a fuzzy-set membership score higher than 0.5" (Schneider and Wagemann 2012, 152). Here, the logical remainders are so called *clustered remainders*, because the empirical cases are grouped in different countries with the same structural processes (ibid.). However, limited diversity is a frequent and quite normal occurrence in comparative studies and will be considered in later steps to create the solution formula. To get the truth table constructed in R, the formula *truthTable* with the inclusion score 0.8 was used here:

```
>truthTable(mun, outcome = c("OUTCOME"),conditions = c("INH","COM",
"NAT", "PAR"), incl.cut = 0.8, show.cases = TRUE, sort = "incl")
```

Row	INH	COM	NAT	PAR	OUT	n	Incl.	PRI	cases
16	**1**	**1**	**1**	**1**	**1**	**3**	**0.934**	**0.859**	**AGD, SET, VIA**
6	**0**	**1**	**0**	**1**	**1**	**1**	**0.909**	**0.801**	**BIE**
8	**0**	**1**	**1**	**1**	**1**	**1**	**0.909**	**0.752**	**COR**
2	**0**	**0**	**0**	**1**	**1**	**2**	**0.901**	**0.754**	**MIL, PRE**
5	**0**	**1**	**0**	**0**	**1**	**2**	**0.845**	**0.665**	**PIS, SZT**
7	0	1	1	0	1	1	0.798	0.496	DOR
13	1	1	0	0	1	1	0.798	0.496	JAS
12	1	0	1	1	0	1	0.716	0.34	LOU
1	0	0	0	0	0	3	0.712	0.333	CIE, PRA, ROZ
14	1	1	0	1	0	5	0.711	0.498	ALI, BUZ, DEV, RAM, ZAL
4	0	0	1	1	0	3	0.631	0.196	ANS, FAR, SYR
11	1	0	1	0	0	1	0.569	0	KAL
9	1	0	0	0	0	1	0.554	0	ZAM

Table 9: Truth table sorted with assigned cases

The five identified sufficient paths can be named **primitive expressions** (Schneider and Wagemann 2012) and a first formula of those rows is:

Row 16 + row 6 + row 8 + row 2 + row 5

INH COM NAT PAR + inh COM nat PAR + inh COM NAT PAR + inh com nat PAR + inh COM nat par

This formula is not very handy and should only serve as describing the truth table more closely for now. Not only the OUTCOME (PRIO) can be tested in a truth table, but also ~OUTCOME, which is helpful to determine contradictory prime implicants and refine the solution formula in the next step. The truth table testing ~OUTCOME is displayed in the Annex E. Although the standard for sufficiency is 0.75, for this truth table the higher value 0.8 was used to exclude rows 7 and 13, which prove as contradictory rows when compared with the truth table of ~OUTCOME. From the empirical reality, I allocate them rather to ~OUTCOME and therefore set the threshold for sufficiency higher. In *Chapter 6* those two cases and their exclusion from the sufficient paths will be explained in more detail.

5.4. Logical minimization

The sufficient paths from the truth table are not yet very informative and the intermediate solution term from 5.3 is too complex to draw general conclusions from it.

The minimization process therefore is an important step to come to common, general "causal recipies" (Legewie 2013). The formula *minimize* executes the logical minimization with data from the truth table. Nowadays, three different algorithms can be used: from the standard Quine-McCluskey, the enhanced Quine-McCluskey and the most recently developed Consistency Cubes (Duşa 2019). Solutions can be drawn in different ways, integrating logical remainders or not. The complex, or mostly referred to as conservative solution only takes paths with the outcome present and no logical remainders at all. The complex solution formula drawn from the truth table above therefore shows three paths, also referred to as prime implicants.

The conservative solution formula is calculated with:

```
> minimize(ttmun, details = TRUE)
```

It transforms the five paths detected as sufficient in the truth table into three *prime implicants*. If the conservative solution is still too complicated, the parsimonious solution integrates all logical remainders. As a third strategy to find a workable solution formula, the intermediate solution only integrates selected logical remainders (Duşa 2019; Schneider and Wagemann 2012). For this analysis, the conservative solution is already in good shape to detect relevant prime implicants and draw theoretical conclusions from it, so that the parsimonious solution does not produce any more valuable results.

The minimization of the truth table with ~OUTCOME is best calculated as parsimonious solution and produces four prime implicants. The relevant steps and results are shown in the Annex E.

5.5. Solution formula

The final solution formula out of the QCA after all the steps conducted is:

inh*COM*nat + inh*nat*PAR + COM*NAT*PAR => OUTCOME

It contains three prime implicants and indicates that those are sufficient, but not necessary. The solution formula has an overall consistency score of 0.824 and coverage of 0.736, which are high enough scores to be valuable results. The three paths are described in detail in table 10 below.

		inclS	PRI	covS	covU	cases
1	inh*COM*nat	0.799	0.625	0.314	0.053	PIS, SZT; BIE
2	inh*nat*PAR	0.883	0.753	0.393	0.132	MIL, PRE; BIE
3	COM*NAT*PAR	0.858	0.73	0.472	0.29	COR; AGD, SET, VIA
	M1	**0.824**	**0.687**	**0.736**		

Table 10: Prime implicants with inclusion and coverage scores

The visualization of the solution formula with an XY plot shows that most of the cases are above the diagonal line and therefore explain also the inclusion score of 0.824 and the PRI of 0.687, which are both sufficiently high to suggest a robust solution formula. Not all cases are explained with those solution formula, as there is no perfect sufficiency, which is marked by the dots below the diagonal line.

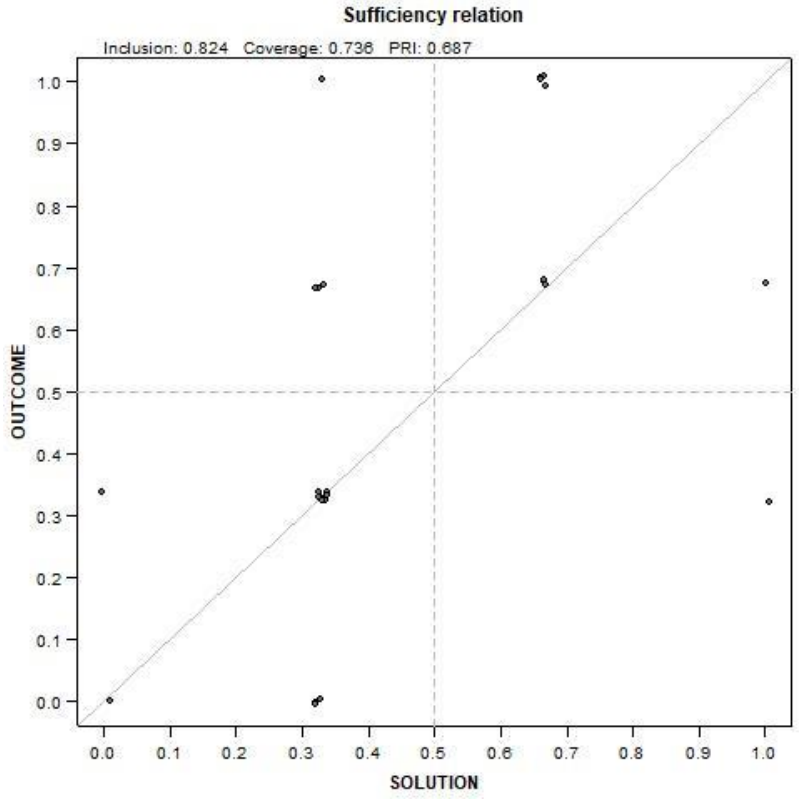


Figure 5: Graphic representation of solution formula in XY plot

5.6. Summary

Now, all relevant steps of a fsQCA have been carried out containing the analysis of necessity, which did not yield any conditions and the analysis of sufficiency. The truth table revealed five sufficient paths after two counterfactuals were excluded. The logical minimization was conducted with the conservative solution and resulted in the solution formula with three prime implicants which was presented previously. The results of the analysis, also including the solution formula for ~OUTCOME will be discussed in the next chapter. Relevant XY plots, additional tables and outputs from the QCA conducted with R are displayed in the Annex.

6. Discussion

Out of the data set of 25 municipalities from five different countries in Europe, the QCA was designed to test enabling conditions like city networks, the national climate policy and local political tendencies. The solution formula revealed three prime implicants, which now will be addressed and discussed in detail. It is important to draw the right conclusions from the solution formula and address several limits of the analysis.

6.1. Objectives of the chapter

A detailed explanation of the results from above is necessary at this point. The chapter aims to:

- **Make sense of the QCA results.** The steps of the fsQCA have been explained above and the findings are discussed closely in this chapter to understand and interpret the solution formula.

- **Discuss limits of the process and the results.** Several limits of the material, the method in general and the propositions made are analysed. This is important to embed the thesis in context and draw the right conclusions.

- **Hint to further implications for research and policy.** Some ideas are derived from the results of the QCA, which could lead to further research for small- and medium-sized municipalities in Eastern and Southern Europe but the issue of local climate action is already high up on the research agenda. Also climate policies can be arranged to better align with the local level, drawing on the conclusions from research.

6.2. Summary of the findings

Municipalities of all sizes and in all countries are motivated and currently working to implement climate action. Their level of experience and situation varies quite throughout the dataset so that not one stringent way of approaching climate action can be seen.

The analysis generally supports the claim for looking at local climate action differently because no single factors hardly ever are decisive for an ambitious outcome. The collection of data on those municipalities, which have not yet been subject to scientific disposure, is a first step to recalibrate the focus to more research on the local level, especially if national governments are not striving for a sustainable future. The thesis shows that local climate action happens everywhere, also in small municipalities and outside the big innovative hubs – but of course in different pace and scale. Interestingly, national climate policy seems not to have such a strong impact on the local level implementation.

The solution formula explains five paths of the truth table, which include nine cases and results in three prime implicants. It is quite surprising that the issue of size was not detected as a strong indicator for being a forerunner in climate action (among a set of small- to medium -sized municipalities). Furthermore, the first two prime implicants also contradict the hypothesis A) and B) which suggest that more than one enabling condition should be present for small municipalities to be successful. Local parties seem to have an influence on the level of climate action, as does a horizontally structured network like the CoM.

The last path suggests that if horizontal networks, national climate policies and local parties are strong, also climate action will be prioritized highly in municipalities, independently of being a smaller or larger municipality. While this result might seem obvious, it also indicates that the interplay of different factors and well-aligned goals lead to success, which is a central claim from multi-level governance.

For the interpretation of the results also the solution formula for ~OUTCOME is important because, due to causal asymmetry, results are not automatically mirrored. The parsimonious solution formula for ~OUTCOME is:

INH*par + com*NAT + com*par + NAT*par => ~OUTCOME

If local parties are conservative or right-wing populist (“par”), the tendency is higher to have a low level of ambition, even in larger municipalities of the dataset (“INH”). So hypothesis D) is supported here (although not in the exact formula, but the idea). Whereas the national level seems to have a rather limited impact for OUTCOME, its

presence for ~OUTCOME suggests that there is a low relevance as a single factor, but combined with horizontal and local level, it leads to good results.

Due to the fact that the condition NAT is identical for all five cases in one country, a regional pattern emerges out of the solution formula. The paths one and two only explain paths with cases from Eastern European countries (Poland and Czech Republic), whereas the third path covers Southern Europe. All five Romanian cases are covered with path 14.

After the finding that path seven and 13 are counterfactuals because they are both important for the OUTCOME solution formula as well as for ~OUTCOME, I assigned them to ~OUTCOME for two reasons. First, the inclusion score is slightly higher for ~OUTCOME (0.801 compared to 0.798) but also the path seven, which would be COM*NAT and 13 (INH*COM) only are empirically found in one case each. Those cases are not known for being very experienced in climate action so that from my working knowledge I did not expect them to be considered ambitious. So I adapted the inclusion score from 0.75 to 0.8 to assign every path to one concrete outcome.

On the other side, path 14, which symbolizes INH*COM*PAR, includes five cases. Those are all five Romanian municipalities and in reality they have very different points of experience and level of ambition. I would disagree with this finding that none of the Romanian cases are very ambitions due to my work experience. A deeper understanding of the cases would be necessary to explain the results. But due to limits of time, the issue could not be solved here. This calls for a closer look in the cases and points to some limits of the method or material, which will be discussed below.

6.3. Limits of materials

To my knowledge, the analysis was one of the first ones that studies this dataset and those cases, which usually are too small and not visible for scientific research. Only one or two municipalities were previously part of studies or have been mentioned in relation to pioneering ideas on the local level. As the dataset was built up on the basis of all municipalities participating in a project about local climate action, these results are not representative for local climate action in Europe or the five countries of analysis. Only municipalities which generally would have some interest to work on local climate action applied and take part in the project. The many that do currently not show any interest

are left out of the analysis. However, this should not suggest that results are not valuable, but to be seen with a limited explanation power for all municipalities across those countries.

The collection of material was limited for two reasons. First, data often was only available in the particular language and seldom in English. Online translation was used in many cases. Not all representatives of municipalities speak English so that also the pool of initial interviews was limited to those people who could give an interview. Internal administrative situation plays a key role according to interviews but was not considered when hypothesize about enabling factors. Motivated city planners can be important drivers of the process and might even be a necessary condition for good implementation, but assessing such data is difficult.

Secondly, municipalities are rather sensitive to being the objective of the analysis and feared to be shown in a bad light or "ranked poorly". Therefore, municipalities are kept anonymous and no project-sensitive data was used for the analysis. The knowledge of cases presented is in reality much deeper than a couple of conditions. Individual in-depth case studies would be a valuable research project for such small and medium sized municipalities, to get to know the specific situation of the municipality including financing mechanisms.

At the beginning, the argument of a lack of financial options for climate action was raised, but not integrated in the analysis for several reasons. In two interviews finance was not mentioned as the challenge but rather the knowledge to apply to existing funding options, which are plenty, mainly from the European Union and a couple of municipalities, which are in dept, still could realize project through funding. This already indicates that a condition about finance would be hard to justify, since debt was not seen as a barrier to climate action. Generally, the financing of climate action is an issue, currently also debated within the European Green Deal. But for this analysis, the material collected was too inconsistent to make sense of the different options and financing mechanisms. Local climate finance would be an interesting topic for further studies.

6.4. Limits of QCA

QCA was suggested by several scientists (Kemmerzell 2018; Lamb et al. 2019; van der Heijden 2019) as a valuable method for analysing local climate action. As this analysis with a fsQCA provided some new insights to smaller municipalities I agree that the method is a useful tool. However, many factors could not be integrated or had to be simplified to construct a truth table and provide a solution formula. Only four conditions were chosen in the end to be used as enabling conditions, but the reality might even be more complex. I explicitly used the fuzzy-set values instead of crisp-set, because for this case constructing a black and white dataset was just too much of a simplification of a complex reality.

QCA is a living method and not as stringent as presented in *Chapter 5*. The process presented is the final one, but many trials and steps in between actually where taken and this is one central feature of the method. Going back and forth during the process on the one side ensures to get meaningful results but also makes it the more difficult for outsiders to follow. A critique which is made very often for QCA is that the calibration process or the conditions are modified until a significant result can be presented.

Furthermore, replicability in this method is difficult if the whole process is not made transparent, which is generally a disadvantage of QCA. Therefore, transparency is a key component for researchers using QCA to keep in mind. In my specific case prior to a QCA in-depth case studies of those municipalities would have been an interesting step, which could have provided a more detailed picture of local climate action in smaller municipalities in Southern and Eastern Europe, as there is a scientific gap for those studies. Analysing 25 cases however was not inside the time or space frame of this thesis.

6.5. Limits of the proposition

The assumptions raised not only came through literature but also due to the familiarity with the cases and work experience, which might bias results into wishful thinking. This analysis cannot function as a generalization for municipalities in those countries or of a specific size or characteristics but can only describe those actions of the dataset – and also here only partly.

As has been stated before, not every possible factor could be integrated in the analysis. The governmental structure was not fully projecting reality, as only the national level was one condition. The five countries are unitary states with district levels or some

intermediate governance level which also has regulatory power or even holds funds available.

Furthermore, the outcome was taken for granted as an implementation guarantee, but no monitoring of actual implemented actions was conducted. However, having this material available is still one step closer to the actual implementation than analysing planning documents.

6.6. Implications for research

The results show that small- and medium sized municipalities are actively seeking ways to implement climate action in different contexts. The question of how they best can be supported when willingness and motivation has been stated can be answered for those cases now. Horizonal networks for cooperation like the CoM but also local parties pushing the issue on the agenda can be facilitators even for small municipalities when national policies are weak. But the best way to support is, if all conditions mentioned work together and go hand in hand to support municipalities. This calls for more research in multi-level governance to identify gaps and how to align the levels better.

Polycentric systems might be beneficial for cities which have the capacity to govern quite independently with the necessary knowledge and budget, but for small- and medium-sized municipalities at the beginning of their transformational process, a good government structure can help. An interesting question, which could not be addressed here is how and why those municipalities decide to implement climate action, because none of those countries has an obligatory local climate policy. To find the driver of starting climate action voluntarily could also trigger others to do so.

The scientific interest for climate issues on the local level is globally rising, but I already indicated some existing gaps, which I wanted to dig into with this thesis. More research is needed to understand how mechanisms work for unexperienced small municipalities or local entities. A “leave no one behind” approach should be more present in current and future research to support motivated municipalities to be part of the transition we as a whole generation have to face.

More on the ground research and case studies can provide valuable lessons for understudied areas like Eastern European municipalities. In specific, the result of this analysis showed that the argument of “size matters” is not a necessary condition but

other factors motivate also smaller municipalities. Research needs to refocus from studying the pioneers of climate action towards the black box of followers or even deniers of local climate action and determine supportive mechanisms. Furthermore, a new line of research currently is evolving around climate change and political parties' influence. The results here also point to a vital role of parties on the local level, more so if climate action is neglected than being pushed by the parties. With the ongoing right-wing wave across Europe, studying right-wing parties influence on climate policy will become a more pressing issue, which we currently know little about.

6.7. Implications for policy

Projects like the one analysed here are getting more and more, as the local actors are stepping up and establishing themselves as important players on the table of international climate negotiations. This trend is out of question. The analysis just added another proof. Climate policy is not a side issue anymore, also not for the often called "laggards". Especially when national governments bloc ambitious effort in climate policy, the regional and local level can be approached and often show willingness to act. Results hint to more stringent policy at all levels and more cooperation between levels. It seems that multi-level governance – horizontally and vertically- could be a worthwhile concept for the future of climate action – from international to local aspects. The results of the QCA pinpoint once again that there is no single solution and not one lever that needs to be pushed. Rather, a whole system, aligned to each other gives the highest chance for successful climate action. Politicians, administrators and climate negotiators should know that.

It is helpful to know for mayors of towns, who might join the CoM that step is beneficial for them. But also national governments can be in closer contact to their colleagues "on the ground" to develop fitting policies and government regulations, which can be implemented locally. The Paris Agreement should be a guideline affecting all levels of government. The issue of financing those local climate action will be one of the major discussion points. For local leaders, there is a clear signal that you can have an impact in your municipality with local climate action. But institutions and research should support motivated leaders and have fitting tools at hand. If plausible steps are taken to reach agreed goals, citizen might be convinced easier to strive for a common goal.

6.8. Summary

The results of my fsQCA are not entirely surprising but add another piece to solving the puzzle of good climate governance. Although several limits had to be taken to conduct this analysis, it provides a valuable insight to what, how, and under what circumstances local climate action is prioritized. The findings hint to a concept of multi-level governance being a good enabler, independent of size of the municipality. Researchers, governments and political institutions still have work to do to find the best working mechanisms, which vary from case to case but should support as many municipalities as possible. Not only the drivers for climate action, but also the stumbling blocks need to be identified.

7. Conclusion

Cities are becoming leaders in climate action and show ambitious goals for a sustainable future. They increasingly influence the international climate negotiations. But this analysis has shown that also small- and medium-sized municipalities are taking climate change mitigation seriously. They not only develop sustainable mobility plans or smart city concepts, but also implement climate action, mostly in the area of energy management, building retrofitting, mobility or energy production. Even if national governments are blocking efforts of climate policies like Poland and Czech Republic, municipalities are finding ways to get funding for their activities and try to reduce emissions. By far, this cannot yet be a generalization of municipal climate action in Eastern and Southern Europe, but a start to recognize their activities.

The objective of the thesis was twofold. First, the contribution to research was to start filling gaps and overcome biases of local action being studied in metropolitan areas. Also, and especially small municipalities need to be considered. They will not bring tremendous emission reduction but will foster acceptance and the willingness to act among citizens. There was little data available for those regions, especially Eastern Europe. In Southern Europe, namely Portugal, people get more and more affected by climate hazards like fires and droughts and think about ways to cope with a changing climate. The national governments also took relevant steps to reduce emissions like phasing-out coal fired power plants. Efforts are quite diverging from country to country.

Second objective of the thesis was to touch upon political measures which could be taken. The concept of multi-level climate governance could be supportive towards local climate action and bridging international with local goals, while polycentricity might be a better suitable concept for big cities with own capacities. The fuzzy-set QCA results can be interpreted as a good sign for that, although they have a very limited scope and a generalization of the findings would be too soon. In detail, national governments, the Covenant as a transnational network as well as local parties in council have been identified as enabling conditions for some cases. If combined, these hint to more local climate activities. But both the CoM and also local parties in council can enable climate action even if municipalities are small and national climate policies might be weak. Contrary, not participating in the CoM and if local parties are rather conservative or right-wing, the tendency for a low priority to climate action is higher. Therefore, it looks like multi-level

climate governance could support municipalities in their activities, if those levels are well aligned with each other.

The idea of polycentricity might be harder to apply to small municipalities as they are not as independent, not have enough own financial and resource capacity or knowledge to develop innovative formats. In this analysis, the surprising result is that the size of a municipality is not a strong enabling condition for setting high priorities on climate action. That result points even more to the claim that more attention needs to be shifted to such motivated small- and medium-sized municipalities, both from politicians as well as from research. More detailed research is necessary in this field to determine general enabling factors and advice governments on how to cooperate better among different levels. Researchers might need to build interdisciplinary teams to tackle those question of how to govern, which regulations work as well as what kind of emission reductions can be expected from small-and medium-sized municipalities. Climate change is a challenge that cannot leave anyone behind.

8. References

Aceleanu, Mirela I., Andreea C. Șerban, Diana M. Pociovălișteanu, and Gina C. Dimian. 2017. "Renewable energy: A way for a sustainable development in Romania." *Energy Sources, Part B: Economics, Planning, and Policy* 12 (11): 958–63.

Acuto, Michele, and Susan Parnell. 2016. "Leave no city behind." *Science (New York, N.Y.)* 352 (6288): 873.

Adriázola, Paola, Eleni Dellas, and Dennis Tänzler. 2018. *Multi-Level Climate Governance Supporting Local Action*. Berlin: adelphi consult GmbH.

Agora Energiewende. 2019. *Climate (Un)ambition in South East Europe: - A Critical Assessment of the Draft National Energy and Climate Plans*. Berlin. https://www.agora-energiewende.de/fileadmin2/Projekte/2019/Climate_Un-ambition_SEE/162_Climate_Un-ambition_SEE_WEB.pdf.

Alessandrini, Michele, Pietro Celotti, Andrea Gramillano, and Marco Lilla. 2017. *The future of industry in Europe*. European Union. https://espas.secure.europarl.europa.eu/orbis/sites/default/files/generated/document/en/report_future_industry_form_pdf.pdf.

Andreas, Jan-Justus, Charlotte Burns, and Julia Touza. 2019. "Portugal under austerity: from financial to renewable crisis?" *Environmental Research Communications* 1 (9): 91005.

Araos, Malcolm, Lea Berrang-Ford, James D. Ford, Stephanie E. Austin, Robbert Biesbroek, and Alexandra Lesnikowski. 2016. "Climate change adaptation planning in large cities: A systematic global assessment." *Environmental Science & Policy* 66: 375–82.

Azevedo, Isabel, Isabel Horta, and Vítor M.S. Leal. 2017. "Analysis of the relationship between local climate change mitigation actions and greenhouse gas emissions – Empirical insights." *Energy Policy* 111: 204–13.

Bäckstrand, Karin, Jonathan W. Kuyper, Björn-Ola Linnér, and Eva Lövbrand. 2017. "Non-state actors in global climate governance: from Copenhagen to Paris and beyond." *Environmental Politics* 26 (4): 561–79.

Bae, Jungah, and Richard Feiock. 2012. "Forms of Government and Climate Change Policies in US Cities." *Urban Studies* 50 (4): 776–88.

Baldersheim, H., J. Bucek, and P. Swianiewicz. 2002. "Mayors Learning across Borders: The International Networks of Municipalities in East-Central Europe." *Regional & Federal Studies* 12 (1): 126–37.

Bazaz, Amir, Paolo Bertoldi, Marcos Buckeridge, Anton Cartwright, Heleen de Coninck, Francois Engelbrecht, Daniela Jacob, Jean-Charles Hourcade, Ian Klaus, Kiane de Kleijne, Shauib Lwasa, Claire Markgraf, Peter Newman, Aromar Revi, Joeri Rogelj, Seth Schultz, Drew Shindell, Chandni Singh, William Solecki, Linda Steg, and Henri Waisman. 2018. *Summary for Urban Policymakers: - What the IPCC Special Report on 1.5C Means for Cities*.

Bellali, Johara, Lisa Strauch, Francis Oremo, and Benson Ochieng. 2018. *Multi-level climate governance in Kenya: Activating mechanisms for climate action*. Berlin: adelphi consult GmbH.

Block, Debora de, and Barbara Vis. 2018. "Addressing the Challenges Related to Transforming Qualitative Into Quantitative Data in Qualitative Comparative Analysis." *Journal of Mixed Methods Research* 14 (6): 503-535.

Bloomberg Philanthropies. 2019. *Accelerating America´s pledge: Going all-in to build a prosperous, low-carbon economy for the United States*. New York. https://www.bbhub.io/dotorg/sites/28/2019/12/Accelerating-Americas-Pledge.pdf (Accessed January 19, 2020).

BMU. 2020. “What is climate action? : General information.” BMU. https://www.bmu.de/en/topics/climate-energy/climate/what-is-climate-action-about/ (January 25, 2020).

Bulkeley, Harriet, and Michele Betsill. 2005. “Rethinking Sustainable Cities: Multilevel Governance and the 'Urban' Politics of Climate Change.” *Environmental Politics* 14 (1): 42–63.

Bulkeley, Harriet, and Michele M. Betsill. 2003. *Cities and climate change: Urban sustainability and global environmental governance* [eng]. Vol. 4 of *Routledge studies in physical geography and environment*. London, New York: Routledge.

Bulkeley, Harriet, and Vanesa Castán Broto. 2013. “Government by experiment?: Global cities and the governing of climate change.” *Transactions of the Institute of British Geographers* 38 (3): 361–75.

Burck, Jan, Ursula Hagen, Franziska Marten, Niklas Höhne, and Christoph Bals. 2018. *Climate Change Performance Index: Results 2019*. Germanwatch. www.germanwatch.org/en/16073.

Busch, Henner. 2015. “Linked for action?: An analysis of transnational municipal climate networks in Germany.” *International Journal of Urban Sustainable Development* 7 (2): 213–31.

Campos, Inês, João Guerra, José F. Gomes, Luísa Schmidt, Filipe Alves, André Vizinho, and Gil P. Lopes. 2017. “Understanding climate change policy and action in Portuguese municipalities: A survey.” *Land Use Policy* 62: 68–78.

Capizzi, Pasquale, Emily Castro, Ingrid Gonzalez, Robert Kehew, Jakob Lindemann, Patricia Lizarazo, Tangmar Marmon, and Maryke van Staden. 2017. *Enabling subnational climate action through multi-level governance*. Bonn: GIZ, UN-Habitat and ICLEI. https://www.international-climate-initiative.com/fileadmin/Dokumente/2017/GIZ_ICLEI_UNHabitat_2017_EN_Enabling_subnational_climate_action.pdf.

Carlisle, Keith, and Rebecca L. Gruby. 2019. “Polycentric Systems of Governance: A Theoretical Model for the Commons.” *Policy Studies Journal* 47 (4): 927–52.

CEMR. 2016. *Local and Regional Governments in Europe: Structures and Competences*. Brussels: CEMR. https://www.ccre.org/img/uploads/piecesjointe/filename/CEMR_structures_and_competences_2016_EN.pdf.

Chow, Denise. 2019. “In wake of Trump's withdrawal from Paris climate accord, small-town USA says 'we are still in'.” *NBC News*, December 11. https://www.nbcnews.com/science/environment/city-led-lights-how-carmel-indiana-other-u-s-cities-n1099336.

Cole, Daniel H. 2015. “Advantages of a polycentric approach to climate change policy.” *Nature Climate Change* 5 (2): 114–18.

Delbeke, Jos, and Peter Vis, eds. 2016. *EU Climate Policy Explained*.

Dennison, Susi, and Livia Franco. 2019. *The instinctive multilateralist: : Portugal and the politics of cooperation*. European Council on Foreign Relations. https://www.ecfr.eu/page/-/instinctive_multilateralist_portugal_politics_cooperation.pdf.

Dijkstra, Lewis, and Hugo Poelman. 2012. *Cities in Europe: The new OECD-EC definition*. European Commission, OECD and European Committee of the Regions. https://ec.europa.eu/regional_policy/sources/docgener/focus/2012_01_city.pdf.

Dudău, Radu, and Mihnea Cătuţi. 2019. "The Decarbonisation Challenge of Southeast Europe: A Case Study of Romania." *Intereconomics* 54 (6): 341–46.

Duşa, Adrian. 2019. *QCA with R*. Cham: Springer International Publishing.

ESPON. 2014. *Town: Small and medium sized towns in their functional territorial context*. Final Report. Luxembourg: ESPON.

EU Energy Poverty Observatory. 2019. *Member State Report: Romania*. https://www.energypoverty.eu/sites/default/files/downloads/observatory-documents/19-06/member_state_report_-_romania.pdf.

Europe beyond Coal. 2019. *Overview: National coal phase-out announcements in Europe: Status September 2019*.

European Commission. 2018. *A Clean Planet for all: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*. Brussels. COM/2018/773. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0773&from=EN.

———. 2019a. *Communication from the Commission to the European Parliament,the Council, the European Economic and Social Committee and the Committee of the Regions: United in delivering the Energy Union and Climate Action - Setting the foundations for a successful clean energy transition*. Brussels: European Commission.

———. 2019b. *Czechia: Summary of the Commission assessment of the draft National Energy and Climate Plan 2021-2030*. Brussels: European Commission. https://ec.europa.eu/energy/sites/ener/files/documents/necp_factsheet_cz_final.pdf.

———. 2019c. *Greece: Summary of the Commission assessment of the draft National Energy and Climate Plan 2021-2030*. European Commission. https://ec.europa.eu/energy/sites/ener/files/documents/necp_factsheet_el_final.pdf.

———. 2019d. *Poland: Summary of the Commission assessment of the draft National Energy and Climate Plan 2021-2030*. https://ec.europa.eu/energy/sites/ener/files/documents/necp_factsheet_pl_final.pdf.

European Environmental Agency. 2018. *National policies and measures on climate change mitigation in Europe in 2017: Technical overview of the information reported by Member States under the European Union's climate monitoring mechanism regulation*. No 9/2018 of *EEA report*. Luxembourg: Publications Office.

Evans, Henry E., and Adam Easton. 2019. "Poland revises draft energy policy to 2040." Warsaw: S&P Global Patts. https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/110819-poland-revises-draft-energy-policy-to-2040.

Finn, Donovan, and Lynn McCormick. 2011. "Urban climate change plans: How holistic?" *Local Environment* 16 (4): 397–416.

Gancheva, Mariya, Argyro Kepesidi, and Sarah O'Brien. 2019. *The role of local and regional authorities in National Energy and Climate Plans taking into account the recommendations by the European Commission*. Brussels.

Gendzwill, Adam, and Pawel Swianiewicz. 2016. “Does Local Democracy Perform Better in Smaller Jurisdictions?: Survey Evidence from Poland.” *Lex localis - Journal of Local Self-Government* 14 (4): 759–82.

Getimis, Panayiotis. 2007. *EU enlargement and multi-level governance in European regional and environment policies: patterns of learning, adaptation and Europeanization among cohesion countries (greece, ireland, portugal) and lessons for new members (Hungary, Poland): Adapt, final report*. Luxembourg.

GGCA. 2020. “Frequently asked questions about the climate groundswell.” http://www.climategroundswell.org/.

Giannakopoulos, Christos, Effie Kostopoulou, Konstantinos V. Varotsos, Kostas Tziotziou, and Achilleas Plitharas. 2011. “An integrated assessment of climate change impacts for Greece in the near future.” *Regional Environmental Change* 11 (4): 829–43.

Guarascio, Francesco. 2019. “Europe to consider law on climate neutrality by March.” *Reuters*, November 29. https://www.reuters.com/article/us-eu-climate/europe-to-consider-law-on-climate-neutrality-by-march-idUSKBN1Y31BL (Accessed December 7, 2019).

Hale, Thomas. 2016. ““All Hands on Deck”: The Paris Agreement and Nonstate Climate Action.” *Global Environmental Politics* 16 (3): 12–22.

Hardin, Garrett. 1968. “The tragedy of the commons.” [eng]. *Science (New York, N.Y.)* 162 (3859): 1243–48.

Heidrich, O., D. Reckien, M. Olazabal, A. Foley, M. Salvia, S. de Gregorio Hurtado, H. Orru, J. Flacke, D. Geneletti, F. Pietrapertosa, J. J.-P. Hamann, A. Tiwary, E. Feliu, and R. J. Dawson. 2016. “National climate policies across Europe and their impacts on cities strategies.” *Journal of environmental management* 168: 36–45.

Heikkinen, Milja, Tuomas Ylä-Anttila, and Sirkku Juhola. 2018. “Incremental, reformistic or transformational: What kind of change do C40 cities advocate to deal with climate change?” *Journal of Environmental Policy & Planning* 21 (1): 90–103.

Hennessey, Ryan, Jeremy Pittman, Annette Morand, and Allan Douglas. 2017. “Co-benefits of integrating climate change adaptation and mitigation in the Canadian energy sector.” *Energy Policy* 111: 214–21.

Hiscock, Rosemary, Arja Asikainen, Jouni Tuomisto, Matti Jantunen, Erkki Pärjälä, and Clive E. Sabel. 2017. “City scale climate change policies: Do they matter for wellbeing?” [eng]. *Preventive medicine reports* 6: 265–70.

Homsy, George C. 2018a. “Size, Sustainability, and Urban Climate Planning in a Multilevel Governance Framework.” In *Climate Change in Cities: Innovations in Multi-Level Governance*. *The Urban Book Series*, eds. Sara Hughes, Eric K. Chu and Susan G. Mason. Cham: Springer International Publishing, 19–38.

———. 2018b. “Unlikely pioneers: Creative climate change policymaking in smaller U.S. cities.” *Journal of Environmental Studies and Sciences* 8 (2): 121–31.

Homsy, George C., and Mildred E. Warner. 2012. “Cities and Sustainability.” *Urban Affairs Review* 51 (1): 46–73.

Hsu, Angel, John Brandt, Oscar Widerberg, Sander Chan, and Amy Weinfurter. 2019. "Exploring links between national climate strategies and non-state and subnational climate action in nationally determined contributions (NDCs)."

Ioannis, Panos. 2016. "Successive local government institutional reforms in Greece: From regionalization to regionalism?" *East West Journal of Economics and Business* 14: 99–131.

IPCC. 2018. *Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf.

Jordan, Andrew, Dave Huitema, Harro van Asselt, and Johanna Forster. 2018. *Governing Climate Change*. Cambridge University Press.

Kamenders, Agris, Marika Rosa, and Kristaps Kass. 2017. "Low carbon municipalities. The impact of energy management on climate mitigation at local scale." *Energy Procedia* 128: 172–78.

Kemmerzell, Jörg. 2018. "Innovations in European Climate Governance and Their Impact on LocalClimate Policy: An Analysis of German Major Cities." In *Climate Change in Cities: Innovations in Multi-Level Governance*. *The Urban Book Series*, eds. Sara Hughes, Eric K. Chu and Susan G. Mason. Cham: Springer International Publishing, 39–57.

Kern, Kristine. 2019. "Cities as leaders in EU multilevel climate governance: embedded upscaling of local experiments in Europe." *Environmental Politics* 28 (1): 125–45.

Kolodziejski, Marek, and Filipa Azavedo. 2019. *Cohesion Fund: Fact Sheets on the European Union*. Brussels: European Parliaments. http://www.europarl.europa.eu/ftu/pdf/en/FTU_3.1.3.pdf (Accessed December 9, 2019).

Kona, Albana, Paolo Bertoldi, Fabio Monforti-Ferrario, Silvia Rivas, and Jean F. Dallemand. 2018. "Covenant of mayors signatories leading the way towards 1.5 degree global warming pathway." *Sustainable Cities and Society* 41: 568–75.

Kunikowski, Grzegorz. 2018. "Low carbon economy planning in the public sector." *Proceedings of the 2018 International Scientifi c Conference 'Economic Sciences for Agribusiness and Rural Economy'* (1): 103–8. 10.22630/ESARE.2018.1.14.

Lamb, William F., Felix Creutzig, Max W. Callaghan, and Jan C. Minx. 2019. "Learning about urban climate solutions from case studies." *Nature Climate Change* 9 (4): 279–87.

Lee, Taedong. 2018. "Local energy agencies and cities' participation in translocal climate governance." *Environmental Policy and Governance* 28 (3): 131–40.

———. 2019. "Network comparison of socialization, learning and collaboration in the C40 cities climate group." *Journal of Environmental Policy & Planning* 21 (1): 104–15.

Legewie, Nicolas. 2013. "An Introduction to Applied Data Analysis with Qualitative Comparative Analysis (QCA)." *Forum Qualitative Sozialforschung* 14 (3).

Leyen, Ursula von der. 2019. "Speech by President von der Leyen on the occasion of the COP25." Madrid. https://ec.europa.eu/commission/presscorner/detail/en/speech_19_6651 (Accessed December 5, 2019).

Lockwood, Matthew. 2018. "Right-wing populism and the climate change agenda: Exploring the linkages." *Environmental Politics* 27 (4): 712–32.

Lucas, Samuel R., and Alisa Szatrowski. 2014. “Qualitative Comparative Analysis in Critical Perspective.” *Sociological Methodology* 44 (1): 1–79.

Lysek, Jakub, and Dan Ryšavý. 2018. “Empowering through regional funds?: The impact of Europe on subnational governance in the Czech Republic.” *Regional & Federal Studies* 10 (1): 1–20.

Mahoney, James. 2008. “Toward a Unified Theory of Causality.” *Comparative Political Studies* 41 (4-5): 412–36.

Marcinkiewicz, Kamil, and Jale Tosun. 2015. “Contesting climate change: Mapping the political debate in Poland.” *East European Politics* 31 (2): 187–207.

Melica, Giulia, Paolo Bertoldi, Albana Kona, Andreea Iancu, Silvia Rivas, and Paolo Zancanella. 2018. “Multilevel governance of sustainable energy policies: The role of regions and provinces to support the participation of small local authorities in the Covenant of Mayors.” *Sustainable Cities and Society* 39: 729–39.

Mello, Patrick A. 2017. “Qualitative comparative analysis and the study of non-state actors.” In *Researching Non-State Actors in International Security*, eds. Andreas Kruck and Andrea Schneiker. Routledge, 123–42.

Ministry of the Environment of the Czech Republic. 2017. *Climate protection policy of the Czech Republic: Executive Summary*. Prague. https://unfccc.int/files/na/application/pdf/cze_climate_protection_policy_summary.pdf.

OECD. 2010. *Cities and Climate Change*. OECD.

———. 2018. *OECD Environmental Performance Reviews: Czech Republic 2018*. Organisation for Economic Co-operation and Development.

Oikonomou, Giorgio. 2019. “Decentralizing Governance within the European Union’s Framework: Evidence from Greece.” *International Journal of Public Administration* 1: 1–13.

Olszewski, Michał. 2019. “Poland has a Climate Ministry.” Heinrich Böll Foundation. https://energytransition.org/2019/12/poland-has-a-climate-ministry/.

Ostrom, Elinor. 2007. “A diagnostic approach for going beyond panaceas.” *Proceedings of the National Academy of Sciences of the United States of America* 104 (39): 15181–87.

———. 2009. *A Polycentric Approach For Coping With Climate Change*. The World Bank.

Ostrom, Vincent, Charles M. Tiebout, and Robert Warren. 1961. “The Organization of Government in Metropolitan Areas: A Theoretical Inquiry.” *American Political Science Review* 55 (4): 831–42.

Pahl-Wostl, Claudia, and Christian Knieper. 2014. “The capacity of water governance to deal with the climate change adaptation challenge: Using fuzzy set Qualitative Comparative Analysis to distinguish between polycentric, fragmented and centralized regimes.” *Global Environmental Change* 29: 139–54.

País ao Minuto. 2019. “Zero congratula-se com antecipação do fecho das centrais do Pego e Sines.” *País ao minuto*, October 26. https://www.noticiasaominuto.com/pais/1346813/zero-congratula-se-com-antecipacao-do-fecho-das-centrais-do-pego-e-sines.

Paravantes, Maria. 2019. “WWF: Majority of Greeks Calling for Climate Measures Now.” *GTP headlines*, June 24. https://news.gtp.gr/2019/06/24/wwf-majority-greeks-calling-climate-measures-now/.

Peters, D. T. J. M., S. Verweij, K. Grêaux, K. Stronks, and J. Harting. 2017. “Conditions for addressing environmental determinants of health behavior in intersectoral policy networks: A fuzzy set Qualitative Comparative Analysis.” [eng]. *Social science & medicine (1982)* 195: 34–41.

Purdon, Mark. 2014. *The Comparative Turn in Climate Change Adaptation and Food Security Governance Research*. 92nd ed. Copenhagen (Accessed August 16, 2019).

Ragin, Charles C. 2000. *Fuzzy-set social science* [eng]. Chicago: Univ. of Chicago Press.

Reckien, Diana, Monica Salvia, Oliver Heidrich, Jon M. Church, Filomena Pietrapertosa, Sonia de Gregorio-Hurtado, Valentina D'Alonzo, Aoife Foley, Sofia G. Simoes, Eliška Krkoška Lorencová, Hans Orru, Kati Orru, Anja Wejs, Johannes Flacke, Marta Olazabal, Davide Geneletti, Efrén Feliu, Sergiu Vasilie, Cristiana Nador, Anna Krook-Riekkola, Marko Matosović, Paris A. Fokaides, Byron I. Ioannou, Alexandros Flamos, Niki-Artemis Spyridaki, Mario V. Balzan, Orsolya Fülöp, Ivan Paspaldzhiev, Stelios Grafakos, and Richard Dawson. 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: 207–19.

Roger, Charles, Thomas Hale, and Liliana Andonova. 2016. “The Comparative Politics of Transnational Climate Governance.” *International Interactions* 43 (1): 1–25.

Rosenzweig, Cynthia, William Solecki, Stephen A. Hammer, and Shagun Mehrotra. 2010. “Cities lead the way in climate-change action.” *Nature* 467 (7318): 909–11.

Sailler, Aurélien. 2019. *National Energy and Climate Plans fail to acknowledge cities´ leading role in the european energy transition*. Energy Cities. https://energy-cities.eu/wp-content/uploads/2019/06/nceps-analysis-local-authorities.pdf.

Schaller, Stella, and Alexander Carius. 2019. *Convenient Truths: Mapping climate agendas of right-wing populist parties in Europe*. Berlin: adelphi consult GmbH.

Schneider, Carsten Q., and Claudius Wagemann. 2007. *Qualitative Comparative Analysis und Fuzzy Sets: Ein Lehrbuch für Anwender und jene, die es werden wollen* [ger]. Opladen Germany: Verlag Barbara Budrich.

———. 2010a. “Qualitative Comparative Analysis (QCA) and Fuzzy-Sets: Agenda for a Research Approach and a Data Analysis Technique.” *Comparative Sociology* 9 (3): 376–96.

———. 2010b. “Standards of Good Practice in Qualitative Comparative Analysis (QCA) and Fuzzy-Sets.” *Comparative Sociology* 9 (3): 397–418.

———. 2012. *Set-Theoretic Methods for the Social Sciences*. Cambridge: Cambridge University Press.

Smithson, Michael, and Jay Verkuilen. 2006. *Fuzzy set theory: Applications in the social sciences* [eng]. Vol. 147 of *Sage University papers series Quantitative applications in the social sciences*. Thousand Oaks, Calif.: Sage.

Spaczek, David, and Juraj Nemec. 2018. *Public administration characteristics and performance in EU28:: The Czech Republic*. Brussels. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=2ahUKEwisuPq23qPmAhXJGewKHfPeCmkQFjAJegQICBAC&url=http%3A%2F%2Fec.europa.eu%2Fsocial%2FBlobServlet%3FdocId%3D19944%26langId%3Dsv&usg=AOvVaw2yfXelsPiMbG7XyafXbFZg.

Steluța Georgeta, Enache. 2015. *The economic and social situation in Romania*. Brussels: EESC.

Stephan, Mark, Graham Marshall, and Michael McGinnis. 2019. "An Introduction to Polycentricity and Governance." In *Governing Complexity*. Vol. 41, eds. Andreas Thiel, William A. Blomquist and Dustin E. Garrick. Cambridge University Press, 1–44.

Sustainable Development Goals Knowledge Platform. 2020. "Sustainable Development Goal 13: Take urgent action to combat climate change and its impacts*." New York: United Nations. https://sustainabledevelopment.un.org/sdg13 (January 25, 2020).

Tefer, Peter. 2019. "Four states block EU 2050 carbon neutral target." *EUobserver,* June 20. https://euobserver.com/environment/145227 (Accessed December 7, 2019).

Termeer, Catrien, Art Dewulf, and Maartje van Lieshout. 2010. "Disentangling Scale Approaches in Governance Research: Comparing Monocentric, Multilevel, and Adaptive Governance." *Ecology and Society* 15 (4). https://www.ecologyandsociety.org/vol15/iss4/art29/.

Tews, Kerstin. 2015. "Europeanization of Energy and Climate Policy." *The Journal of Environment & Development* 24 (3): 267–91.

The Guardian. 2019. "Romanian centrist president re-elected by a landslide." *The Guardian,* November 24. https://www.theguardian.com/world/2019/nov/24/romania-centrist-president-re-elected-by-a-landslide-klaus-iohannis (Accessed January 2, 2020).

Thiel, Andreas. 2016. "The polycentricity approach and the research challenges confronting environmental governance." *THESys Discussion Paper* 1: 1–27. edoc.hu-berlin.de/series/thesysdiscpapers (Accessed January 27, 2020).

Thomann, Eva, and Martino Maggetti. 2017. "Designing Research With Qualitative Comparative Analysis (QCA)." *Sociological Methods & Research* 66: 004912411772970.

Tworzecki, Hubert. 2018. "Poland: A Case of Top-Down Polarization." *The ANNALS of the American Academy of Political and Social Science* 681 (1): 97–119.

UNDP. 2020. "Goal 13: Climate Action." UNDP. https://www.sdfinance.undp.org/content/sdfinance/en/home/sdg/goal-13--climate-action.html (January 25, 2020).

UNFCCC. 2016. *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015: FCCC/CP/2015/10*. https://unfccc.int/resource/docs/2015/cop21/eng/10.pdf#page=30 (Accessed December 5, 2019).

van der Heijden, Jeroen. 2018. "Voluntary urban climate programmes: Should city governments be involved and, if so, how?" *Journal of Environmental Planning and Management* 62 (3): 446–65.

———. 2019. *Using Qualitative Comparative Analysis Logic and Tools for Theory Testing and Development in a Medium-n Urban Climate Governance Research*. SAGE Publications Ltd.

van der Heijden, Jeroen, James Patterson, Sirkku Juhola, and Marc Wolfram. 2018. "Special section: Advancing the role of cities in climate governance – promise, limits, politics." *Journal of Environmental Planning and Management* 62 (3): 365–73.

Watts, Mark. 2017. "Cities spearhead climate action." *Nature Climate Change* 7: 537 EP -.

Worldbank. 2019. “The Worldbank in Romania.” https://www.worldbank.org/en/country/romania/overview.

Wurzel, Rüdiger K.W., Duncan Liefferink, and Diarmuid Torney. 2019. “Pioneers, leaders and followers in multilevel and polycentric climate governance.” *Environmental Politics* 28 (1): 1–21.

9. Annex

A) Interview material

1st Interview 8th October: representative of Romanian municipality

1. **What project is your municipality currently implementing?**
   We implement a big smart city project – it is the first project in Romania to implement this since 2016 so we are a pioneer in this. Now we are moving things to the next level with increased EU funding to smart mobility and smart lighting. We want to make the city a livable city.
2. **What are biggest challenges?**
   The team – people are the biggest challenge. It is very hard to have a team which is very dedicated to such a project. We need to develop a department like "smart city department", but most of the municipalities – and the politicians even more – don't realise you cannot do anything without dedicated – mostly young people. We need problem- solvers and not problem- seekers. We need a new way of thinking in public administration. We had a great municipal manager – which now is in the European parliament and he taught us about personal development and leadership. When you have leadership, meaning open minded mayors and local councillors, you can do things! If you don´t – it is hard! When we first presented our idea of smart city project to the local council they said ' oh no no, we first need to solve our basic problems'. But we have to do both (deal with things like sewage) and also do innovative project at the same time.
3. **How is the municipality financing climate projects?**
   We get EU funding and have partnerships with companies. They are very interesting to test and explore such smart city solutions.
4. **So is this now also implemented in other Romanian cities?**
   The companies want to sell this to other municipalities and want to make money. Also the municipalities are interested in buying those solutions. They are in open dialogue currently.
5. **What or who drives climate action?**
   The local level drives this action! We are into this project! We have been involved in URBACT for a couple of years and we learnt a lot and tried to replicate. We are connected to many other cities in Europe – now we also give advice, not only learning! But we had to be careful not to get into the loop: Struggle with local councillors, struggle with politicians, other departments and then you give up and think 'that´s not worth it'. But we have more enthusiasm.
6. **So collaboration between municipalities has helped you?**
   Yes, collaboration is the key.
7. **How do you see the national level in climate action?**
   Policies from top-down are not applicable. Municipalities are all different. IF they had set up a national smart city national programme, then the regulations would be very strict and you could only buy solutions from one company. The start needs to be at the municipality. We are promoting the idea that you have to create public policies from the local level.

2nd Interview 16th October: representative of Greek municipality

1. **Which projects are currently implemented in your municipality?**
   City works on SDG implementation. There is also an sustainability report of the city. Furthermore, we are working on a SECAP renewal for 2030. That was the decision of our Mayor to do this. We exchange ideas with others about sustainable mobility planning. And we can share with them our knowledge on SDG reporting. So it is not a one way street for us.
2. **Does the city have a strategy document for sustainability or climate?**
   Yes, we have a document, which is more than a SECAP contains. It can be found on the website, but only available in Greek. There we have 5 pillars, which are very important for us to work on.
3. **What are the biggest challenges?**
   A challenge is the city budget. It is hard for us to get funds as we do not have much experience in this. More challenges would be citizen awareness and communication. But this is slowly improving.
4. **How is the municipality financing climate projects?**
   Unlike many other participants of the project we do not have the knowledge and capacity to apply for funds on EU level as it is very bureaucratic. We get some support from regional budget - For example, for school buildings and green spaces, but we have some own resources!
5. **What or who drives climate action?**
   The mayor pushes for climate actions, but this is out of a necessity we feel. It is a bit more top-down, but it changes. People are realizing slowly the need for more sustainable living. Also, the regional funds are a motive for us to refurbish schools.
6. **From whom would you need more support?**
   We need more support from the press and the public to see what we are doing. It should happen as a bottom-up activity and not so much top-down. Media and press are good for our municipality.
7. **How do you see Greece as a country in climate policy?**
   We get funding from the regional level, not from the national level.
8. **What do you know that other Greek municipalities are doing in terms of climate change?**
   Other municipalities are probably a bit more innovative to engage their citizens.
9. **Do you see advantages in transnational networks like the Covenant?**
   Yes, workshops are helpful to exchange ideas, but especially city-partnerships increase the knowledge transfer in our experience.

3rd Interview 14th November: representative of municipality in Czech Republic

1. **Which projects are currently implemented in your municipality?**
   Currently we are planning an energy saving and improved heating project for our townhall. The start will be in January and we get coaching for this. Heat will come centrally with gas. We also do some events like for the European Week of sustainable mobility or air quality.
2. **Does the municipality have a strategy document for climate action?**
   Our town does not have a strategy document, but we are working on it. Next year we want to prepare a new strategy. There is an old strategy, but it is not active anymore.
3. **How would you rate the overall situation of environmental concerns in the municipality?**
   I am the only one in our municipality to work on this topic and I am also responsible for the Local Agenda 21. The mayor is not involved in such activities, but the Vice-Mayor is interested in the environment, as he is a teacher.
4. **What are your biggest challenges at the moment for climate action?**
   Implementation is a big problem. The understanding of the need for such climate action is not present in the municipality. We have other issues on the top of the agenda.
   The topics of climate action are hard for me to understand because I am not an engineer. I am a vet, but haven´t practised in 20 years. I have been working for the municipality for so many years now. My husband is a farmer and we have cows, so this is where I can help with my professional knowledge.
5. **Does the municipality have funding/money for climate action?**
   I am not sure about finance. But I know that some public buildings are financed with European funding. Also, the regional level finances some things. One problem are our forests and water availability. Sometimes there is too little water and in other times the area gets flooded. The forests suffer from that and get infected by bark beetles a lot.
6. **Your municipality is not part of the Covenant of Mayors – why, in your opinion, is that the case and do you consider joining?**
   We discussed the Covenant of Mayors about 10 years ago and the mayor decided against it. Since then we haven´t discussed it anymore. It didn't seem relevant for us.
7. **How do you see the Czech national level climate governance? Do they support local climate action?**
   I am not so sure about the national level- there are many critical voices. I read some parts of the Czech national climate strategy document, but I am not sure.
8. **How do you benefit from attending workshops and the network of the project?**
   I get very inspired and take home many new ideas. At a workshop I connected with Romanian colleagues about energy management and gave contacts to my colleagues at home, but I don´t think that anything came out of this. I also talk to other Czech municipalities, who have a strategy document for climate. I think this is very useful.

4th Interview 16th November: representative from polish municipality

(Interview was held in German, as the representative lived in Germany many years and does not speak English)

1. **Which climate projects are currently implemented in your municipality?**
   We are retrofitting six school buildings and will by hybrid busses for public transport.
2. **How many people are working in your department and are you working together with other departments as well?**
   We are currently seven people. Sometimes we exchange with others, but very rarely.
3. **What are current challenges?**
   Climate and environment are not a priority for the mayor or the political parties here. So nobody talks about it.
4. **Does your city have financial resources for climate action? Or access to funds?**
   All our projects are financed by EU or the national fund for environment. The money is not the issue, but key stakeholders are not prioritizing it – the problem is the motivation.
5. **Would you see a benefit in joining the Covenant of Mayors for your municipality?**
   Currently, this has no priority for the mayor and the local council so that it does not seem relevant for us.
6. **Do you connect and exchange with other municipalities in some other form?**
   Yes, but on a personal level, if you know the people from some previous activities or workshops. In Poland there are also national local networks, but again we do not participate in those.
7. **Who or what can support climate action in your municipality?**
   Good question, I don't know.

B) Uncalibrated case information

Municipality	inhabitants (= INH)	National CO2 Emissions in 2017 (EEA)	National coal strategy	CCPI 2019	CoM signatory (according to Covenant website) (= COM)	parties in municipality (for poland at Powiat level)(=PAR)
AGD	71.000	8.9	phase-out by 2028	50.86	SEAP 2020	local, conservative-right, communist
ALI	63.000	5.8	no discussion	59.42	SEAP 2020	liberal, socialdemocrat
ANS	13.100	6.9	phase-out by 2023	60.54	interested	liberal-conservative, socialist
BIE	30.000	10.9	no discussion	47.59	SEAP 2020	modern liberal, national conservatives, center, left
BUZ	115.500	5.8	no discussion	59.42	CoM without SEAP	socialdemocrat, liberal, conservative, socialist
CIE	33.000	10.9	no discussion	47.59	no	national conservative, modern liberal
COR	19.900	6.9	phase-out by 2023	60.54	SEAP 2020 and adapt	socialist, green-left, liberal
DEV	69.000	5.8	no discussion	59.42	SEAP 2020	socialdemocrat, socialist, liberal
DOR	13.600	8.9	phase-out by 2028	50.86	SEAP 2020	independent local
FAR	18.500	8.9	phase-out by 2028	50.86	no	independent - mayor wants an overarching coalition that focusses on citizen participation
JAS	35.700	10.9	no discussion	47.59	CoM without SEAP	national conservative, center-agrarians, modern liberal
KAL	69.800	8.9	phase-out by 2028	50.86	interested	conservative-right, conservative-left, local
LOU	70.600	6.9	phase-out by 2023	60.54	interested	socialist, liberal

MIL	8.500	12.2	discussed	49.73	planning to join	liberal, local conservative-right
PIS	30.100	12.2	discussed	49.73	CoM without SEAP	local, liberal-left, populist
PRA	10.800	12.2	discussed	49.73	no	local-right, liberal
PRE	7.100	12.2	discussed	49.73	planning to join	liberal, communist
RAM	118.400	5.8	no discussion	59.42	SEAP 2020	ecologist, socialdemocrat, liberal
ROZ	16.500	12.2	discussed	49.73	no	populist, local
SET	121.200	6.9	phase-out by 2023	60.54	SEAP 2020	green-left, socialist
SYR	22.000	8.9	phase-out by 2028	50.86	no	local
SZT	18.000	10.9	no discussion	47.59	SEAP 2020	modern liberal, national conservative, center-agrarian
VIA	88.700	6.9	phase-out by 2023	60.54	SEAP 2020	socialist, liberal
ZAL	69.500	5.8	no discussion	59.42	SEAP 2020	socialdemocrat, liberal, Hungarian democrat
ZAM	65.000	10.9	no discussion	47.59	no	national conservative, center-agrarian, modern liberal

Table B1: Uncalibrated values of the conditions

municipality	priority working area for 2019	calibration
AGD	Sustainable Development Goals & mobility	0.67
ALI	smart city, mobility and data management	1
ANS	LED street lightning and energy efficiency	0.33
BIE	Renewable Energy supply, tourism and enhancing life quality	1
BUZ	SEAP submission	0
CIE	air quality and awareness, renewable energy use	0.67
COR	zero coal project	0.67
DEV	SEAP submission, mobility	0.67
DOR	EU funding opportunities	0
FAR	energy community and create local climate action plan	0.33
JAS	renewable energy and energy efficiency	0.33
KAL	energy saving and energy supply	0.33
LOU	internal structure and SEAP submission	0.67
MIL	heating and mobility	0.67
PIS	mobility and schools	0.67
PRA	school energy and street lighting	0.33
PRE	communication and urban planning; renewable energy	0.67
RAM	energy efficiency and waste management	0.33
ROZ	street lighting and heating	0.33
SET	reduce emissions and increase industry collaboration	1
SYR	energy community	0.33
SZT	air quality and energy poverty	0.33
VIA	decarbonization (circular economy project)	1
ZAL	energy management	0.33
ZAM	air quality and education/awareness	0

Table B2: outcome qualitative data with calibration

C) Descriptive statistics of dataset

Displayed here are some further statistics that describe the dataset of 25 municipalities.

Condition	Mean Value	Standard Variation
Inhabitants	47,940	36357
Connection	125 km	63.96
National emissions (CO2 equivalents) per person	9t/year	2.44
Unemployment rate	7 %	5.81

Table C1: mean values and standard variation of four conditions INH, CON, NATEM, UNEMP

	size	CoM	Unemployment (in %)	Strategy Documents
ANS	13100	interested	5.6	1
DOR	13600	yes	18.9	0
MIL	8500	interested	1.4	0
PRA	11000	no	1.4	0
PRE	7000	interested	1.5	0
ROZ	16500	no	1.85	0.67

Table C2: small municipalities (< 18000 inhabitants) with some characteristics

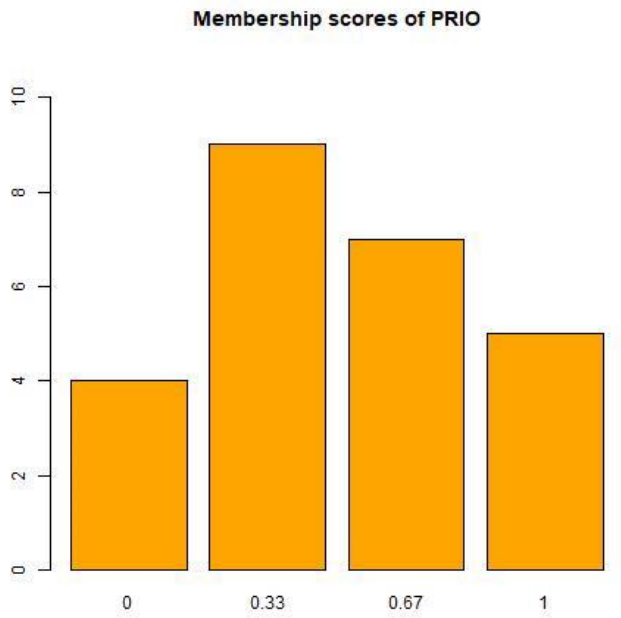


Figure C1: membership scores of priority

D) Further tables and figures from the analytical moment

XY plots of analysis of necessity

None of the conditions is individually necessary, so the plots look quite scattered.

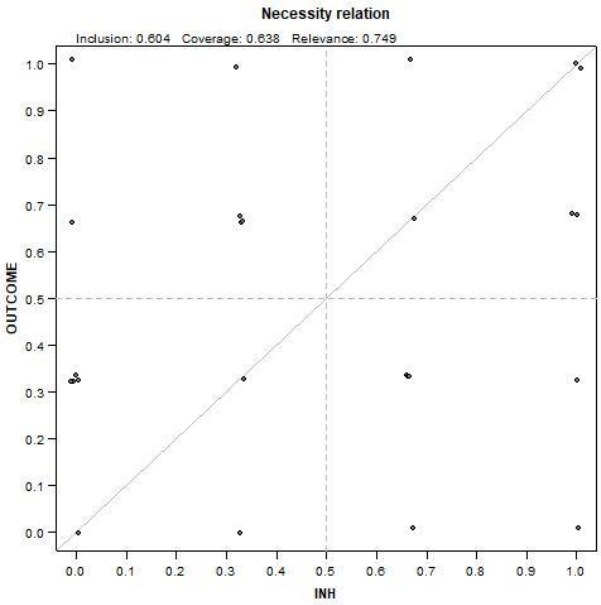


Figure D1: necessity of INH

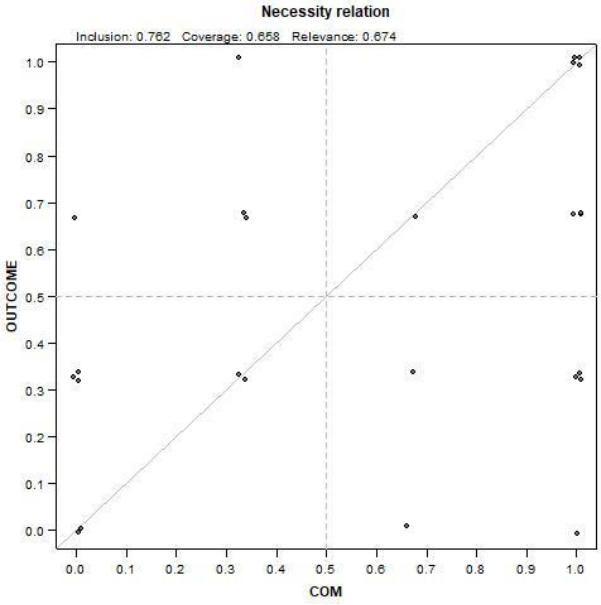


Figure D2: necessity of COM

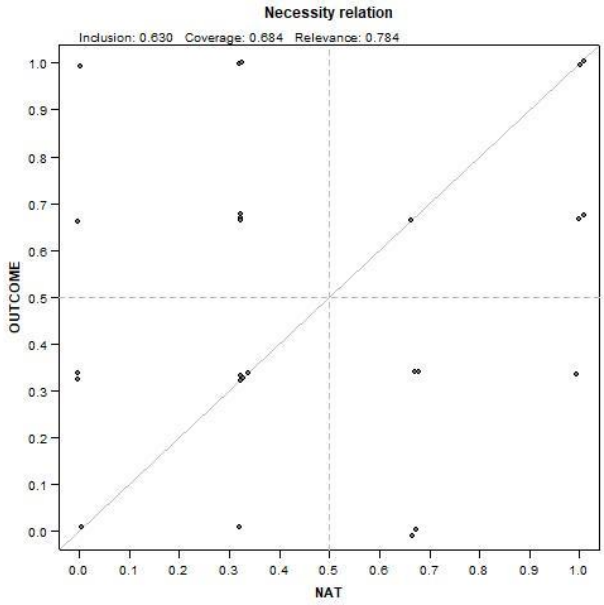


Figure D3: necessity of NAT

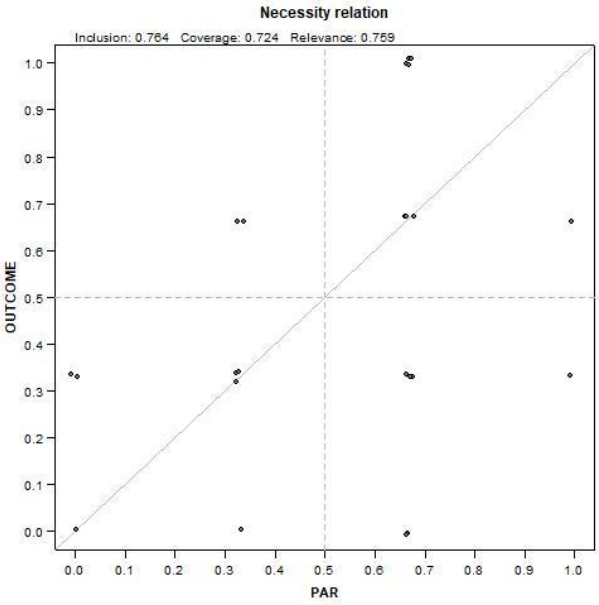


Figure D4: necessity of PAR

XY plots of analysis of sufficiency

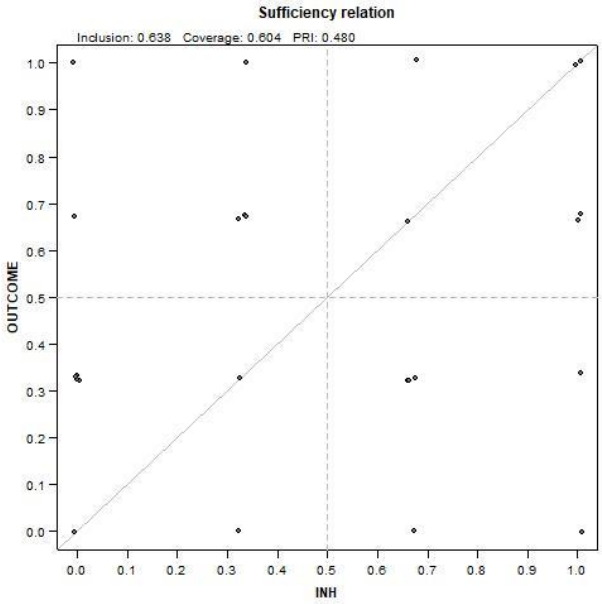


Figure D5: sufficiency of NAT

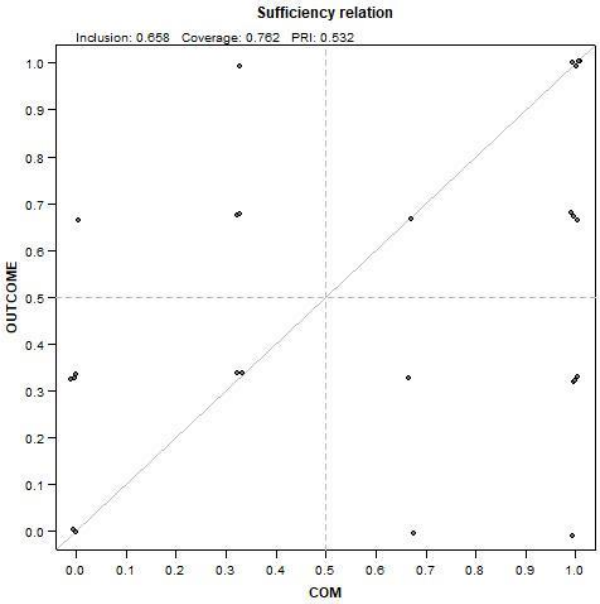


Figure D6: sufficiency of COM

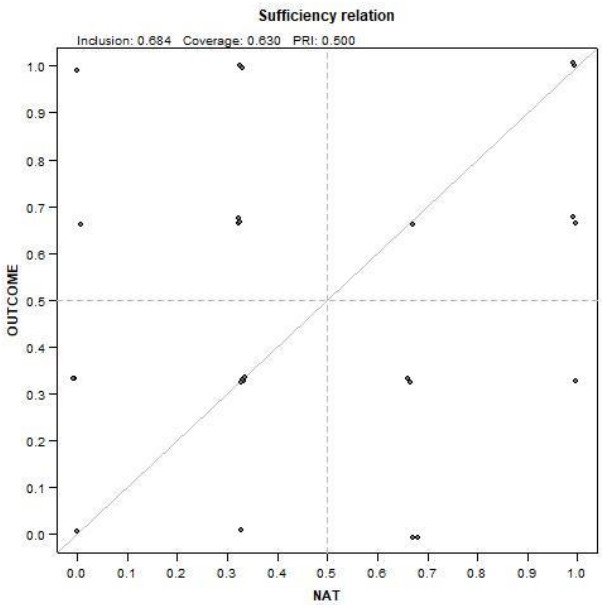


Figure D7: sufficiency of NAT

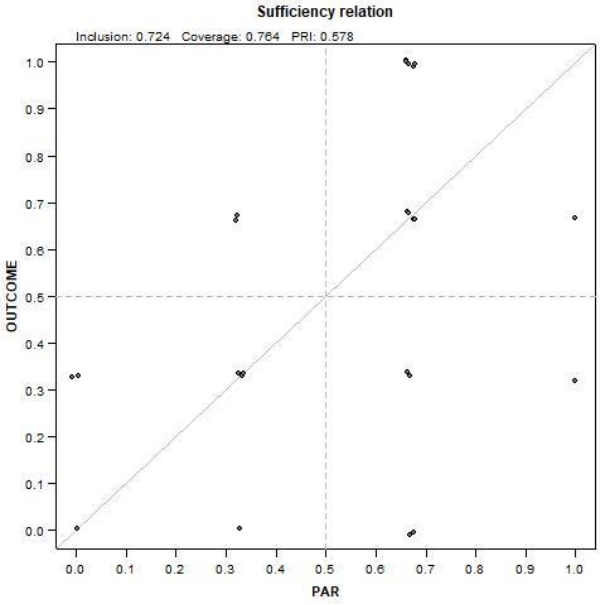


Figure D8: sufficiency of PAR

XY plot of the prime implicants

The first prime implicant is inh*COM*nat. As the figure shows, not all cases are above the diagonal line, meaning that some cases are not represented by this prime implicant (FAR, DOR and SZT).

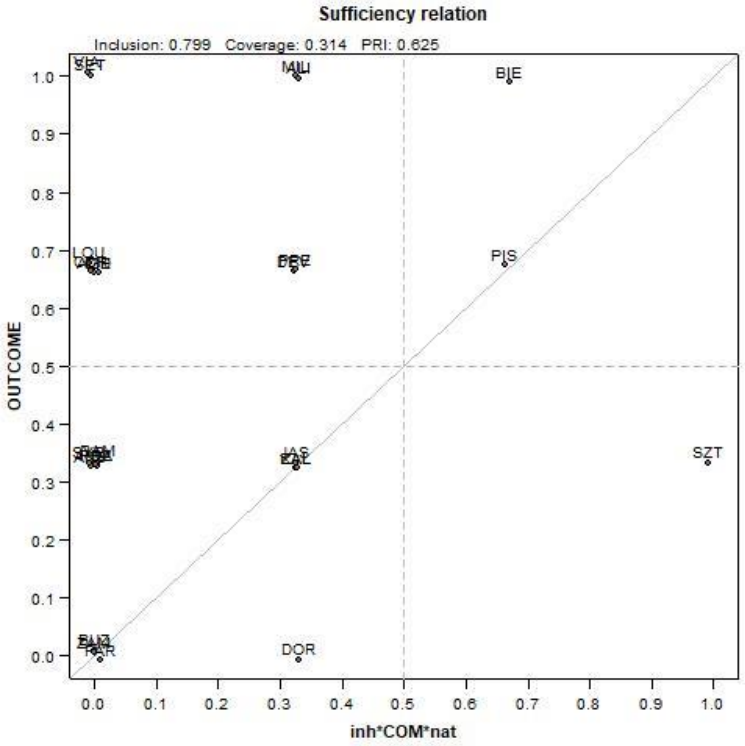


*Figure D9: XY plot of prime implicant inh*COM*nat*

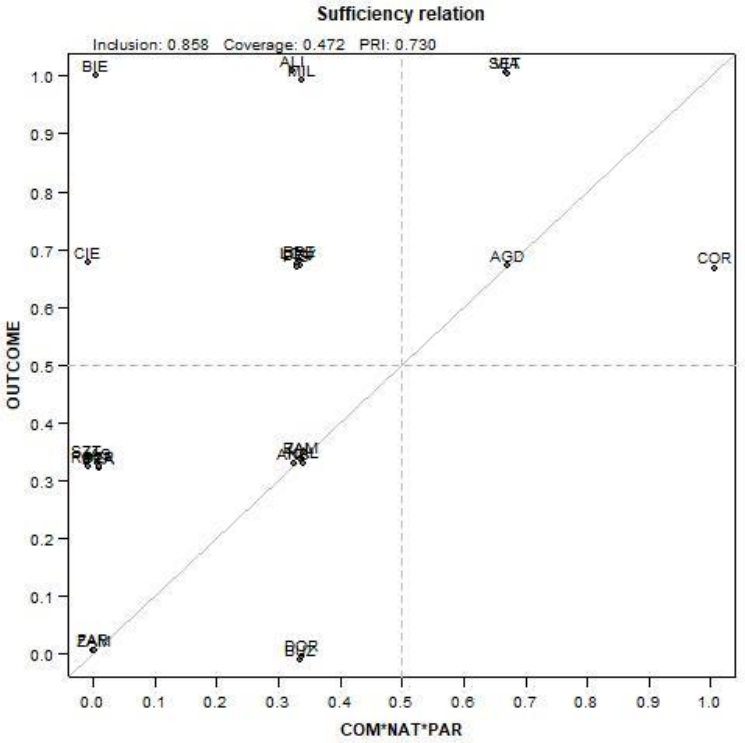


*Figure D10: XY plot of prime implicant COM*NAT*PAR*

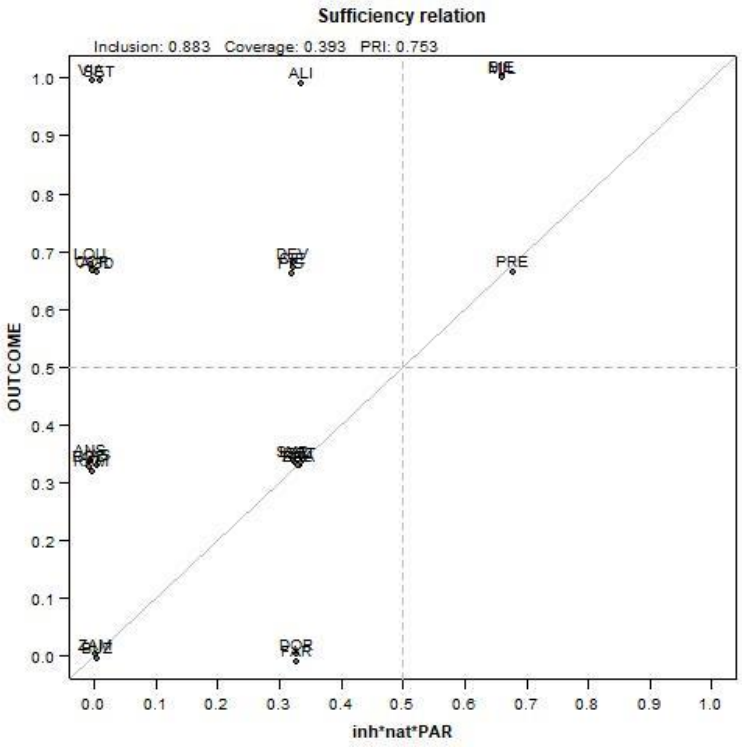


*Figure D11: XY plot of prime implicant inh*nat*PAR*

E) Analysis of ~OUTCOME

The truth table for ~OUTCOME was calculated with a threshold of 0.8 after the two counterfactuals row 7 and row 13 were detected and assigned to ~OUTCOME.

row	INH	COM	NAT	PAR	~OUT	n	incl	PRI	cases
9	**1**	**0**	**0**	**0**	**1**	**1**	**1.000**	**1.000**	**ZAM**
11	**1**	**0**	**1**	**0**	**1**	**1**	**1.000**	**1.000**	**KAL**
4	**0**	**0**	**1**	**1**	**1**	**3**	**0.91**	**0.804**	**ANS, FAR, SYR**
1	**0**	**0**	**0**	**0**	**1**	**3**	**0.856**	**0.667**	**CIE, PRA, ROZ**
12	**1**	**0**	**1**	**1**	**1**	**1**	**0.853**	**0.66**	**LOU**
7	**0**	**1**	**1**	**0**	**1**	**1**	**0.801**	**0.504**	**DOR**
13	**1**	**1**	**0**	**0**	**1**	**1**	**0.801**	**0.504**	**JAS**
8	0	1	1	1	0	1	0.725	0.248	COR
14	1	1	0	1	0	5	0.713	0.502	ALI, BUZ, DEV, RAM, ZAL
2	0	0	0	1	0	2	0.696	0.246	MIL, PRE
5	0	1	0	0	0	2	0.691	0.335	PIS, SZT
6	0	1	0	1	0	1	0.635	0.199	BIE
16	1	1	1	1	0	3	0.596	0.141	AGD, SET, VIA

Table E1: truth table of ~OUTCOME

The result of the logical minimization is too complex if the logical remainders are not included, so that the **parsimonious solution** is chosen here.

It produces the solution formula:

INH*par + com*NAT + com*par + NAT*par => outcome

The inclusion score is 0.772 and coverage is 0.729.

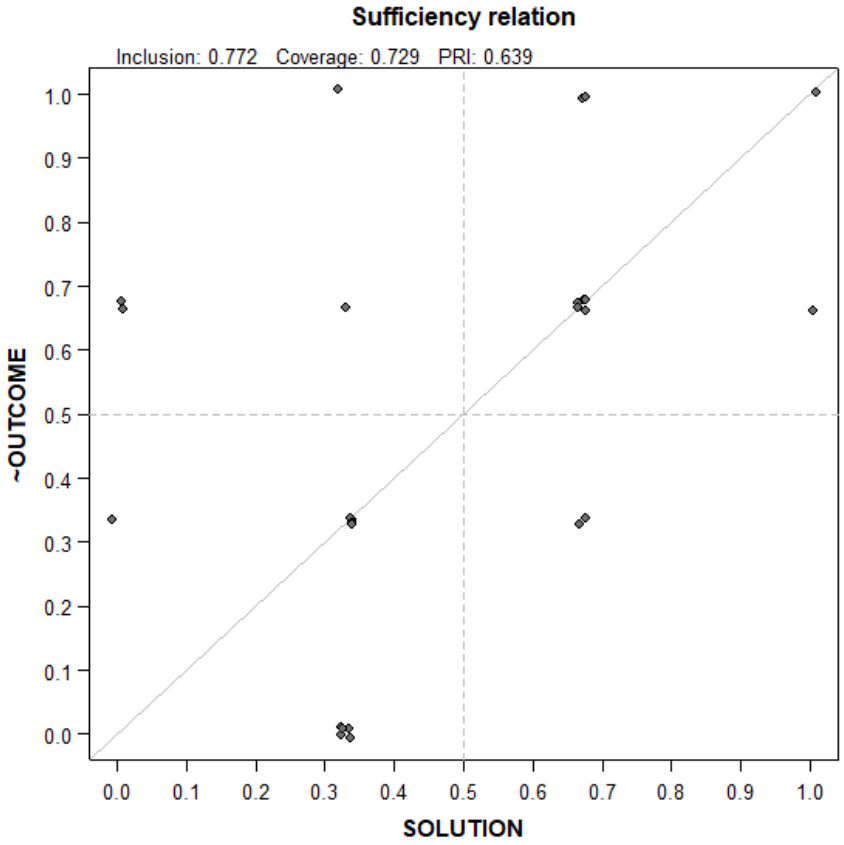


Figure E1: XY plot of the solution for ~OUTCOME

F) The R script

```
#QCA Analysis of dataset with 25 municipalities in
Czechia, Greece, Poland, Portugal and Romania#

                              ####prepare analysis####
rm(list = ls())
setwd("C:\\Users\\Magsl\\Documents\\Studium\\R codes Setwd")
#on Magdalena´s computer

library(QCA)
library(SetMethods)
library(venn)

                              ####DESCRIPTIVE ANALYSIS####
desc <- read.csv("desc_final.csv",
header = TRUE, sep=";", row.names = 1, stringsAsFactors = FALSE)
#attach(desc)
    colnames(desc)
    rownames(desc)
    head(desc)
    str(desc)

#mean and standard variation of 4 conditions

meanvalues <- c(mean(desc$INH), mean(desc$CON),
mean(desc$NAT), mean(desc$UNEMP))
    round(meanvalues) -> meanvalues

standardvariationvalues <- c(sqrt(var(desc$INH)),
sqrt(var(desc$CON)), sqrt(var(desc$NAT)), sqrt(var(desc$UNEMP)))
    round(standardvariationvalues, digits = c(0, 2, 2, 2)) -
> standardvariationvalues

    descriptive = cbind(meanvalues, standardvariationvalues)
    colnames(descriptive) = c("MEAN", "STD")
    rownames(descriptive) = c("INH", "CON", "NAT", "UNEM")
    descriptive


# INH - Population

    summary(desc$INH)
    sqrt(var(desc$INH))

    plot(sort(desc$INH),
            col = "white",
            main = "Population",
```

```
            ylim = c(0, max(desc$INH)),
            ylab = "Population")

    text(sort(desc$INH),
            labels = rownames(desc)[order(desc$INH)],
            cex = 0.85)

# DOCS - strategy documents (pre-calibrated)
    plot(sort(desc$DOCS),
                    col = "white",
                    main = "Strategy Documents",
                    ylim = c(-0.1, 1.1),
                    ylab = "Strategy Documents")

            text(jitter(sort(desc$DOCS)),
                    labels = rownames(desc)[order(desc$DOCS)],
                    cex = 0.85)
# CON – distance to next bigger city
    plot(sort(desc$CON),
                    col = "white",
                    main = "CON",
                    ylab = "CON")

            text(sort(desc$CON),
                    labels = rownames(desc)[order(desc$CON)],
                    cex = 0.85)


# NAT
jpeg(file = "Membership scores national policy index.jpeg")
    plot(sort(desc$NAT),
                    col = "white",
                    ylim = c(min(desc$NAT)*0.9, max(desc$NAT)*1.1),
                    main = "National policy",
                    ylab = "NAT")

            text(jitter(sort(desc$NAT)),
                    labels = rownames(desc)[order(desc$NAT)],
                    cex = 0.85)
    dev.off()

# PRIO - the outcome (pre-calibrated)
jpeg(file = "Membership scores of Priority 2019.jpeg")

   barplot(table(desc$PRIO),
                axes = TRUE,
                ylim = c(0, max(table(desc$PRIO))*1.2),
                main = "Membership scores of PRIO", col= "orange")
    dev.off()
```

```
        jpeg(file = "Membership scores of Priority 2019-2.jpeg")
        pie(table(desc$PRIO),
                main = "Membership scores of PRIO",
                labels = c("  not a priority",
                           "CA not really a priority",
                           "CA almost a priority",
                           "CA a priority"),
                clockwise = TRUE,
                radius = 0.6)

        dev.off()

# small municipalities & their characteristics (<18000 in habitants)

    desc[desc$INH < 18000, c("INH", "COM", "UNEMP", "DOCS")] -
> smallcities
    rownames(smallcities) = c("ANS", "DOR", "MIL", "PRA", "PRE", "ROZ")
    colnames(smallcities) = c("size", "CoM", "unemployment", "Docs")
    smallcities



                ####QUALITATIVE COMPARATIVE ANALYSIS####

mun = read.csv("mundata coded_FINAL.csv",
header=TRUE, sep=";", stringsAsFactors = FALSE, row.names = 1)
#calibration done outside QCA - see thesis annex
    attach(mun)
    str(mun)
    summary(mun)

this_column = which(colnames(mun) == "PRIO")
colnames(mun)[this_column] = "OUTCOME"
# certain QCA functions want the outcome to be called "OUTCOME"

    ##Inspection of sets##

table(mun[, 1]) #INH:   12 inside (INH = inhabitants)
table(mun[, 2]) #CON: 14 inside (CON = Connection to next bigger city)
table(mun[, 3]) #NAT: 10 inside (NAT = National level climate policies )
table(mun[, 4]) #COM: 14 inside (COM = Covenant of Mayors signatory)
table(mun[, 5]) #PAR: 16 inside (PAR = Party in local council)
table(mun[, 6]) #UNEMP: 13 inside (UNEMP = unemployment  in NUTS II regi
on)
table(mun[, 7]) # INTERN: 11 inside (INTERN = internal admin. situation)
table(mun[, 8]) #DOCS: 13 inside (DOCS= Strategy Documents)
table(mun[, 9]) #PRIO: 12 inside --
> this is the OUTCOME! (PRIO = working priority for the year 2019)
```

```
    ##analysis of necessity and sufficiency of single conditions##

        mun$OUTCOME
        mean(mun$OUTCOME)
        table(mun$OUTCOME)

        the_outcome_column = which(colnames(mun) == "OUTCOME")
        mun[, -the_outcome_column]

QCAfit(mun[, -the_outcome_column], mun$OUTCOME, necessity = TRUE)
# none of the conditions is individually necessary

superSubset(mun, outcome = "OUTCOME", incl.cut = 0.9, ron.cut = 0.6)
# no relevant union detected

QCAfit(mun[, -the_outcome_column], mun$OUTCOME, necessity = FALSE)
# two of the conditions are individually sufficient: CON & INTERN

    ##graphical analysis of 4 selected conditions: INH, COM, NAT, PAR##

    jpeg(file = "Necessity of INH.jpeg")
        XYplot(mun$INH, mun$OUTCOME, jitter = TRUE, relation = "necessit
y")
    dev.off()

    jpeg(file = "Sufficiency of INH.jpeg")
        XYplot(mun$INH, mun$OUTCOME, jitter = TRUE, relation = "sufficie
ncy")
    dev.off()

    jpeg(file = "Necessity of COM.jpeg")
        XYplot(mun$COM, mun$OUTCOME, jitter = TRUE, relation = "necessit
y")
    dev.off()

    jpeg(file = "Sufficiency of COM.jpeg")
        XYplot(mun$COM, mun$OUTCOME, jitter = TRUE, relation = "sufficie
ncy")
    dev.off()
    jpeg(file = "Necessity of NAT.jpeg")
        XYplot(mun$NAT, mun$OUTCOME, jitter = TRUE, relation = "necessit
y")
    dev.off()

    jpeg(file = "Sufficiency of NAT.jpeg")
        XYplot(mun$NAT, mun$OUTCOME, jitter = TRUE, relation = "sufficie
ncy")
    dev.off()
```

```
    jpeg(file = "Necessity of PAR.jpeg")
        XYplot(mun$PAR, mun$OUTCOME, jitter = TRUE, relation = "necessit
y")
    dev.off()

    jpeg(file = "Sufficiency of PAR.jpeg")
        XYplot(mun$PAR, mun$OUTCOME, jitter = TRUE, relation = "sufficie
ncy")
    dev.off()

    ##preparation of truth table##
        pmin(mun$INH, mun$COM, mun$NAT, mun$PAR)#
                pmin(mun$INTERN, mun$CON, mun$PAR)#
                pmin(mun$INTERN, mun$DOCS, mun$PAR,mun$CON)
        mun$OUTCOME
        mean(mun$OUTCOME)


    #truth table OUTCOME#

ttmun <- truthTable(mun, outcome = c("OUTCOME"),
conditions = c("INH","COM", "NAT", "PAR"), incl.cut = 0.75, show.cases =
 TRUE, sort = "incl")
ttmun
#7 paths detected

    #truth table ~OUTCOME#

ttmunnot <- truthTable(mun, outcome = c("~OUTCOME"),
conditions = c("INH","COM", "NAT", "PAR"), incl.cut = 0.75, show.cases =
 TRUE, sort = "incl")
ttmunnot

    #check for contradictions
truthTable(mun, outcome = "OUTCOME",conditions = c("NAT", "COM", "INH",
"PAR"), incl.cut = 0.75, show.cases = TRUE, neg.out = FALSE)[["tt"]]["OU
T"] -> suff4Y
truthTable(mun, outcome = "OUTCOME",conditions = c("NAT", "COM", "INH",
"PAR"), incl.cut = 0.75, show.cases = TRUE, neg.out = TRUE)[["tt"]]["OUT
"] -> suff4y
            pmin(suff4Y, suff4y) == 1

data.frame(ttmun$tt[1:4], suff4Y, SUFF_NEG = suff4y) -> comparison
colnames(comparison)[5:6] = c("SUFF_OUT", "SUFF_NEG")
comparison
#rows 7 and 13 are contradictory -->  assign to ~OUTCOME with incl.cut
at 0.8

    #truth table OUTCOME 0.8#
```

```
 ttmun <- truthTable(mun, outcome = c("OUTCOME"),conditions = c("INH","C
OM", "NAT", "PAR"), incl.cut = 0.8, show.cases = TRUE, sort = "incl")
ttmun
#5 paths detected

    #truth table ~OUTCOME 0.8#

ttmunnot <- truthTable(mun, outcome = c("~OUTCOME"),conditions = c("INH"
,"COM", "NAT", "PAR"), incl.cut = 0.8, show.cases = TRUE, sort = "incl")
ttmunnot

        #first visual check of truth table
        jpeg(file = "venn diagramm ttmun.jpeg")
        venn(ttmun)
        dev.off()
        jpeg(file = "venn diagramm ttmunnot.jpeg")
        venn(ttmunnot)
        dev.()

    # logical minimization OUTCOME

 consol_Y = minimize(ttmun, details = TRUE) #the conservative solution
 consol_Y
 parsol_Y = minimize (ttmun, include = "?", details = TRUE)
#the parsimonious solution does not provide any "better" solution formul
a #> take conservative solution
  consol_Y

# logical minimization ~OUTCOME #
  consol_y = minimize(ttmunnot, details = TRUE) # conservative solution
  consol_y
  parsol_y = minimize(ttmunnot, include = "?", details = TRUE)
# parsimonious solution --> take this one here
  parsol_y


    ##Visual inspection for the prime implicants##

jpeg(file = "prime implicant inhCOMnat.jpeg")
XYplot(consol_Y$pims[, 1], mun$OUTCOME, jitter = TRUE, relation = "suffi
ciency", clabels = rownames(mun))
dev.off()

jpeg(file = "prime implicant inhCOMnat outcome.jpeg")
XYplot(consol_Y$pims[, 1], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))
dev.off()
```

```
jpeg(file = "prime implicant inhnatPAR.jpeg")
XYplot(consol_Y$pims[, 2], mun$OUTCOME, jitter = TRUE, relation = "suffi
ciency", clabels = rownames(mun))
dev.off()

jpeg(file = "prime implicant inhnatPAR outcome.jpeg")
XYplot(consol_Y$pims[, 2], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))
dev.off()

jpeg(file = "prime implicant COMNATPAR.jpeg")
XYplot(consol_Y$pims[, 3], mun$OUTCOME, jitter = TRUE, relation = "suffi
ciency", clabels = rownames(mun))
dev.off()

jpeg(file = "prime implicant COMNATPAR outcome.jpeg")
XYplot(consol_Y$pims[, 3], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))
dev.off()

    ##Visual inspection for the prime implicants => outcome ##
XYplot(parsol_y$pims[, 1], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))

XYplot(parsol_y$pims[, 2], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))

XYplot(parsol_y$pims[, 3], 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))


    ##Visual inspection for the entire solutionn=> OUTCOME##

        SOLUTION = apply(consol_Y$pims, 1, max)
        jpeg(file = "SOLUTION OUTCOME.jpeg")
        XYplot(SOLUTION, mun$OUTCOME, jitter = TRUE, relation = "suffici
ency")
        dev.off()

        jpeg(file = "SOLUTION outcome.jpeg")
        XYplot(SOLUTION, 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency")
        dev.off()
```

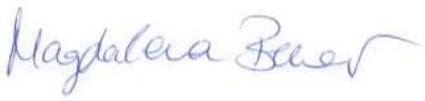
```
    ##Visual inspection for the entire solution => outcome ##

        SOLUTION = apply(parsol_y$pims, 1, max)
        XYplot(SOLUTION, 1-
mun$OUTCOME, jitter = TRUE, relation = "sufficiency", clabels = rownames
(mun))
```

Declaration of authorship

I hereby declare that this thesis is the result of my own work and that I have indicated all sources, including online sources, which have been cited without changes or in modified form, especially sources of texts, graphics, tables and pictures.

I confirm that I have not submitted this thesis for any other examination. I am aware that in case of any breach of these rules procedures concerning plagiarism or attempted plagiarism will be taken in accordance with the subject-specific examination regulations and/or the *Allgemeine Satzung zur Regelung von Zulassung, Studium und Prüfung der Humboldt-Universität zu Berlin* (ZSP-HU).



Berlin, 27 March 2020 Magdalena Bauer