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Making cities work

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Summary

Over the past decades, cities have constantly exhibited high levels of ambition in the field of climate action implementation. As cities and regions become key locations as well as essential initiators, climate action at the city and municipal level have become a well-established phenomenon in global environmental governance. Hence, cities are acknowledged as vital actors in the global mitigation and adaptation efforts in response to climate change. In parallel to these commitments towards climate change responses, several Transnational city networks have emerged providing a global/regional platform for shaping local climate initiatives while instigating transnational relations. The formation of city to city transnational networks promotes collaboration and interaction among different cities and disciplines offering policy makers the opportunity to acquire key data from prior experiences.

However, investigations examining how climate network memberships influence local climate actions are rare. The objective of this study is to address this knowledge gap by distinguishing and measuring the impacts of climate network memberships on local climate measures. With this study focusing on the local level of urban climate measures, the aim is to contribute to the scientific understanding of the influence of different types of transnational climate networks enabling cities to acquire certain characteristics and functions through their membership, resulting in the facilitation of climate change measures.

The study was conducted by following a desk research based on European cities policy documents regarding climate change action plans. The analysis and findings are based on mainly 120 cities with 306 memberships to eight different transnational city networks across Europe.

The findings indicate that despite the widely acknowledged leadership role of Europe in terms of environmental policy, climate change response measures depict a high disparity in its distribution with adaptation measures being significantly less in comparison to mitigation measures. Across the sample, only 23.3% have adaptation plans, while 89.2% have mitigation plans and 28.3% have a joint M+A plans. The results of the multiple and binary regression analysis indicate that among the different attributes and functions acquired through membership, **funding** is the most significant predictors for the total number of action plans a member city implements. **C40 cities and Euro-cities** indicate that its members have implemented a higher number of climate actions (both mitigation and adaptation or Joint M+A) and higher emission reduction targets in comparison to the other networks. **Gross Domestic Product** and **Combined Adaptive Capacity** are drivers indicating that prosperous cities with better institutional, technological, and infrastructural capacity direct extensive employment in the overall number of action plans and total emission reduced.

Keywords

Climate change, Transnational City Network, Mitigation, Adaptation

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Abbreviations

IHS	Institute for Housing and Urban Development
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
GHG	Green House Gas
TCN	Transnational City Networks
IPCC	Intergovernmental Panel for Climate Change
ICLEI	International Council for Local Environmental Initiatives
COM	Covenant of Mayors
ACCCRN	Asian Cities Climate Change Resilience Network
GDP	Gross Domestic Product
EU	European Union
UN-Habitat	United Nations Human Settlement Program
SEAP	Sustainable Energy Action Plan
SPSS	Statistical Package for the Social Sciences

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Chapter 1: Introduction

1.1 Background of the research

Climate change is a global phenomenon with urban areas expected to experience most of its considerable effects. At the same time cities are key contributors as cities account for around 70% of global greenhouse gas emissions, consume 2/3 of all natural resources and use 80% of global energy supply (UN-HABITAT 2011; UNEP 2015). Since several root causes reside in cities, so tangible climate solutions can also be created from cities as well. Cities around the world have been platforms for diverse urban climate change experimentation and innovation (Bulkeley and Broto, 2012).

Over the past decades, cities have constantly exhibited high levels of ambition in the field of climate action implementation. Climate governance on a global scale has been designated by a distinctive escalation in the scale and scope of actions by local governments around the world emphasizing their significant role in the advancement of climate change adaptation and mitigation. The prevailing discourse concerning climate actions and policy-making in the urban context designates that cities holds distinct potential for effective implementation by independently instigating climate policy action through measures of bypassing national and intergovernmental agendas.

As cities and regions become key locations as well as essential initiators, climate action at the subnational and municipal level have become a well-established phenomenon in global environmental governance (Castan Broto and Bulkeley 2013).The discourse prompting that instead of states, cities are better equipped to confront with wicked problems such as climate change has established itself as a critical subject of discussion among academics, the public and policy-makers. (Kousky and Schneider 2003) .The diversity and practical understanding of local projects in cities stimulates innovations producing credible ideas which as an outcome can be applied on a larger scale (Gustavsson et al. 2009). Most scholars agree on the importance of inclusive integration of various actors, and facilitation of local actions at multiple levels, for the development of global environmental governance. Ostrom (2009) observed that global solutions initiated at the international level for complex problem such as climate change, will not succeed unless various efforts are collaborated and reinforced at the national, regional and local level.

Hence, cities are acknowledged as vital actors in the global mitigation and adaptation efforts in response to climate change. However, cities in Europe, despite being a highly urbanized region with significant policy advancements in terms of environmental issues, depict substantial difference in the regional distribution, commitment and scope of climate change responses. Moreover, a recent study of urban climate measures in Europe indicated that among large and medium sized cities, 35% have no determined mitigation plans, 72% have no adaptation plan, and only 25% comprised of both mitigation and adaptation plans with quantifiable targets for greenhouse gas emission reductions. (Reckien, Flacke, et al., 2015).

The constraints for the implementation of climate actions are often asserted to the uncertainty of climate change impacts. However, scientific interpretation to date indicates that refined and verifiable information on climate change impacts and greater certainty do not necessarily result in additional and improved (i.e., locally adapted and appropriate) climate change actions.

The Fourth and Fifth assessment report of the Intergovernmental Panel on Climate Change(AR4 and AR5 ,IPCC) equally highlight the influence of several driving factors as well as potential barriers in the facilitation of climate mitigation and adaptation efforts in the urban context. It was acknowledged that drivers and barriers do not always imply clear-cut causality and their measure of effect to climate change efforts may to some degree vary across context. Nonetheless, as stated in the IPCC's Fifth Assessment Report, it can be assumed that a number of factors are observed to be common across contexts and scales.(Reckien, et al., 2015)

Furthermore, considerable proliferations in studies of potential drivers and obstacles that influence climate efforts have underlined one main influential factor as membership of climate networks. Basic definition designates it as a network of cities that functions in a collective manner in response to climate change impacts. Climate networks instigate information and knowledge exchange, lobbying and resource acquisition such as technical and financial support (Hakelberg, 2014; Lee & Van de Meene, 2012).The formation of city to city transnational networks promotes collaboration and interaction among different cities and disciplines offering policy makers the opportunity to acquire key data from prior experiences involving adaptation and mitigation measures.

Networking developments have the capability to address an extensive range of issues and converse in multifaceted interactions between different levels of governments and variety of domestic/global actors involved in the climate change discourse. Collaborative networks initiated and directed aptly can enable effective solutions applicable to the local contexts while distributing key information and ideal practice models for others (Innes et al., 1994). Addressing environmental issues is highly complex and is a contextual field of work, hence networks provide more flexibility and less limitations compared to the governments rigid programmatic constraints. Additionally, networks have an extensive reach in communicating with several proficient actors, acquiring various resources and collaborating with multiple government entities (Goldsmith and Eggers, 2004).

1.2 Problem Statement

In times of escalating pressure due to climate change induced threats, implementation of climate change policies for mitigation and adaptation is gradually becoming the responsibility of the local government. Cities deliver ample capability and potential for local climate measures since they indicate accumulation of flows of physical resources and carbon (Anderberg, 2012, Bulkeley et al., 2013)

In this context, transnational city networks have become imperative forums for shaping local climate initiatives while instigating international relations for global urban climate governance (Bulkeley, 2005).. However, investigations examining how climate network memberships influence local climate policies are rare (Davies, 2005; Hakelberg, 2014; Zeppel, 2012) .The objective of this study is to address this knowledge gap by distinguishing and measuring the major impacts of climate network memberships on local climate measures in a comprehensible and rational manner. With this study focusing on the local level of urban climate measures, the aim is to contribute to the scientific understanding of the influence of transnational climate networks enabling cities to acquire certain characteristics and functions through their membership, resulting in the facilitation of climate change measures.

Vast majority of scientific studies on the drivers and barriers to mitigation and adaptation measures focus on the local or regional level and are grounded on a small sample size or single case study.(Reckien, et al., 2015) Few comparative studies exist on the factors influencing climate change responses across cities and a comprehensive in depth research about common influential factors such as climate networks are distinctly limited. Hence by analyzing diverse city to city climate networks, this study aims to categorize different climate networks according to their various attributes and identify the distinct function each network provide to the members, in facilitating climate change adaptation and mitigation measures in cities in Europe.

Despite the value-added contributions of earlier scientific studies on climate network, evidence based research regarding the identification of specific characteristics and functions of varying climate networks influencing urban climate actions are still absent. In addition, research on the level of activity with regards to their functions of these networks is rare. Continued existence of the network is a pre-requisite for the network's influence on the individual cities effort on the diffusion of local climate action as well as for various roles including its impact on cities climate policies.

The study investigates the link between the activity level and different functions as an indication for the networks future survival. The knowledge gap in understanding the underlying influence of attributes and functions of climate networks could be answered by providing a classification of city to city networks based on their level of network/geographic spread, identifying the institutions and main stakeholders involved in the network structure, and analysing the function that each specific network provide to their members (such as information exchange, lobbying, networking, standards and commitment provision, research, project financing , certification and monitoring). The development of such a typology is beneficial in helping cities identify and understand the advantages/disadvantages from their mode of participation and partnership with certain transnational city networks.

1.3 Research Objective

This research is aimed to assess the relationship and level of influence of Transnational city network's characteristics and functions on the facilitation of member city's climate change adaptation and mitigation measures in Europe.

1.4 Provisional research question(s)

In order to accomplish the research objective, the main research question is.

To what extent do the characteristics and functions of Transnational city networks explain the Facilitation of climate Adaptation and Mitigation measures in member cities in Europe?

1.4.1 Sub-questions:

- What are the City characteristics and functions acquired through membership to the different types of Transnational city networks?
- What are the existing (natural) city characteristics that serve as a driver/ barrier in the implementation of climate action plans in cities?
- What are the Climate action plans (*Adaptation and Mitigation)* under implementation in European cities with membership in a Transnational city network? What are the emerging patterns of Climate action plans?
- What is the identifiable City characteristic Typology with similar activities across different sectors in the member cities?
- Which city characteristics (acquired and existing) explain the facilitation of these climate adaptation and mitigation measures in member cities in Europe?

1.5 Significance of the Study

The urgent calls for immediate action by scientists, policymakers, politicians and the public have advanced international negotiations and collaborations in an effort to address climate change in a more effective and collective manner. With the increased emphasis on the local government's central role on climate change adaptation and mitigation, Transnational City Networks have emerged as an indispensable component in enabling improved implementation of climate policy.

The significance of the rise of cities profile in the international platform is a notable development in international policymaking and network governance. Transnational relations among cities regarding climate networks are multi-faceted, involving domestic and global policy prospects and limitations, political power dynamics and difficulties involving cities' legal stature at the international arena(Kubler & Piliutyte, 2007; Lee, 2013).

Previous research into transnational networks have primarily focused in investigating qualitatively the governance experiments and strategies being applied, and exploring the development and functions of transnational climate governance(Giest & Howlett, 2013; Kern

& Bulkeley,2009) Nevertheless, quantitative studies of cities and their affiliation with climate network are still limited. A further extensive investigation into the operations of transnational networks, notably explicit examination of their activities and attributes is necessary. Pursuing a quantitative research that assesses various climate networks and their functions can enhance our knowledge of the multi-faceted relations and interaction dynamics among the network members.

This study aims to contribute in developing a better understanding of the effective roles played by various climate networks and provide insights for policy makers and network facilitators in directing more credible strategies to implement local climate policy against climate change.

Scientifically this study will contribute to the call for more empirical work on influence of Transnational networks in advancing local climate actions. The findings of this study can be utilized by local governments in aiding them with better understanding of the impacts that Climate networks can have on furthering the resilience of a city through resource acquisition for diffusion of local climate actions and its influential aspect in the progression of climate policy in the urban context.

1.6 Scope and limitations

Considering the time constraint, research is dependent on a quantitative desk research method assessing secondary data. The scope of the study is delimited to large, medium and small sized cities in Europe evaluating the presence and value of climate mitigation and adaptation measures or both. The research focuses on the characteristics and functions of Transnational networks provided to member cities in facilitating/ advancing local climate measures. It is understood that climate networks and its relation with cities are immensely complex and while this research contributes to only a certain component of the study, it is not an overall comprehensive conclusion. Extensive range of different externalities and factors exist that effect cities on both a localized and global scale.

Furthermore, this study on transnational networks and it's in influence in cities in Europe may provide valuable and insightful information for research in other cities from other parts of the world, but it should be noted that policy making regarding climate actions is an extremely contextual field of work .Policy and research for a certain region does not necessarily represent the same deductions for all regions.

Figure 1. European regions at Global scale

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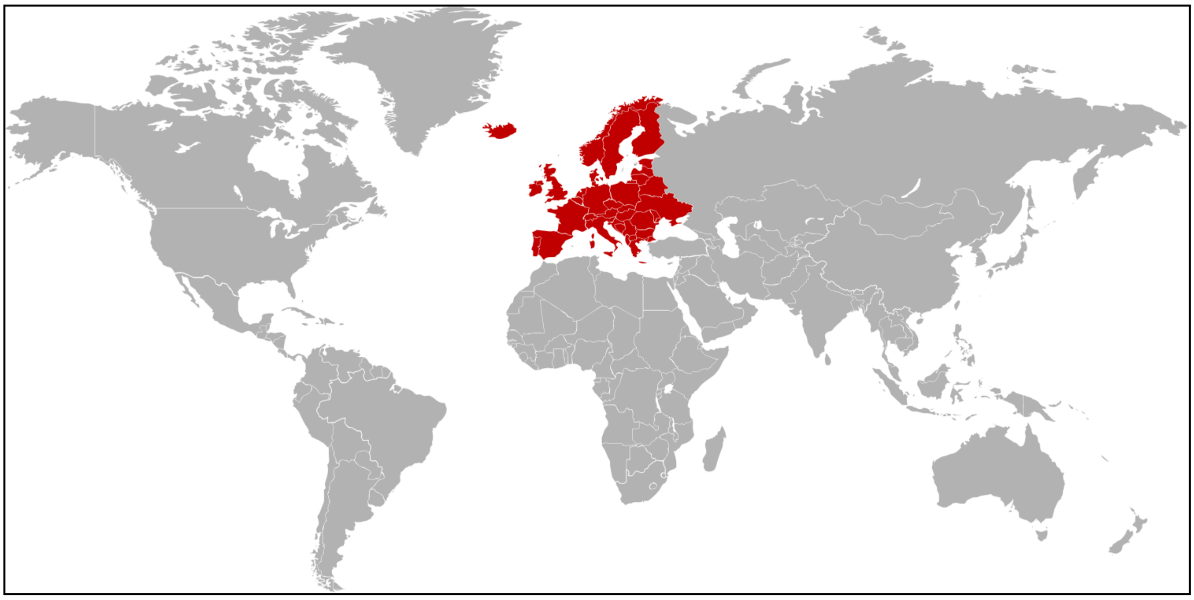
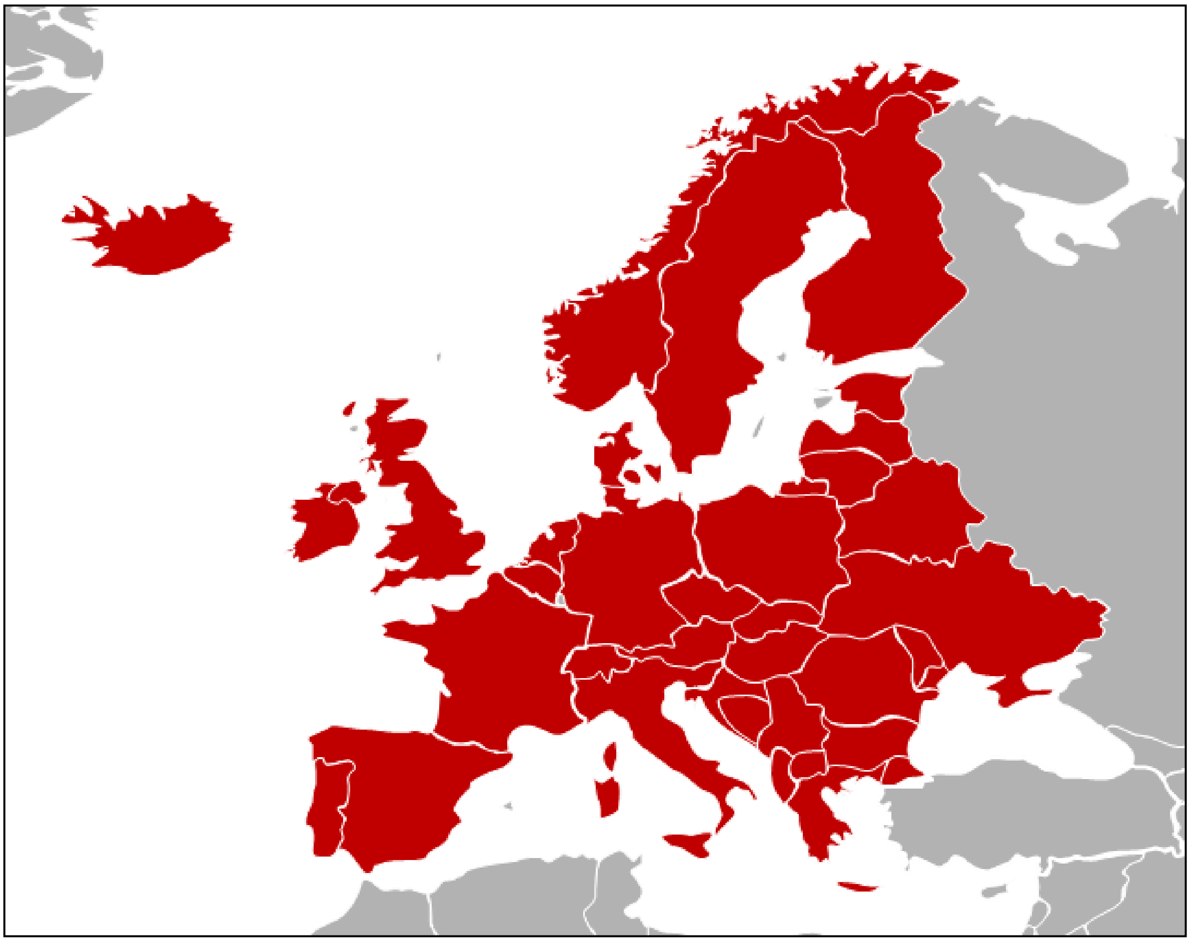


Figure 2. Europe at regional scale



Chapter 2: Literature Review / Theoretical Background

2.1 Introduction

In this chapter existing literature related to policy and action plans and transnational city networks will be reviewed to site this research in the context of academic relevance and policy practice. It will elaborate on the theoretical concepts linked to the study as well as provide actual world context with empirical examples of various networks and their activities. A theoretical basis is established for this research founded on existing concepts to categorize different climate networks according to their various characteristics and identify the distinct function each network provide to the members, in facilitating climate change adaptation and mitigation measures in cities.

The various dimensions discussed in this section range from definition and conceptualization of transnational city networks to its influence on facilitating local climate actions in cities. The effects of climate change networks in the European context is examined, followed by reviewing various literature in characterizing and identifying the different attributes by such as level of network/geographic spread, structure of network (institutions and stakeholders involved) , level of activity, functions involving information exchange, lobbying, funding, research, target setting, plan, and monitoring. These attributes and function have been considered as acquired city characteristics in this study as cities obtain these benefits as their own in facilitating climate measures through membership to the climate networks.

2.2 Climate Action Plans.

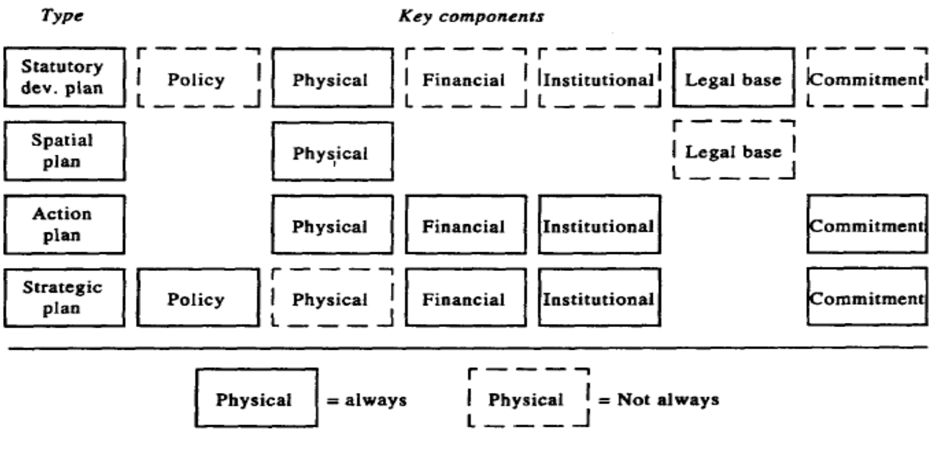
2.2.1 Policy and Action Plans.

Yanow (1996) defines policy as a deliberated system guiding a set of practices to achieve a rational outcome which may vary across different context such as spatial and temporal planes. Similarly, Davidson (1996) states that different context in cities of various countries may influence the policy effectiveness as context is always altering.

Moreover, Davidson (1996) distinguishes three types of different planning concepts:

- Statutory development planning, (spatial planning)
- action planning, and
- strategic planning

Figure 3. Key components of major forms of planning



Source: (Davidson, 1996)

Statutory planning is described as the urban management tool and planning system designed and specified by law. Although statutory planning provides legal reinforcing of critical elements of planning, it however lacks flexibility, suffers problems of commitment and bureaucratic division and government instability can render it ineffective.
Action planning and strategic planning are based as forms of performance-oriented planning.
Action planning is defined as an implementation-directed plan on a limited time frame specified towards a fixed objective. It provides effectiveness in a short period of time encompassing flexibility and innovation. But it lacks legal support unless linked to statutory planning and brings potential risk of being ad hoc.
Strategic planning is defined as medium to long term plan specified towards a strategic objective with the inclusion of key stakeholders in the process. It involves a policy framework combining physical, institutional and financial aspects while also focusing on multi-sectoral strategies.
In this context, this research primarily focuses of actions plans for addressing climate change but strategic and development plans may also be considered in regards to their mid to long term objectives where the overall framework may include/relate to several action plans.

Table 1. Comparison of performance of different plan types

Performance requirement	Statutory development plan	Strategic plan	Action Plan
Be a tool for policy implementation		●	●
Achieve support and commitment by all main actors in development		●	●
Be a basis for establishing partnerships		●	●
Provide a medium to long-term framework for development decisions		●	
Provide a framework for early action			●
Provide locational guidance	●	○	○
Result in implementation that meets objectives		●	●
Achieve objectives with efficient use of resources		●	●
Provide a framework for sustainable development	●	○	○
Guide inter-sectoral public investment		●	○
Guide city level public investment		●	
Guide local level public investment	○	○	●
Be a framework for non-physical action programmes		●	●
Be able to respond to changing environment		●	●
Provide basis for development control	●		
Be a tool for institutional capacity building		●	○

Key: ●, key area of performance; ○, sometimes area of performance.

Source: (Davidson, 1996)

2.2.2 Typology of Local Climate Plans.

1) **Comprehensive and stand-alone**

D. Reckien et al. (2017) distinguishes local climate plans of European cities in terms of its detail, structure and scope. A comprehensive and stand- alone plan is defined as a local climate plan of the urban authority addressing climate change through multiple sectors. Either adaptation or mitigation for climate change are mentioned in the title and acknowledged as the main objective for developing the plan.
Despite the recent emerging significance on climate change related interventions, middle and low-income cities which are still susceptible to climate risks implement a plan comprising only adaptation or mitigation separately. The main reason normally linked with their financial limitations which constrain them with the selection of only a single component of the available climate policies/actions.

2) **Mainstream and inclusive (integrated into other policies)**

Mainstream and inclusive plans are described as Local climate plans where climate change is included as a partial aspect in another municipal plan such as sustainability plan, or Local Agenda 21. The aspects of climate change are integrated into other policies or plans prepared for other purposes. (D. Reckien et al., 2017). These plans are excluded as this research mainly concentrates on actions employed to address climate change.

3) **Combined mitigation and adaptation plans**

With the changing perspectives of the international community on climate policies and actions, the adoption of a holistic approach (joint M+A plans) has been vastly emphasized. Significantly, IPCC have highlighted the integration of mitigation and adaptation policies, in order to effectively respond to climatic variability. Multiple benefits and cost-effectiveness on climate actions are associated with a combined approach (Di Gregorio et al., 2017).
There are several indications that an integrated policy direction addressing M+A measures results in the reduction of the likely resource competition among the measures and enhance the cost effectiveness of climate policy (Klein et al., 2005).
In this context, this study will only consider stand-alone plans and combined mitigation and adaptation plans where climate change is presented as the main aspect for its design and implementation.

2.3 Networking for Facilitating (driving) climate actions in cities.

Member Cities from networks such as C40 have reported from 2013 - 2015, an observation of 30% of overall climate change actions being implemented involve collaboration with other cities. It identified 450 new actions from out of 1550 were achieved through city-to-city networking. (Climate Action in Megacities 3.0, 2015). These findings demonstrate the capabilities of such city networks in facilitating climate change actions regardless of geographical and other impending obstacles. Links are observed in relation to the degree of networking between cities and the scale of actions implemented. This developing trend establishes the role of networking in delivering more transformative actions in cities enabling exposure to other expertise and resources from beyond their local boundaries.
Mitigation measures delivered through networking are predominantly in the energy supply, transport and building sector, setting individual emission reduction targets. The sectoral divide for action differs depending on the type of network established. For example, in C40 cities, the percentage of actions instigated through networking, ranged from 40% in the waste sector, and 35% in the mass transit sector. While the accounts of adaptation measures indicated a steady growth from 11%-16% in C40 cities reported from 2011-2015.The study suggests the advancement of a new period of climate action, that equally highlights cities emphasis on adaptation measures along with the scaling of mitigation efforts in parallel.(Climate Action in Megacities 3.0, 2015).
Advancing in adaptation measures to climate change in cities involves multi-faceted interaction with various actors as well as different levels of governments with increasing dependence for political support and additional resources. In this context, city networks play a crucial role enabling horizontal information distribution with other municipal sectors while advocating for better policy integration across different levels of government.

2.4 Financing climate actions through networking

Insufficient financial resource is a primary concern hindering active responses for implementing local climate actions in cities. Funding is an essential requisite for driving local climate actions in cities. In this regard, networks within cities produce a collective power to gain access to financial supports normally outside an individual city's boundaries. Networks provide a global platform for cities, expanding their range to attract investors /donor communities to fund climate actions. Collaborating with networks reduces pressures of depending merely on traditional funding sources such as central city budget to deliver climate response projects. Networking provides city officials with a broader spectrum of financing options ranging from grants to subsidies such as city climate funds, green bonds etc. For example report on cities with C40 cities network determine a higher percentage of actions initiated in comparison to other cities, potentially due to their ability to access innovative financing mechanisms. (Climate Action in Megacities 3.0, 2015).

2.5 Identifying City characteristics Typology

Networks aim to connect cities with similar characteristics to face specific climate action challenges together. Certain city characteristics (existing and acquired through membership) may be apparent (such as population/GDP) but others remain unexplored resulting in missed opportunities to drive action. Identifying similar characteristics and activities among cities presents the potential for policy makers to exchange information from cities facing similar challenges and opportunity for attracting investors seeking to place their funds where they might have the greatest benefits for all parties concerned.
This research aims to fill that knowledge gap by identifying the natural city characteristics existing among the member cities of the different transnational city networks in Europe. The TCN associated characteristics and functions are also considered as the acquired city characteristic as the membership enables the member city to use such attributes as their own.

2.6 Natural (existing) City Characteristics

Existing natural city characteristics are identified which may serve as a driver/ barrier in the implementation of climate change actions in cities. Several scholars recognized socio-economic and environmental factors as the most important influential factors.

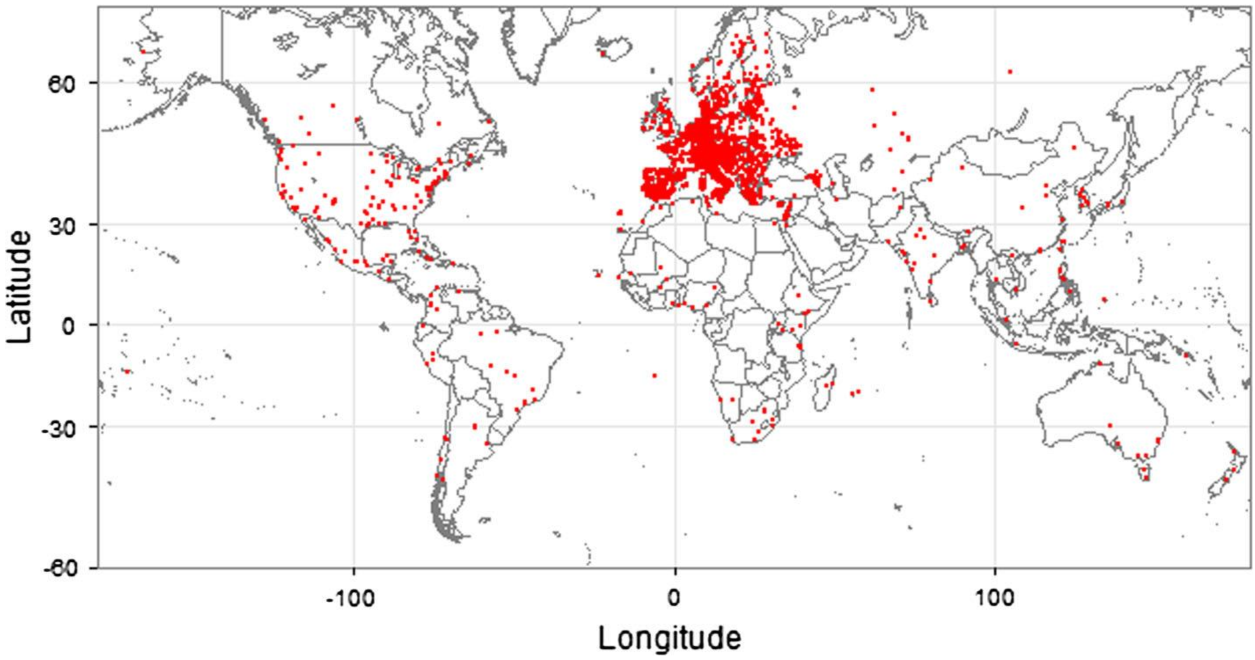
Satterthwaite, et al. (2007) identifies vulnerability in an urban context as being dependent on its social and economic development. Romero, et al. (2014) also points out that the adaptive capacity to climate change is influenced by societal changes such as **unemployment** due to economic dislocation.

Buob and Stephan (2011) claim a region's **income level** defines the adoption between mitigation and adaptation strategies .High income regions tend do both M+A measures while low income regions implement only mitigation actions stemmed by their limited resources. In addition, Hardoy and Lankao (2011) claim that key determinant of GHG emissions in cities are identified in the consumption patterns which directly relates to the income level. **Population size**, climate change, and disaster risk are strongly interlinked and inter-influential. In this context, **adaptive capacity, GDP of the city, GDP per capita, population size and unemployment rate** is adopted in this study. Additionally Reckien, et al. (2015) also identified projected **exposure to future climate impacts** as a main factor in regards to city adoption of climate actions. ESPON (European Spatial Planning Observation Network) climate project provided the required data in terms of the aggregated indices of climate change impacts and adaptive capacity for the European regions. The project defined the impacts of climate change as weighted combination of the possible exposure and vulnerability to the social, environmental, economic, physical and cultural aspects in the region from a period between 2071–2100. Adaptive capacity is considered as the weighted combination of the infrastructural, technological, economic and institutional capacity of the regions. The knowledge and awareness of the people to climate change have also been considered.

(Milfont, Evans, et al., 2014) had identified physical proximity to coastline was linked to climate change belief and concern. The people in these regions expressed greater support for climate measures and better governmental regulations for carbon emissions. Rising sea level and flooding are the serious impacts to coastal cities, while cities at higher altitudes are susceptible to droughts and landslides. **Distance from the coast and altitude above sea level**, are thus treated as environmental factors in this study.

2.7 Climate change networks in European context.

Figure 4. Regions and Cities in Transnational City/municipal networks



Source:(Bansard, Pattberg, et al., 2017)

Current European efforts in implementing climate change policies reflect the incorporation of vertical and horizontal dimensions of governance (Bulkeley and Betsill, 2003) emphasizing the importance of place-based models and application of adaptation and mitigation measures in local context. It highlights the significance of support structures by national governments to the local level in the field of environmental policy. This development has initiated bilateral corporations among cities around Europe to develop locally adapted climate measures. Furthermore, Policy networks have been constructed through these collaboration structures.

The opportunities available in the European Union's multi-level system have enabled transnational city networks to achieve accessibility to both principal decision-makers and resources (Ladrech, 2005). These networks mostly emphasize on two primary goals: representative roles of their member's interest at the European level and enabling the transfer of information and transnational learning among their constituents (Bennett and Howlett, 1992). Norway, Germany and France exemplify as models for adopting such bottom-up approaches. The Norwegian government emphasizes on growth of cross-level strategies while trading essential information from other country's experiences. In addition, municipalities accordingly are allotted funding to initiates specific projects. A series of cities in Germany have instigated plans to design and implement climate actions. Government of France through collaboration between the national and local level, supports the development of locally adapted strategies of the local governments with its own individual objectives.

Certain municipalities in Austria and cities among Europe have engaged in non-governmental networks such as Climate Alliance founded in 1990 which targets carbon emission reductions and sustainable forestry initiatives through partnerships with indigenous rainforest peoples. Climate Alliance currently comprises of 1700 members spread across 26 European countries (Westerhoff, 2010; Climate Alliance, 2017). Euro cities is another recognized European-wide network, established in 1986 consisting of 140 local government members of Europe's major cities from 39 countries. The Policy priorities of the network are facilitation of climate actions, economic development and reinforcement of the local government's role ranging from planning to the integration of prevailing international policy objectives to local actions. (Corfee-Morlot et al., 2009: Eurocities, 2018)

In addition to Eurocities and Climate Alliance, two more networks were established under the climate protection agenda since the early 1990s. Before the United Nations Conference on environment and development in Rio, Brazil in 1992, Energie-cités and Cities for Climate protection (CCP) were created. (Kern and Bulkeley, 2009). The CCP programme is part of an international coalition of Local Governments for Sustainability Initiative (ICLEI) initiated as a platform for global climate discourse advancing policy coordination, technical and financial support (Corfee-Morlot et al., 2009).The programme with currently 176 cities from 19 countries, offers packages to cities based on its five milestone methodology ranging from climate impact assessment, target setting, action plan development and implementation to evaluation and monitoring. (ICLEI Global, 2018).

Energie-cités is a network established 1990 in Europe, predominantly dedicated to supporting the city transition to sustainable energy and representing their member's interest in terms of energy, urban and environmental policy at the European level. It represents more than 1000 cities from 30 countries instigating mutual learning experiences, knowledge transfers and joint implementation of projects. The C40 Cities Climate Leadership Group is another prevalent network in its 10thyear representing 80 major cities from around the globe. Through its 16 thematic networks, it primarily focuses on facilitating dialogue among its members for tailoring locally appropriate urban actions for addressing climate change threats.

From such associations that reinforced the local government networks involving multitude of actors at various levels, projects such as Covenant of Mayors were initiated.
The Covenant of Mayors is a bottom-up movement adopted in 2008 endorsed by all European institutions, committed to mainstreaming local actor involvement in climate action planning and implementation of sustainable energy policies. The initiative now represents more than 7,000 local and regional authorities across 57 countries.

Overall various climate networks functioning across transnational limitations highlight the significance of reinforcing and creating opportunities for local actor involvement across all levels in the field of climate policy. It also indicates that the European context provides favorable settings in which transnational city networks can prosper instigating opportunities for collaboration among multi-levels of governments. Though similar trends can be observed across Asia and North and South America, the notion of utilizing municipal networks in advancing adaptation and mitigation measures to address climate change has not yet been realized for its entire capability.

Table 2. Overview of Transnational City Networks

	Name	Abbreviation	Members	Year	Type	Geography
1	Climate Alliance of European Cities with Indigenous Rainforest Peoples	Climate Alliance	1717	1990	Cities	Europe/Latin America
2	Covenant of Mayors	CoM	5717	2008	Cities	Europe
3	EUROCITIES	EUROCITIES	45	1986	Cities	Europe
4	C40 Cities Climate Leadership Group	C40	75	2005	Cities	Global
5	EnergyCities	EnergyCities	184	1990	Cities	Europe
6	Union of the Baltic Cities	UBC	93	1991	Cities	Baltic
7	Regions of Climate Action	R20	92	2010	Regions	Global
8	New England Governors and Eastern Canadian Premiers' Annual Conference	NEG/ECP	11	1973	Regions	North America
9	World Mayors Council on Climate Change	WMCCC	88	2005	Cities	Global
10	The Climate Group (States and Regions)	TCG-SR	27	2005	Regions	Global
11	North America 2050	NA2050	20	2009	Regions	North America
12	International Solar Cities Initiative	ISCI	5	2003	Cities	Global
13	Western Climate Initiative	WCI	5	2007	Regions	North America

Source:(Bansard, et al., 2017)

2.8 City networks as horizontal trans local relations

Cooperation among cities through networks can be observed from a theoretical perspective of translocal relations. Translocal relation theories supplement prevailing international relation studies by the incorporation of local actors and authorities as crucial players in the global policymaking platform. It studies the horizontal interlinkages and associations between various local actor including private sector, local civil society organizations and municipal authorities within and across transnational borders. A local actor is enclosed within multi-level hierarchical set up comprising of global, national, and regional authorities. Regardless of the hierarchic aspects, local actors can autonomously initiate interactions with other actors (Lee, 2015)

Translocal relations among cities essentially concentrate on local actor cooperation activities encompassing policy learning, financial and technological assistance, advocating and many other forms. In particular, policy learning is fundamentally relational as it refers to constructing decisions based on predictions established from information and knowledge learned from other actor's experiences (Lee and Van de Meene, 2012).

Likewise, transnational city networks offer platforms for knowledge transfers and networking for upgrading policy measures. Collaborative initiatives among cities comprise of information and resource exchange, facilitating research and monitoring climate policy performance (Lee, 2015).

2.9 Transnational City/Municipal Networks; Definition and Conceptualization

The term ‘transnational city/municipal networks’(TCN) is broadly acknowledged by scholars for denotation of city networks of various sizes and at different levels (global, regional, local) with reference to multiple interactions between individual subnational government entities and municipalities. (Betsill and Bulkeley 2006; Toly 2008; Kern and Bulkeley 2009; Giest and Howlett 2013)

According to Kern and Bulkeley (2009), three defining criteria are observed which characterizes a transnational network. First criteria specified is that membership to the network is voluntary and withdrawal and exiting option are available at any time. Second, the structure of the network is arranged in a non-hierarchical system with horizontal relations mainly based on a polycentric setup. Third, network decisions are directly implemented by the members. Likewise, Busch (2015) defines transnational networks as institutionalized platform where local governments from various nations interact as equitable allies in addressing issues related to climate change.

The TCN that originated in Europe from the late 1980s onwards differentiate themselves from conventional national organizations of subnational government entities that generally comprise of all respective territorial bodies of a country. On the contrary, membership to such network is non-mandatory and depends on sole basis of the autonomous decision of the local governmental entity. These networks usually comprise of only few cities of a listed state among their membership. (Bulkeley et al., 2009)
Cities through these networks can interact directly among members across national boundaries enabling policy coordination, resource acquisition, lobbying, monitoring, instigating research etc. in a transnational manner. What constitutes as a city is still debatable among many scholars. The distinguishment when a rural municipality does become a city is undefined and consideration of a mega polis with more than ten million inhabitants as a city or not is a topic of discussion. In relevance to this research, a simple and pragmatic approach of identifying cities is adopted, following if members within the network define and identify themselves and each other as cities, I recognize the association consistent with other features defined in this section as cities in a transnational city network.

According to Karl Kaiser’s interpretation from 1970, transnational is defined as overpassing and covering beyond national boundaries without the inclusion of national governmental bodies (Kaiser 1997).The typology of transnational networks ideally pursue a structural arrangement better characterized as supranational rather than intergovernmental. Additionally, they typically form their membership based mainly on a polycentric setup and arranged in a non-hierarchy system initiating horizontal networking (Kern, 2001). Withdrawal and exiting option are available at any time with exit charges kept at a minimum. Moreover, transnational city networks associate their membership directly with higher levels of other international organizations such as international governmental organizations (IGOs) like the European Union ,United Nations (Bulkeley and Kern 2009; Heinelt and Niederhafner 2008).

2.9.1 Level of Network/Geographic Scope

Different transnational city networks for climate actions emerge with different geographic scope. The level of network coverage of city to city cooperation range from a global scale to regional and domestic levels. Lee et al. (2018) observed potential capabilities and limitation related to this different typology in geographic scope.(Lee and Jung, 2018).

2.9.1.1 Domestic City Networks

The probability of cooperation instigating networks is likely to occur among cities within the same country for the advantage of geographical proximity and as they share similar cultural contexts such as history and language. Conversely, it is also possible that cities within the same nation contest among each other to acquire more financial resources and superior status. Several advantages can be identified for domestic city networks particularly for climate change actions.

The reduction in the transaction cost for city to city corporations is possible on the basis of geographical proximity (Rose, 1991). Cultural similarities and corresponding institutional setting can augment coorporations and collaborations among cities/networks within the country. Cultural alikeness incorporates lifestyle, thought process and communicating manner (Child and Faulkner, 1998). Cities that can communicate under shared language minimize the transaction cost of coorporation. Similarly, cities within one country generally adopt a coherent legislation and admistrative structures. These comparable institutional settings can foster interlinkages among cities within the same country. However, cities vary in size and socio-economic development. Additionally, dissimilarities in political situations and party affiliations may hinder corporation among cities. Cooperating through collective efforts with similar city traits such as socio-economic conditions and size may be beneficial in overcoming such obstacles. Moreover, coordination of local authorities with national government for effective resource allocation will diminish external threat factors and exercise opportunity factors (Parker and Rowland, 2007).

2.9.1.2 Regional City Networks

Certain city networks for climate change extend beyond state and national boundaries to corporate at the regional level (e.g., Europe, Asia, North America). Exploring transnational borders enables cities with the opportunity to interact with a diverse field of actors for collaboration. A principal asset of regional city networks is the geographic scope and diverse range of partnering cities. A wide range of selections for partnerships enables the cities to acquire the suitable cooperative relations desired. Nonetheless, certain disadvantages are also associated with city networks at the regional level. Considering the vast number of cities from various countries around the world, the languages they speak is different and presents dissimilar institutional contexts. This differing attribute results in escalation of transaction cost for city to city cooperation. Contrasting national institutions act as a barrier for interactions and collaborative relations. However, instigating cooperation with supranational institutions or development of coordination among regional institutions can provide opportunities for the member cities.

2.9.1.3 Global City Networks

City networks on climate change measures can range beyond their national and regional boundaries. Certain networks interact and cooperate at a global scale. Enabling Cities to interact are acknowledged as key development elements in climate governance at the global level. The benefit of global city networks exists in its extensive scope and world-wide memberships surpassing transnational and regional limits (Lee and Koski, 2014). Some cities despite the absence of state support have collectively made attempts to lead the way in GHG emission reductions while exchanging information with other cities beyond nation-state borders (Parker and Rowland, 2007). Global city networks deliver multiple benefits among different cities enabling knowledge distribution and coordination necessary for upgrading policy measures, climate financing and many other forms related to climate actions. However, in comparison to domestic and regional networks, global city networks maintain some disadvantages as they require more capacity and involve increased transaction cost. Several small and medium-sized cities mostly from developing countries may lack the institutional and financial capacity for steady global cooperation. (Bansard et al., 2017).

Moreover, cities and global networks are restricted to establish legally binding international agreements as prevailing international settings are based on a state-centric system with authority over such legal matters (Lee, 2015).

2.9.2 Network structure (institution and stakeholders involved)

Lee et al. (2018) in his literature identified two different types of network structures, observing each type with their advantages and disadvantages; multilateral and institution-led city networks (Lee and Jung, 2018).

2.9.2.1 Multilateral City Networks.

Multilateral city networks refer to city to city cooperation and partnerships which are voluntarily instigated by city governments. The difference between the two networks lies in the involvement of actors that initiate the cooperation. City leaders central to climate actions establish collaborative city networks such as C40, EUROCITIES, Climate Alliance of European Cities with Indigenous Peoples etc. (CDC, 2013; Niederhafner, 2013). The emergence of multilateral city networks signifies cities ambitions and influence of trans local actors in global climate governance (Lindseth, 2004).

The benefits of such a network exist in extensive mutual learning among cities around the globe.Due to the wide range of cities engaging in networked governance, various partnership opportunities can be instigated (Lee, 2015). Moreover, flexibility for maneuvering is provided by allowing voluntary participation in a diverse range of city networks. On the other hand, criticism has also emerged regarding leadership and governance concerns in a multilateral city network. For instance, C40 encompasses a representative cities steering committee and an elected chairman who represents member city mayors. The lack of constant coordination in the steering committee without leadership and guidance can deteriorate the city network connections (Acuto, 2013)

2.9.2.2 Institution-led City Networks

Institution-led city networks are collaborations established by institutions other than city governments such as non-governmental organizations. City networks essentially demand consistent coordination, negotiation and decision- making. Such requirements can be achieved by an institution consisting of organizational and collaboration capacity. The advantage of such a network stems from several activities of the institution. The coordinating role of the institution allows dialogue for member cities and exchanging of key information from best practices.

Additionally, an institution such as ICLEI provides standards for local authorities such as GHG emission reduction targets, climate action plan settings, implementation and monitoring etc. (Betsill and Bulkeley, 2004; Reams et al., 2012).

Regarding limitations, as Betsill and Bulkeley (2004) indicated lack of resources and authority to act and not absence of information or guidelines are the main reasons for local government’s limitations for climate actions. If an institution is incapable of rendering sufficient resources required by member cities for implementing climate actions, effectiveness of an institution-led city network can diminish.

Table 3. Mapping City to city networks

	Domestic	Regional	Global
Multilateral	- US Mayor Climate Protection Agreement (research)	- EUROCITIES Declaration on Climate Change (standard) - Climate Alliance of European Cities with Indigenous Peoples (networking) - Energy Cities (networking) - Western Climate Initiative (networking)	- C40 (networking, monitoring) - Connecting Delta City (networking) - Delta Alliance (networking) - World Mayors' Council on Climate Change (networking) - International Solar Cities (networking)
Institution-led	- The Climate Registry standard, monitoring)	- Covenant of Mayors (standard) - ACCRN (Funding, information) - Kitakyushu Initiative for a Clean Environment (Networking) - Clean Air Asia (Networking)	- ICLEI CCP (Standard) - Carbon Disclosure Project (Monitoring) - Slim City Initiative (Networking) - United Cities and Local Governments (Networking) - Connected Urban Development (Networking) - The Climate Group (Networking) - Community Development Carbon Fund (funding) - Renewable Energy and Energy Efficiency Partnership (funding) - Sustainable Cities International (networking)

Source: (Lee and Jung, 2018)

2.9.3 Inter/Intra-network interactions and Activity status

Networking essentially comprises of member city interactions within the network (intra-network) and in some cases consist of interactions with other networks (Inter-network) identifying common objectives and targets. Networking among members involves virtual/real interactions

generally holding forums or meetings encompassing all stakeholders to endorse collaborative decision-making and validate legitimacy to the process (Keiner and Kim, 2007). However, not all city networks remain in operation with time and activity levels diminish. (Lee and Jung, 2018)examined through case studies of different networks that basic provision of functions such as information exchange and networking may not necessarily be enough to sustain the active participation of member cities. Based on his findings in statistical analysis and case studies, it can be observed that provisions of specific and advanced functions attract cities active participation in the networks and sustain the future survival of the network itself.
For the purpose of this research, eight climate networks in Europe have been selected from existing literature. The study analyzes the content of these eight networks to observe their current active status by examining activities and organizational structures through analyzing their websites. In relevance to this research, a simple and pragmatic approach of analyzing network interaction is adopted. Intra-network interactions are assessed through their activities involving meetings, forums, conferences, workshops etc. Inter-network interactions are considered on the basis of partnerships /association with other networks.

2.9.4 Functions of Transnational City Networks

Functions of transnational city networks for climate change include information exchange, funding operations, lobbying, research, target and plan provision (Niederhafner, 2013), and monitoring and certification (Bulkeley et al., 2012; Lee and Koski,2015).

2.9.4.1 Information exchange

With the aim of upgrading their knowledge of climate policies at the local level, cities established networks instigating dialogue for knowledge transfers. The most primary function provided commonly by city networks is information exchange/networking offering provisions and sharing of experience between member cities. Exchanging key practices and expertise leads to cost effectiveness and efficiency with resources in addressing climate threats.

2.9.4.2 Lobbying

The absence of representation/involvement of local authorities at the upper level of national and international climate governance and policy making is another reason for the formation of city networks. So city networks lobby for their member cities collective interest at the national and global platforms regarding climate change policy.

2.9.4.3 Funding

Inadequate financial resource is one of the major reasons impeding active responses for implementing local climate actions in cities**.** Funding is an essential function for driving local climate actions provided by city networks. Formations of city networks acquire several means of financial resources to fund the implementation of planned actions. For instance, European Union grants require the involvement of six or more members as a group. Additionally, city networks can acquire funds from national governments or international institutions through multi-level collaborations. Furthermore, private foundations such as ACCCRN (Rockefeller foundations) provide financial assistance to city networks.

2.9.4.4 Research

Research can be a vital component for city network's effectiveness in policy learning among cities. City networks offering documentation and distribution of research findings rather than just general news. This enables policy learning and dissemination of best practices. City networks such as C40 encompass an extensive database for prioritizing potential areas for action, investigating key practices and recognizing opportunities for additional assistance regarding certain initiatives.

2.9.4.5 Target and plan provisions

Provisions for target setting and climate action plans means that a city network proposes a standard or agenda for the member city to pursue. Standards range from a simple commitment for membership, sharing reduction targets and plans to following procedural standards such as ICLEI's five milestones (Giest and Howlett, 2013).

2.9.4.6 Monitoring and Certification

Certain city networks initiate monitoring to assess city's performance and progress towards achieving their targeted goals. Member cities are requested to disclose information regarding performance within the city network. Information disclosure assures compliance (Kraft et al., 2011). Monitoring verifies member city's actions and development and occasionally, certificates are issued for their achievement. Certification services enhance reputational benefits of being a member (Bartley, 2003).

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2.10 Conceptual Framework

From the literature review, key concepts and indicators have been identified to explain the relationship between Transnational City Networks and Climate Change Adaptation and Mitigation measures in member cities in Europe. The objectives of this study are to explore the correlation between different city characteristics; natural (existing) and acquired through membership of TCN and Climate change measures, as well as explain which different attributes and functions of TCNs have a positive /negative influence in facilitating local climate actions in member cities.

Through the literature review, the Urban Adaptation, mitigation, or both climate change measures are considered as Dependent Variables. And, the independent variables, have been classified into

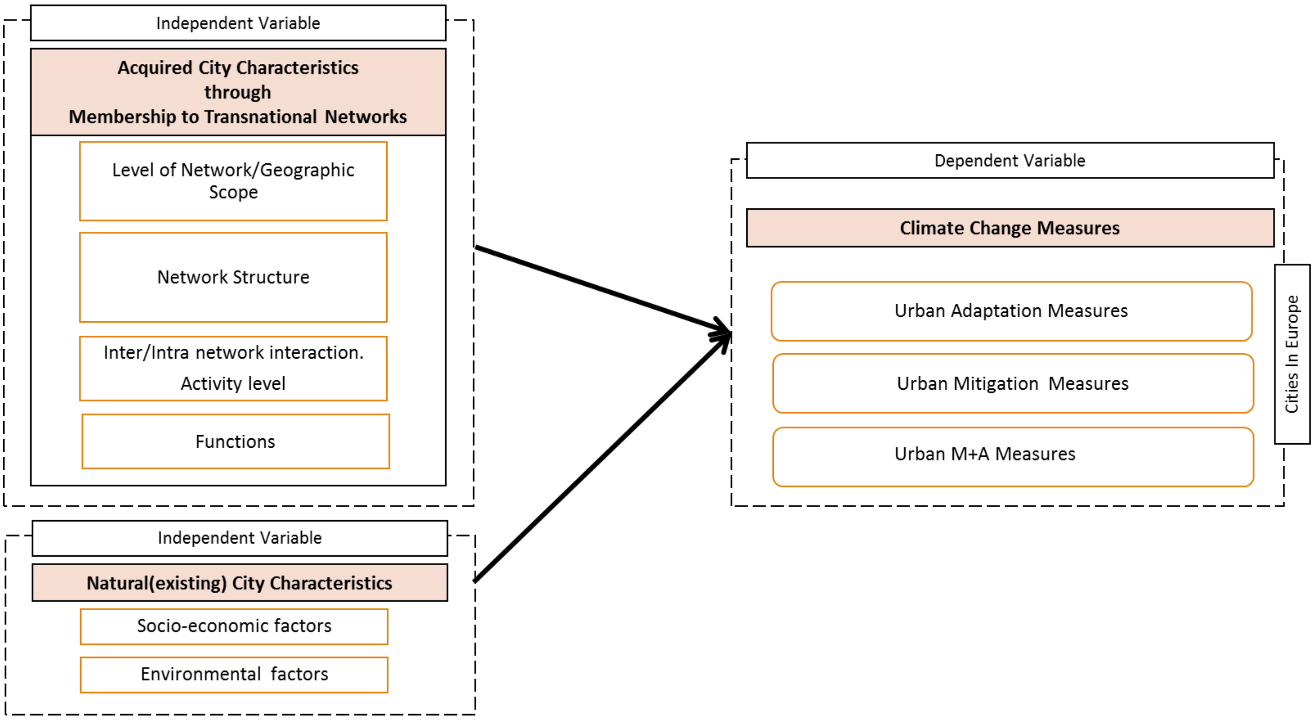
Acquired City characteristics

- Level of network/Geographic scope (Lee and Jung, 2018).
- Network Structure (Lee and Jung, 2018; Betsill and Bulkeley, 2004; Reams et al., 2012).
- Inter/Intra-network interactions and Level of activity(Lee and Jung, 2018)
- Functions(Niederhafner, 2013;Bulkeley et al., 2012; Lee and Koski,2015)

Natural City Characteristics

- Socio-economic factors (Corfee-Morlot, et al., 2009; Reckien, et al., 2015)
- Environmental factors (Reckien, et al., 2015)

Figure 5. Conceptual Framework



Source: Author, 2019

Chapter 3: Research Design and Methods

3.1 Introduction

This chapter introduces the framework adopted for the step-by-step approach for research design, data collection and analysis methods. The research objective of exploring and explaining the relation between the **different city characteristics ; natural(existing) and acquired through membership to various transnational city networks** in facilitating climate response actions in member cities, has led to a desk research strategy involving analysis of secondary data. This chapter includes the operationalization of the concepts into entities that can be evaluated by observation or measurement. The operationalization of concepts is an essential component for instigating theoretical concepts into empirical research by explicating what will be measured and how the measurements will be analyzed.

3.2 Revised Research question(s)

In order to accomplish the research objective, the main research question is.

To what extent do the characteristics and functions of Transnational city networks explain the Facilitation of climate Adaptation and Mitigation measures in member cities in Europe?

Sub-questions:

- What are the City characteristics and functions acquired through membership to the different types of Transnational city networks?

- What are the existing (natural) city characteristics that serve as a driver/ barrier in the implementation of climate actions plans in cities?

- What are the Climate actions plans (*Adaptation and Mitigation)* under implementation in European cities with membership in a Transnational city network? What are the emerging patterns of Climate action plans?

- What are the identifiable City characteristic Typologies with similar activities across different sectors in the member cities?

- Which city characteristics (acquired and existing) explain the facilitation of these climate adaptation and mitigation measures in member cities in Europe?

3.3 Research Approach and Design

As a deductive form of research, the objective of the research is aimed to collect secondary data and assess through a statistical approach the level of influence of Transnational city network's attributes and functions on the facilitation of member city's climate change measures. The study aim is developed for an explanatory research rather than only descriptive to assess the relation of how various TCNs with different attributes impel local climate measures. The study employed secondary data sources which are available and accessible online. In addition to online city documents and climate network websites, published articles and reports relevant to the research are also considered to support policies and fill up missing information. Secondary analyses followed with content analysis have been implemented to find a systematic result regarding dependent and independent variables.

3.4 Research Strategies

The study was conducted by following **desk research** based on European cities policy documents regarding climate change measures which are accessible online and data collected through transnational city networks online websites. Reliable published articles and reports have also been considered to add to the research validity. The **desk research** is selected as the strategy for its form of research approach that encompasses usage of existing databases appropriate for studying a large number of research units(member cities) as well as variables(TCN attributes). Desk research accomplishes the research objective through the analysis of quantitative data establishing relations between different variables.

In this **deductive research**, usage of **secondary data** can study global/country/city level phenomena in facilitating local climate measures through TCNs attributes and functions. It enables the researcher to statistically analyze the general relationships between diverse independent and dependent variables. The advantages of geographic scope required particularly in this research with time and cost effectiveness are the main associated benefits of desk research enabling extensive data collection of cities and TCN from reliable sources. High quality data can be generated from various sources which are openly accessible increasing reliability of the research, and enabling replication for future analysis. This wide range of data from different categories (high, medium and low income) of cities enables quantitative analysis and generalization of the outcome. In a desk research the researcher is unobtrusive in nature implying the researcher does not interfere with the study units while data collection reducing the probability of bias selection/data manipulation and subjectivity.

3.5 Operationalization: Variables and indicators

In order to conduct the research and operationalize the concepts which are depicted on conceptual framework in Chapter two, the concepts have been converted into variables with specific indicators that can be measured for evaluation and analysis. The two main concepts in this study are **different city characteristics ; natural (existing) and acquired through membership to various transnational city networks (Independent variables)** and facilitation of climate response actions under implementation **(Dependent variables)** in member cities of TCN. The specified indicators for each variable are as follows:

Table 4. Operationalization: Variables and Indicators

Concepts	Description	Variables	Measuring indicators	Data type	Measuring scale	Data source
Acquired City characteristics Through Membership to Transnational city networks **(independent variables)**		**Level of Network /Geographic Scope** (Lee and Jung, 2018).	Domestic City Networks	Qualitative	Yes-1	networks official websites
			Regional City Networks	Qualitative	Yes-2	networks official websites
			Global City Networks	Qualitative	Yes-3	networks official websites

		Network structure (institution and stakeholders involved) (Lee and Jung, 2018; Betsill and Bulkeley, 2004; Reams et al., 2012).	Multilateral City Networks	Qualitative	Yes-1 No-0,	networks official websites
			Institution-led City Networks	Qualitative	Yes-1 No-0,	networks official websites
		Inter/intra network interaction. Activity level	online activity within members (conferences, forums, webinar etc.) for Intra network Interactions	Qualitative	Not active-0, UpdatesNews Only-1, News and other activities(conferences, forums, webinar etc)-2	networks official websites
			Inter network interactions (Partnerships/associations with other networks)	Qualitative	Yes-1 No-0,	networks official websites
		Functions of Transnational City Networks (Niederhafner, 2013;Bulkeley et al., 2012; Lee and Koski,2015)	Information exchange	Qualitative	Yes-1 No-0,	networks official websites
			Lobbying	Qualitative	Yes-1 No-0,	networks official websites
			Funding	Qualitative	Yes-1 No-0,	networks official websites
			Research	Qualitative	Yes-1 No-0,	networks official websites
			Target and plan provisions	Qualitative	Yes-1 No-0,	networks official websites
			Monitoring and Certification	Qualitative	Yes-1 No-0,	networks official websites
			Total Functions acquired through membership	Quantitative		

Concepts	Description	Variables	Measuring indicators	Data type	Measuring scale	Data source

Natural City Characteristics **(Independent variables)**	internal factors acting as driving/constraining factors for Climate actions	**Socio-economic Factors**	**GDP per capita** (Hardoy and Lankao , 2011; Buob and Stephan ,2011)	Quantitative	GDP per capita of the city	ec.europa.eu/eurostat
			GDP (Hardoy and Lankao , 2011; Buob and Stephan ,2011)	Quantitative	GDP of the city	ec.europa.eu/eurostat
			population size (Reckien, et al. ,2015)	Quantitative	Number of inhabitants	ec.europa.eu/eurostat
			unemployment rate (Romero, et al. 2014)	Quantitative	the Number of unemployed people as a percentage of the labour force **(% share of labour force aged 15-74)**	ec.europa.eu/eurostat UNHABITAT, OECD
		Environmental Factors	**adaptive capacity** (Romero, et al. 2014)	Quantitative	**Combination of economic, infrastructural, technological, institutional capacity**	ESPON.EU Aggregate potential impact of climate change, 2009
			aggregated indices of climate change impacts (Reckien, et al. ,2015)	Quantitative	**Combination of physical, environmental, social, economic and cultural impacts of climate change.**	ESPON.EU Aggregate potential impact of climate change, 2009
			distance from the coast (Milfont, et al., 2014)	Quantitative		Google Maps

			altitude above sea level (Milfont, et al., 2014)	Quantitative		Google earth

Concepts	Description	Variables	Measuring indicators	Data type	Measuring scale	Data source
Climate response actions Implemented /under implementation **(Dependent Variables)**		**Urban Adaptation measures**	**Number of Climate action plans**	Quantitative		local governments' official websites/ policy documents
		Urban Mitigation measures	**Number of Climate action plans**	Quantitative		local governments' official websites/ policy documents
		Urban M+A measures(Joint)	**Number of Climate action plans**	Quantitative		local governments' official websites/ policy documents
		Total number of action plans	**Sum of action plans**	Quantitative		
		Estimated greenhouse gas emission reduction per sector	**Local electricity production**	Quantitative	Estimated tonnes co2 Reduction Target(in millions)	local governments' official websites/ policy documents
			Transport	Quantitative		
			Tertiary buildings equipment facilities	Quantitative		
			Municipal buildings **equipment facilities**	Quantitative		
			Public lighting	Quantitative		
			Residential buildings	Quantitative		
			Industry	Quantitative		

			Local heat cold production	Quantitative		
			Total emssions	Quantitative		

3.6 Sample size and selection

The sample size of the transnational networks has been selected by following **purposive sampling** based on non-probability. The selection of Eight climate networks are based on its prominence in Europe and its relevance to the research considered on theoretical grounds. The City networks have been selected from existing literatures and by examining websites linked to transnational networks addressing issues of climate change.
The sample size of the member cities of these transnational networks has been selected on the basis of probability following **random sampling** for an indiscrete and unbiased selection.

Cochran's Sample Size formula
Cochran's formula is adopted to calculate an ideal sample size from the total members of the eight selected TCNs in Europe. The margin of error (desired level of precision) is considered at 5% with a 95% confidence interval. Formally, the Cochran's formula is depicted as

$$n_0 = \frac{Z^2pq}{e^2}$$

Where:

- e is the margin of error,
- p is the (estimated) proportion of the member cities which has the attribute in question,
- q is 1 – p.

Finite member cities Correction has been applied to the sample size formula for the total members in each TCNs.

n = N*X / (X + N – 1),

Where,

$X = Z_{\alpha/2}^2 * p * (1-p) / e^2$,

- $Z_{\alpha/2}$ is the critical value of the Normal distribution at α/2 (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96),
- e is the margin of error,
- p is the sample proportion, and
- N is the member size in Europe.

Table 5. Sample Size for different TCNs

Network	Total No. of Members	Members in Europe	Confidence interval (%)	Confidence level Margin of error (%)	Sample Size (Cities)	Sample Size in this study
Climate Alliance (est.1990)	1741	1676	95	5	**313**	**50**
Covenant of Mayors(est. 2008)	9561	9060	95	5	**369**	**116**
ICLEI CP (est.1990)	1750	135	95	5	**101**	**39**
C40 Cities (est.2005)	90	18	95	5	**18**	**18**
International Solar Cities (est.2003)	5	1	95	5	**1**	**1**
Euro Cities (est.1986)	140	140	95	5	**103**	**35**
Energy Cities (est.1990)	180	143	95	5	**104**	**35**
World Mayors Council on Climate Change (est.1990)	80	12	95	5	**12**	**12**
Total					**1023**	**306**

Source: (Author, 2019)

3.7 Data Type and Data Collection method

Considering the time and financial limitations of this thesis, the geographic scope of the research is to study **120 cities(Some members may be repetitive) in 8 Transnational City Networks** in Europe examining the different city Characteristic (existing and acquired through membership) and identifying their corresponding climate change measures .Filtering of existing data is adopted and suitable sources (Triangulation) are selected from different bases to add to the validity and reliability (Local governments official websites/Policy documents/Networks official website (www.climatealliance.org/ , www.covenantofmayors.eu., www.iclei.org., www.c40.org/, www.iscicities.org/, www.eurocities.eu/, www.energy-cities.eu/, www.worldmayorscouncil.org/))

Collecting and ordering the data

Data collection is specified in the initial research design to manage the processing phase at an uncomplicated fashion. The quantification of the research data begins in the operationalization phase as to avoid difficulty as certain analytical techniques may be unfit for the data collected at an earlier period.

Data inspection and data preparation

Datasets need to be checked for errors on completion of the data matrix, as mistakes may have occurred by the researcher during the process of data entry. As a mean to spot irregularities in the data, the researcher must create a frequency distribution for each variable and identify outliers through graphical inspection of boxplots and histograms. The variables are checked for assumptions of linear relationships through scatterplots and multicollinearity between the independent variables through Pearson's correlation test before the multiple regression analysis is conducted.

3.8 Validity and reliability

A major challenge involved in a desk research lies in the issues involved in the data collected by another researcher for a different purpose. The existing qualitative data may not be consistent with research question and the quantitative data may not cover all the necessary indicators influencing the validity of the research. Hence, both qualitative and quantitative data must be thoroughly checked and assessed for a valid research. Another challenge is that operationalization of the variables may be influenced by the existing data which may lead to a different unintended operationalization affecting the validity again. Likewise access to the data can restricted and unobtainable in certain context. Data quickly gets outdated labelling it unfeasible for the proposed research. Certain constraints also consist in terms of the reliability of the data such as data being influenced in collecting and coding processes, unclear and incomplete data sources and attributes which leads to distorting of the results. While processing the data, the researcher must be aware of merging data collected from different periods of time reduces reliability and also merging datasets with different measurements can be a challenging task. (Van Thiel, 2014).

A significant level of reliability and external validity can be preserved in this research since the main sources of data are secondary data generated by reliable entities such as Local government's official websites, City Policy documents and Networks official website. Secondary analysis was conducted on existing data mainly concentrating on breadth rather than in depth study as the purpose of the research was to study city level phenomena spread across a wide geographic scope. Generally, the secondary quantitative analysis offers a high external validity (generalization) but the findings of this research may be delimited to the European region because of the heterogeneity of the research subject in different parts of the globe due to various factors.

Counter measures are adopted to address such issues beginning with cleaning the datasets involving checking the sample for outliers, and incomplete/irrelevant data to increase reliability. Case selection and sample size is representative to establish
a valid result. Since desk research lacks an in depth understanding rather focusing on breadth, a mixed method of collecting quantitative and qualitative data is proposed from different sources necessary to counter such issues. Triangulation is necessary to collect/process information by using different operationalization, data sources and methods to ensure reliability and validity. A diversified approach enables the researcher to gather extensive data ensuring the data collected is valid, irrespective of the number of units studied.

3.9 Data analysis methods

The data analysis technique for analysing the quantitative data is divided into two categories of descriptive and inferential statistical techniques. Descriptive statistical techniques are applied to explore characteristics of the variables in the dataset and measure if correlation exists between **different city characteristics ; natural (existing) and acquired through membership to various transnational city networks (Independent variables)** and facilitation of climate response actions **(Dependent variables)** in member cities of TCN. Pearson's correlation coefficient and significance value is assessed to infer the correlation as statistically significant. Higher the correlation, stronger is the variables statistically related. A positive correlation coefficient indicates a positive relation. GIS, Microsoft Excel tools, and SPSS were used to present the descriptive statistics in the form of graphs, images, and summaries of the data. The inferential statistics include the results of the multiple linear regressions.

Normality test

To determine whether the data for the dependent variables follows a normal distribution, Shapiro-Wilk test is first conducted as a numerical means of assessing normality. The Sig. value of the Shapiro-Wilk test for both dependent variables should present a value more than 0.05 σ, which leads to rejecting the null hypothesis concluding that the data does follow a normal distribution. Secondly, in order to determine normality graphically, we examine the output of a normal Q-Q plot, normality curve on the histograms and boxplots for the dependent variables. The normal Q-Q plots should portray that the data points are located close to the diagonal line and the normality curve on the histograms should be symmetrical forming a bell-shaped curve representing a normal distribution in both cases.

Inferential statistics concentrates on whether the relation as described are systematic and ascertain whether the hypothesized relations are present in this deductive research which is based on the theories of Climate networks. Regression analysis is applied based on independent variables under city characteristics; **natural (existing) and acquired through membership**, and establish their effect on **climate response actions (adaptation and mitigation projects)**.

3.9.1 Multiple Linear Regression Analysis

A multiple regression test is selected to explain how a single response variable (DV) depends linearly on a number of predictor variables (IV). It allows in determining the degree of variation in climate response actions and also explains the relative contribution of each independent variable (City characteristics (existing and acquired through membership) to the total variance.

Certain assumptions are checked for the multiple linear regression analysis to be applicable. Linear relationship between the dependent and independent variables is observed when checked for linearity through the visual inspection of scatterplots and partial regression plots. Independence of residuals is observed using the Durbin-Watson statistic which should present a value between the two critical values of $1.5 < d < 2.5$, indicating no autocorrelation in the residuals. The absence of multi-collinearity is checked between the independent variables in the model through Pearson's correlation test.

Formally, the model for multiple linear regressions, given *n* observations, is

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} + \epsilon \qquad \text{for } i = 1,2, \ldots n.$$

Where

y_i = dependent variable

x_i = independent variables

β_0 = y-intercept (constant term)

β_p = slope coefficients for each independent variable

ϵ = the model's error term (also known as the residuals)

Chapter 4: Research Findings

4.1 Introduction

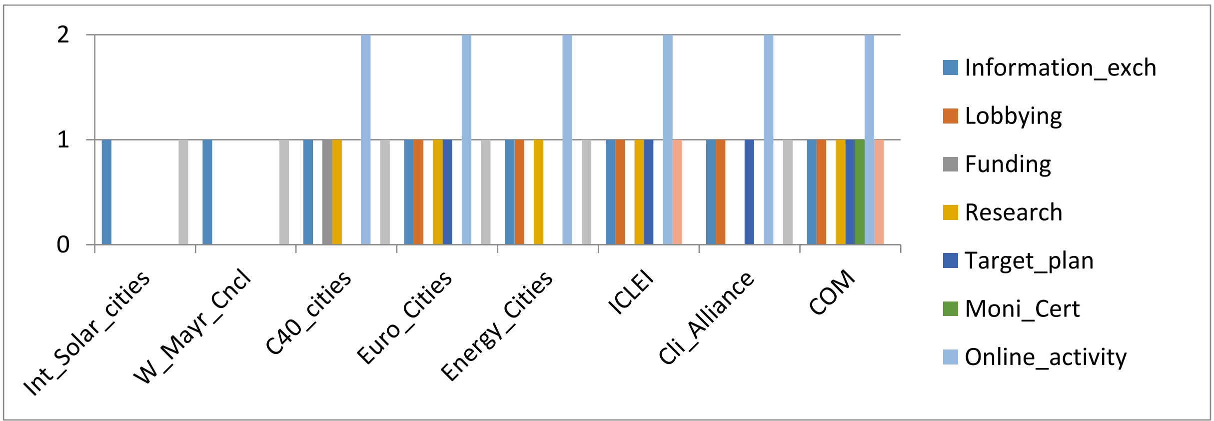
Over the past decades, several cities have engaged in membership to different transnational city networks exhibiting high levels of ambition in the field of climate change actions. However, these member cities in Europe depict substantial differences in the regional distributions, commitment and scope of climate change responses. The analysis and findings of the chapter are based on mainly 120 cities with membership to eight different transnational city networks across Europe. This study examines the different functions acquired by cities through membership and its influence in facilitating climate response measures in the member cities. The development of such a typology is beneficial in helping cities identify and understand the advantages/disadvantages from their mode of participation and partnership with certain transnational city networks. The existing patterns of climate action of the member cities across Europe are explored and furthermore typologies of city with similar characteristics and activities concerning climate actions with greenhouse gas emission reductions per sector have been identified. Identification of such a typology presents the potential for policy makers to exchange information from cities facing similar challenges and opportunity for attracting investors.

4.2 Overview of the Networks

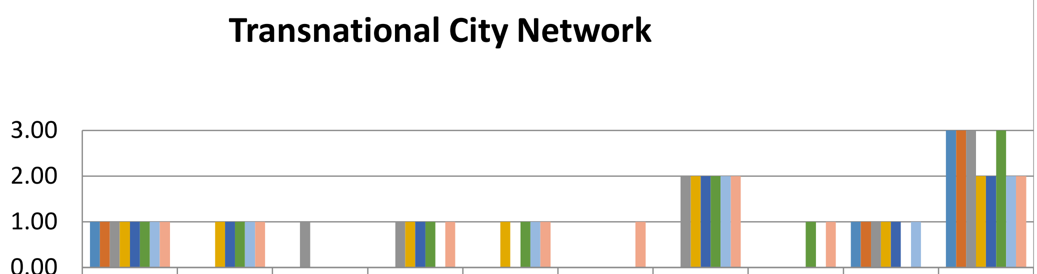
Research Question: What are the City characteristics and functions acquired through membership to the different types of Transnational city networks?

Eight climate networks are selected based on its prominence in Europe and its relevance to the research considered on theoretical grounds. The different characteristics and function of the eight networks have been identified from existing literatures linked to transnational networks addressing issues of climate change and through examination of their relevant websites. Covenant of Mayors encompasses majority of the cities in its membership and similarly offers the highest number of functions with only funding being absent. International solar cities and World Mayors Council on Climate Change offer the least with information exchange/networking being the single function available. In contrast to the other networks, International solar cities and World Mayors Council on Climate Change's online activity level portrays a similar outcome with recent online activity/updates being non-existent for both.

Graph 1. Online activity and Different Functions acquired through membership to TCNs



Graph 2. Transnational City Networks with Different attributes and function



	Information_exch	Lobbying	Funding	Research	Target_plan	Moni_Cert	Online_activity	Insti_led_City_Netw	Multi_City_Netw	Level_of_Network
Int_Solar_cities	1	0	0	0	0	0	0	0	1	3
W_Mayr_Cncl	1	0	0	0	0	0	0	0	1	3
C40_cities	1	0	1	1	0	0	2	0	1	3
Euro_Cities	1	1	0	1	1	0	2	0	1	2
Energy_Cities	1	1	0	1	0	0	2	0	1	2
ICLEI	1	1	0	1	1	0	2	1	0	3
Cli_Alliance	1	1	0	0	1	0	2	0	1	2
COM	1	1	0	1	1	1	2	1	0	2

Functions: 0 - no, 1 - yes

Online activity: 0 – Not active, 1-Update News only, 2- News and Other activities

Network level: 1- Domestic, 2 – Regional, 3 - Global

4.2.1 Functions

Functions of transnational city networks for climate change include information exchange, funding operations, lobbying, research, target and plan provision (Niederhafner, 2013), and monitoring and certification (Bulkeley et al., 2012; Lee and Koski,2015).

4.2.1.1 Information exchange/networking

The most common function provided by transnational city networks is information exchange and we can identify it being prevalent in all eight networks.Fig.1 shows that TCNs in Europe mostly emphasize on information transfer (provision of climate change related policies) and networking through meetings and conferences. For instance Climate Alliance hosts the International Climate Alliance Conference and General Assembly, C40 cities has a mayors submit, Covenant of Mayors has the COM webinars and forums, Energy Cities has an Annual conference, EUROCITIES hosts European Conference on Sustainable Cities & Towns and ICLEI host the Compact of Mayors E-Learning Webinar on Resilient Cities.

4.2.1.2 Lobbying

Advocating change in climate change policy in international institutions or national governments are evident in five out of eight Networks as shown in fig.1.Subsequent to information exchange, Lobbying and Research are the second most prominent functions existing in TCNs. Euro cities, Energy cities, ICLEI, Climate Alliance and Covenant of Mayors all provide the function of lobbying respectively. In contrast International Solar cities, World Mayors Council on Climate Change and C 40 cities not only exhibit the absence of lobbying function but they also lack provisions for target settings and monitoring and certification. Likewise these three Networks share similar characteristics in terms of their level of Network extending at a global scale and are voluntarily instigated by city governments forming multilateral city networks.

4.2.1.3 Funding operations and Monitoring and Certification

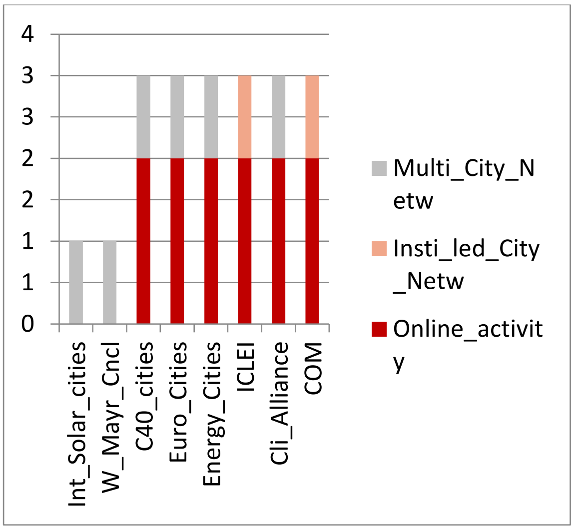
Funding and monitoring are the most absent figure with only two networks providing each function. C40 cities provided the only function of funding for its efforts to gain funding from international institutions, businesses / foundations. And the function of monitoring and certification is available only in Covenant of mayors as its website disclosed individual member's action plan progress reports.

4.2.1.4 Research and target / plan provision

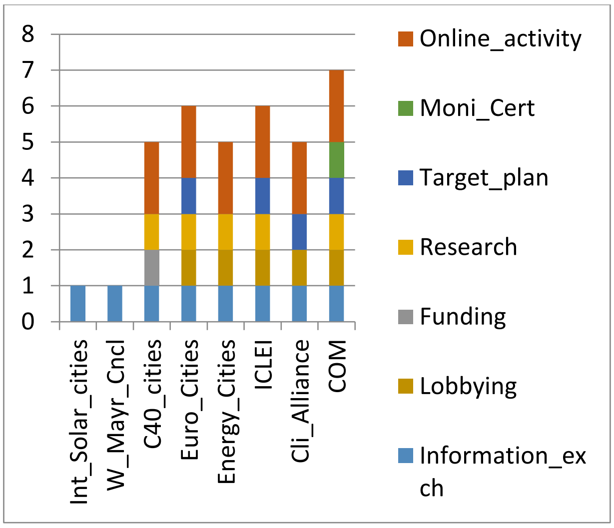
Research and target/plan provision are prominent in most of the networks signifying its pivotal role in policy learning as well as in diffusion of best practices for member cities. Networks such as C40, ICLEI, and COM etc. provided research outcomes rather than just news updates, analyzing key trends and identifying opportunities for further action. Likewise for target and climate change action plans, the networks provided mitigation targets and planning procedures.

4.2.2 Network structure and Level of Network

Graph 3. Network structure and Online activity



Graph 4. Functions and Online activity



The level of network/geographic scope is equally distributed with 4 networks functioning at global scale and the other 4 networks functioning at regional scale (Europe).No domestic level network are identified in the sample. The network structure encompasses of 6 multilateral city networks and 2 institution led city networks (ICLEI and COM)

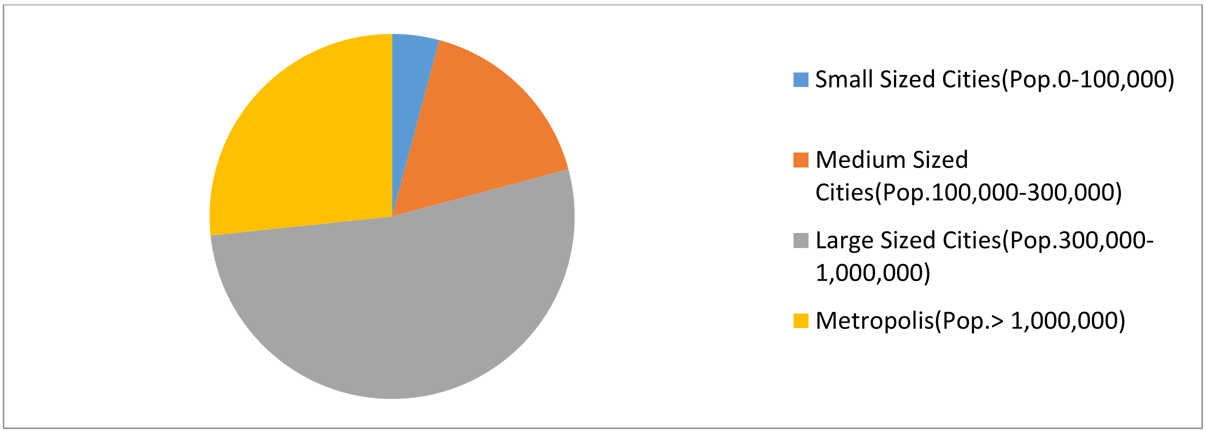
4.2.3 Online activity status

Among the 8 TCN studied focusing on their current events, the degree of online activity is relatively high with 6 networks displaying active participation and interactions between its member cities and only 2 networks were found inactive. International Solar Cities and World Mayors Council on Climate Change displayed no events and news updated since 2014 and 2015. Regarding the Network structure and level of network, there is no major difference in active status between multilateral city networks and institutional led city networks/ global and regional level networks. However those networks with advanced functions such as research, lobbying, target and plan provisions exhibit high online activity. This implies that TCNs with advanced functions are more likely to facilitate climate response measures through policy learning and setting standards and advocating within international institutions or national government to change policies. On the other hand, networks with only basic function of information exchange/networking are less likely to be active.

4.3 Sample Cities and Membership

This study consists of a representative sample of 120 member cities from 21 European countries. The Sample encompasses 5 small-sized cities (Pop.0-100,000), 20 Medium-sized cities (Pop.100, 000-300,000), 63 Large-sized cities (Pop.300, 000-1,000,000) and 32 Metropolis (Pop.> 1,000,000).

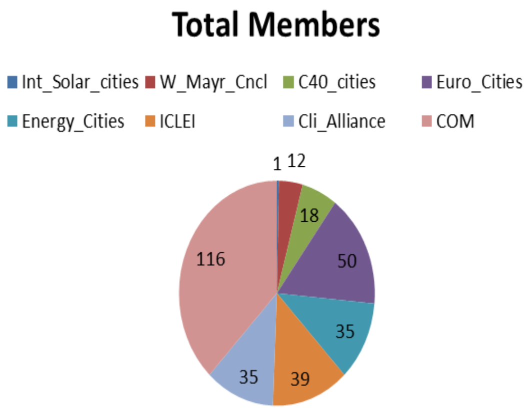
Figure 6. Sample cities distributed according to Size

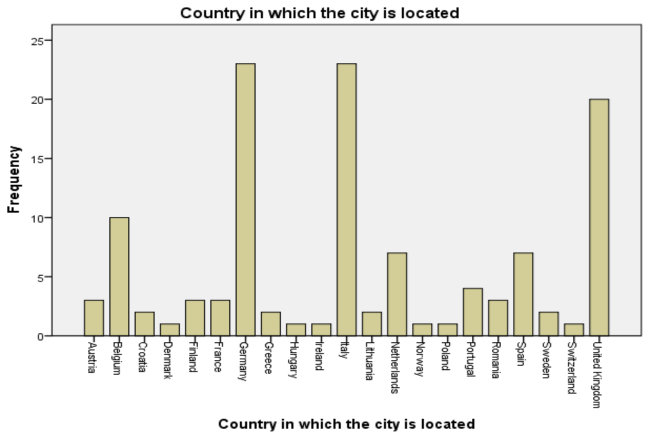


From these 120 member cities, German and Italian cities represent the majority (19.2%) comprising of 23 cities each. This is followed by United Kingdom comprising of 20 member cities representing 16.7% of the sample size. Belgium, Spain and the Netherlands are represented with 10 cities (8.3%), 7 cities (5.8%) and 7 cities (5.8%) respectively. The remaining countries have a relatively low number with 4 member cities from Portugal being the highest.

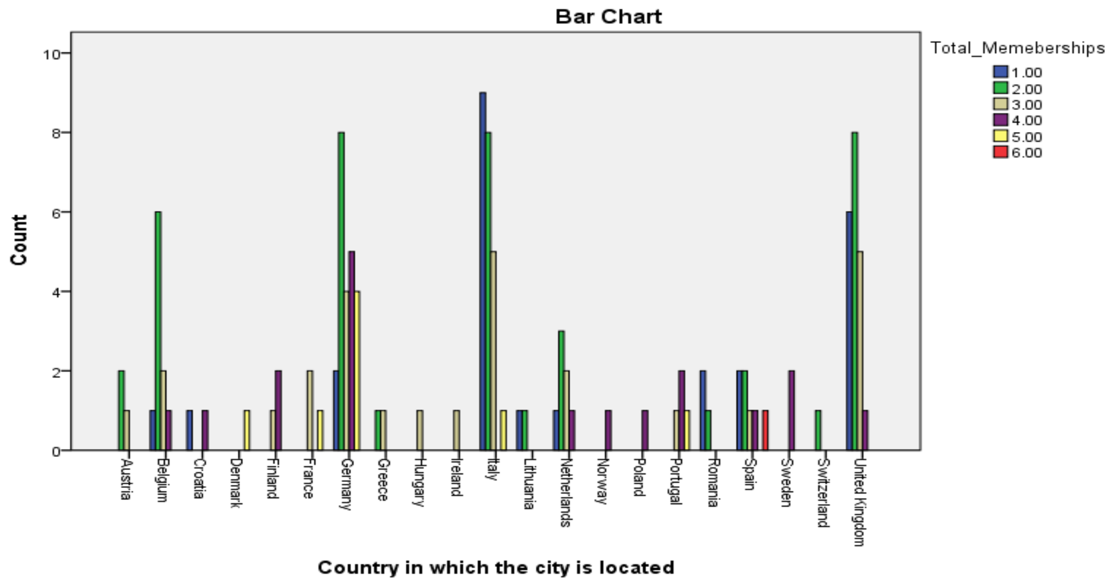
A total of 306 different memberships were identified from the 120 cities sample in association with the 8 TCNs. Majority of the cities demonstrated high level of commitment to various networks with 6 different memberships for a single city depicting the highest. Covenant of Mayors was the most prevalent with a total of 116 members within its network and international Solar Cities had the least member with only a single city in Europe engaged in the network.

Figure 7. Total members in Different TCNs **Graph 5. Total members in different Countries**





Graph 6. Different memberships across countries



Assessing the overall extent of memberships across Europe, as shown in Fig., Italy depicts a relatively high number in single membership with all of its 23 cities actively engaged in Covenant of Mayors. Double memberships establishes itself as the most prominent with majority of the cities among various countries such as Germany, Italy, United Kingdom, Belgium etc. depicting involvement in at least two networks. In terms of overall quantity of memberships to various networks, German Cities demonstrate as high level of engagement to different TCNs. Barcelona city from Spain is identified as the lone city with 6 memberships to different TCNs.

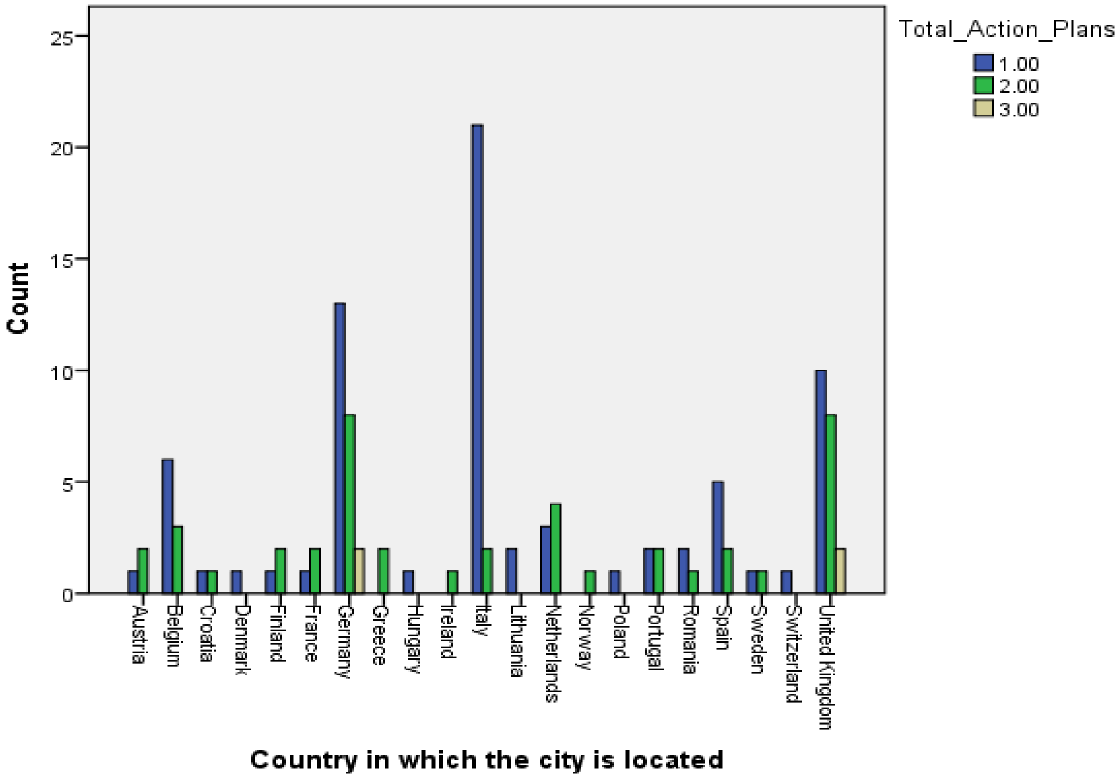
4.4 Climate actions plans (*Adaptation and Mitigation)* in member cities in Europe

Research Question: What are the Climate actions plans (Adaptation and Mitigation) under implementation in European cities with membership in a Transnational city network? What are the emerging patterns of Climate action plans?

Table 6. Distribution of number of action plans

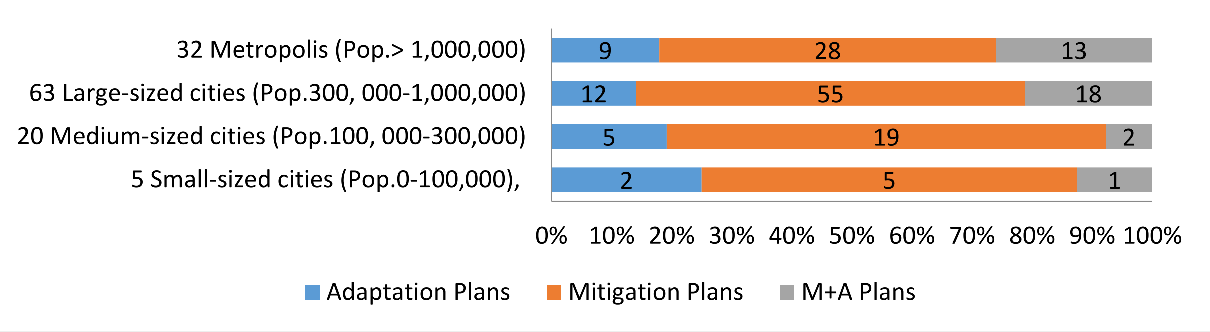
		Frequency	Percent
Valid	1.00	73	60.8
	2.00	42	35.0
	3.00	3	2.5
	Total	119	99.2
Missing	System	1	.8
Total		120	100.0

Graph 7 . Total Number of action plans across countries



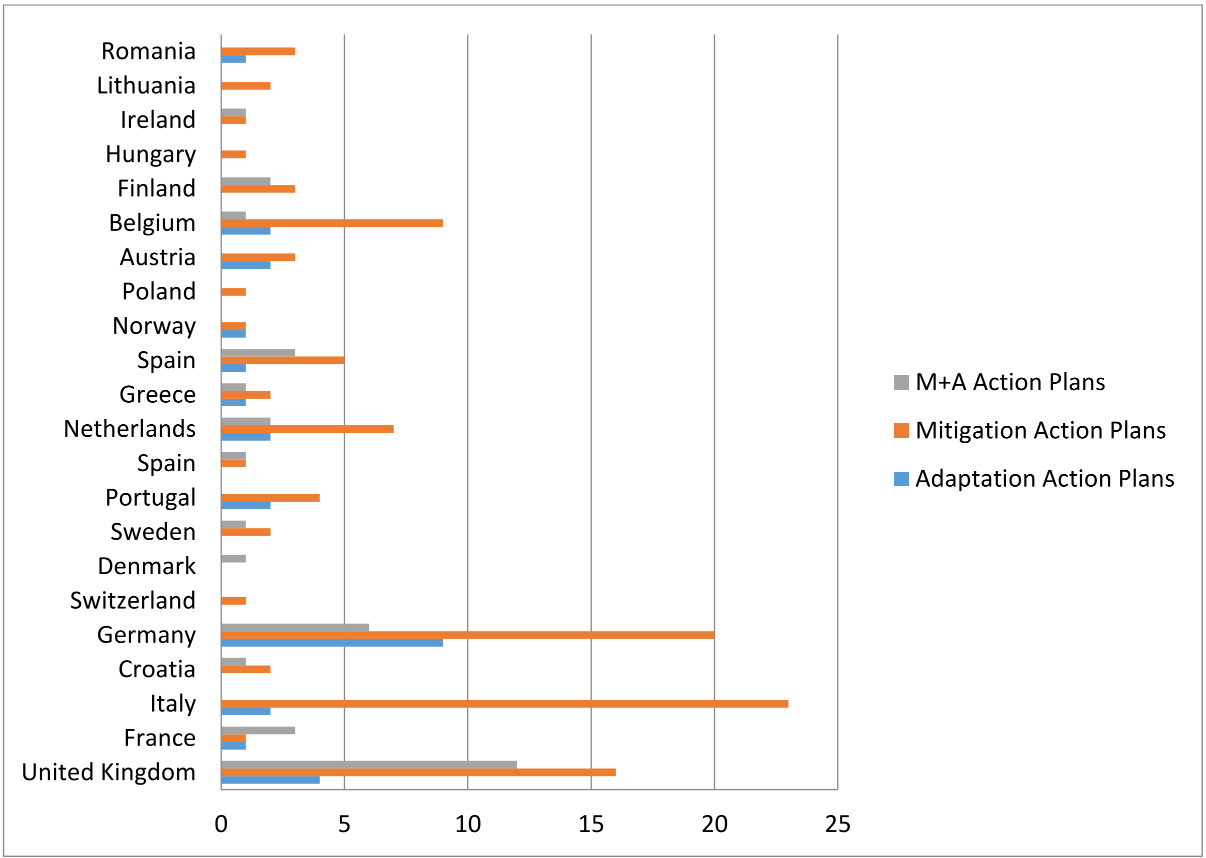
Overall distribution of action plans within member cities as presented in Fig.— indicates that a high number of cities (60.8%) contain at least one climate response measure with a mitigation action plan being the general inclusion. 35 % of the member cities indicate having 2 action plans while a minor 2.5% with only 3 cities contained all 3 climate action plans (Berlin, London and Liverpool)

Figure 8. Action plans distributed according to city sizes



The above figure shows the distribution of climate action plans across city sizes. The proportion of cities with Joint M+A plans increases in line with the size of the city. Economic and institutional capacity may be considered for this positive relation for the development of joint M+A plans in larger cities. In contrast, the proportion of mitigation and adaptation plans does not necessarily show a positive correlation with city size. Small sized cities in terms of percentage depict a higher proportion in adaptation plan (25%) in comparison to other larger cities. Similarly mitigation plans also present a high percentage, however the data in that category is not as representative because of its small sample size.

Graph 8. Different type of action plans across countries



Despite the widely acknowledged leadership role of Europe in terms of environmental policy, climate change response measures depict a high disparity in its distribution with adaptation measures being significantly less in comparison to mitigation measures. Across the sample, only 23.3% have adaptation plans, 89.2% have mitigation plans and 28.3% have a joint M+A plans mainly comprising of cities from United Kingdom. The existence of plans differs noticeably across countries. For example almost all British cities have both or joint climate plans in place (80% have a mitigation plan, 20% adaptation plans and 60% M+A plans). Likewise German cities also demonstrate high levels of activity (87%, 39.1% and 26.1%).While in contrast, earlier findings on Italy's high membership to TCNs does not reflect a similar outcome but a disparity in the dispersion of the total action plans can be identified with all 23 cities (100%) containing a mitigation action plan, but only 2 cities (8.7%) containing an adaptation plan and none of the cities contained a joint M+A action plan. Aggregated indices of climate change impacts indicate that most of the Italian cities are at probable risk settled in medium-highest negative impact regions (0.3-1).Yet Italian cities have prioritize mitigation efforts above adaptive measures as 91.3% lack any adaptation plans and joint M+A measure are non-existent.

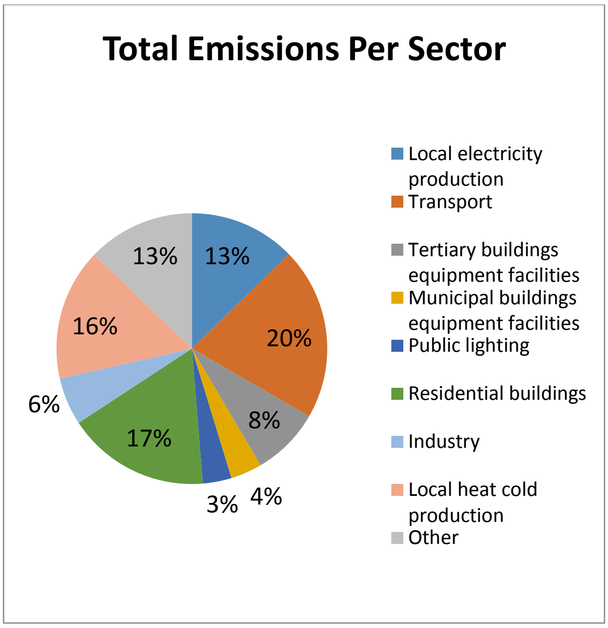
Table 7.Different type of action plans across countries

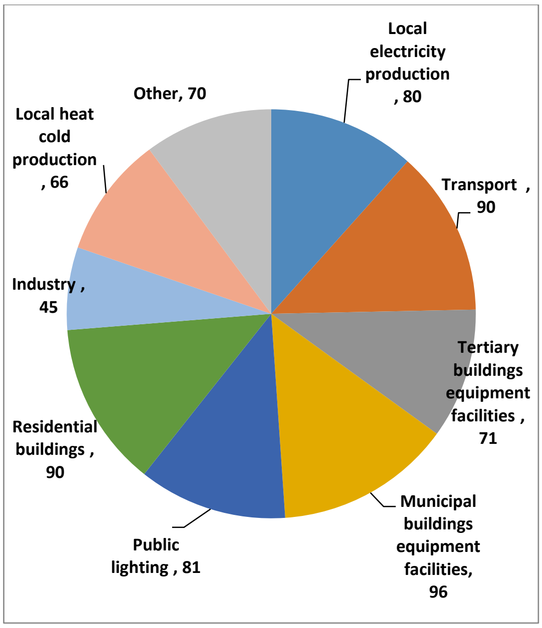
		Frequency	Percent	Adaptation	Mitigation	M+A
	Austria	3	2.5	2	3	0
	Belgium	10	8.3	2	9	1
	Croatia	2	1.7	0	2	1
	Denmark	1	.8	0	0	1
	Finland	3	2.5	0	3	2
	France	3	2.5	1	1	3
	Germany	23	19.2	9	20	6
	Greece	2	1.7	1	2	1
	Hungary	1	.8	0	1	0
	Ireland	1	.8	0	1	1
	Italy	23	19.2	2	23	0
	Lithuania	2	1.7	0	2	0
	Netherlands	7	5.8	2	7	2
	Norway	1	.8	1	1	0
	Poland	1	.8	0	1	0
	Portugal	4	3.3	2	4	0
	Romania	3	2.5	1	3	0
	Spain	7	5.8	1	5	3
	Sweden	2	1.7	0	2	1
	Switzerland	1	.8	0	1	0
	United Kingdom	20	16.7	4	16	12
	Total	120	100.0	28	107	34

4.5 Sectors Involved

Research Question: What are the identifiable City characteristic Typologies with similar activities across different sectors in the member cities?

Figure 9. Total emissions per Sector (percentage) Figure 10. Total no. of cities involved in different sector





Majority of the member cities contain a dedicated mitigation plan especially cities with membership to Covenant of Mayors having submitted a Sustainable Energy Action plan (SEAP). Various sectors were identified with estimated GHG emission reduction targets with the adoption of the individual city's SEAP. Almost all Covenant signatories pledge action to support implementation of 20-30% greenhouse gas-reduction target by 2020.

4.5.1 Municipal buildings

GHG emission reductions targeted at municipal buildings and it facilities through the decrease of energy consumption demonstrated the highest number with 96 cities currently engaged in this sector. Municipalities indicate high ambitions in the direction of renewable energy in terms of hydroelectric, photovoltaic, biomass usage etc. Direct competency/authority to implement such actions to reduce CO_2 in municipal territory in comparison to other sectors may suggest this high involvement in this sector. However this sector with only 4 %(3,104,074 million tonnes CO_2) represents only a minor section of the total emission reduction targets. Reduction targets ranged from a minimum of 11.7 to a maximum of 721,000 tonnes co_2 reduction target (in millions)

4.5.2 Industry

The industrial sector was the least incorporated component in the action plans with only 45 cities committed to implementing mitigation measures in industries. Similarly, the total emission reduction target also represents a low percentage of 6% and 4,711,642 million tonnes of CO_2 reduction. Germany represented the highest number with 12 cities in which Berlin dedicated the highest emission reduction target of 326,000 million tonnes of CO_2 reduction.

4.5.3 Transport

The Transport sector exhibited the highest total emission reduction target of 17,049,694 million tonnes CO_2 with an equally high number of involvements with 90 cities indicating mitigation measures focused towards the transport sector in their region. Majority of the cities reside from Italy, Germany and United Kingdom at a frequency of 21, 16 and 14 respectively. However, the two cities of Helsinki from Finland and Paris from France were identified with the highest emission reduction targets of 1,414,462 and 6,142,584 million tonnes $CO_{2.}$ Both Helsinki and Paris administration have instigated key actions in this field starting with improvement and extension of public transport services including trams, metros and local bus lines. Sustainable government mobility plan has been initiated to change the behaviour of travellers in favour of less polluting modes of travel. Cycling lanes and infrastructures have been further developed and incentives for electric mobility have also been introduced.

4.5.4 Residential buildings

A total of 90 cities mainly comprising again of Italian, German and British cities similar to the transport sector, also indicate considerable involvement in mitigation measures concerning residential buildings. The total emission reduction target for residential building present a high percentage (17%) as the second most prominent figure of 14,111,050 million tonnes CO_2. From all the cities involved, Berlin in similarity to the industry sector also has the highest emission reduction target for residential building with 2,120,377million tonnes of CO_2 estimated reduction. Key actions have been implemented in this sector through intervention of rules for energy efficiency in constructions, and through energetic rehabilitation of the high rise residential building. Certain programmes have been initiated for behavioural changes and the conscious use of energy. Other measures include renewal of heating plants and boilers in residential existing buildings to reduce fossil fuels consumptions, new building regulation for high energy performance and other energy saving measures.

4.5.5 Public Lighting

The sector involving public lighting presented a considerable number of involvements with 81 cities; however the percentage (3%) for the total emission was the lowest in comparison to other sectors. The sectors GHG emission reduction target was set at 2,839,653 million tonnes of CO_2.

In similarity to the highest emission reduction target for earlier sectors of industry and residential building, city of Berlin yet again demonstrated the greatest ambition in Public lighting as well with a target of 1,122,000 million tonnes of CO_2 reduction. Majority of the actions encompassed projects related to the conversion of old lighting system to modern LED technology for high efficiency.

4.5.6 Local electricity production and Local heat cold production

A considerable number of cities (80, 66) demonstrated presence for both sectors of Local electricity and Local heat cold production in their action plans. Likewise the percentages of total emission reduction for both sectors are also relatively high with 16% and 13%. Both Germany and Italy showed significant interest in Local electricity production with 20 cities from each country involved in the sector. However, the city of Warsaw from Poland was identified with the highest emission reduction target with a figure of 2,321,276 million tonnes $CO_{2.}$

In the case of local heat cold production, Germany, Italy and United Kingdom again had significant numbers with several cities engaged in local energy production. Dusseldorf of Germany had the highest emission reduction target with a figure of 1,823,000 million tonnes $CO_{2.}$

4.6 City Characteristics Typology Clusters (CCTC)

Networks enable city to city interaction in resolving specific climate action challenges similar in nature. Networks provide a platform to assemble cities of similar characteristics with the purpose to resolving related issues through collaboration. By providing a database, we can identify certain characteristics that remain unnoticed and undetected leading to missed opportunities to drive action. This research has resulted in a projected set of information on cities' characteristics and activities, from simple GDP and unemployment statistics, to detail on the preferred sectors a city employs in its climate action plan.

This section briefly presents four examples of CCTCs identified, together with perceptive insights and key actions available in these clusters. We can observe that city clusters with similar characteristics are not defined/limited to its national boundaries. Cities clusters formed from different location exhibit plausible prospects for a range of city stakeholders from policy makers to exchange information from cities facing similar challenges, to creating opportunity for attracting investors seeking to place their funds where they might have the greatest benefits for all parties concerned.

Birmingham, Grand Lyon, Helsinki, Paris, Warsaw

Cities in this cluster show similar characteristics in terms of their population size with all ranging above 1 million and the aggregated indices of climate change impacts indicated a relatively low negative impact index with all of the cities scoring below 0.3. Despite this city clusters showing a high unemployment rate, it's combined adaptive capacity for all cities were significantly high. This indicates the strong economic, infrastructural, technological and institutional capacity these cities possess regardless of the unemployment rate. The most noteworthy characteristics shared among the cities in this cluster are the significant emission reduction targets set in the Transportation sector with all targets ranging above 500,000 million tonnes CO_2.

This cluster is also extensively engaged in both mitigation and adaptation measures with a single exception of Helsinki city which lacked any stand alone or joint adaptation actions.

Berlin, Grand Lyon and Hamburg

This cluster of 3 metropolises with their population size exceeding beyond 1.8 million, exhibit similarity in their low aggregated indices of climate change impacts and similar high adaptive capacity. The industry sector is the point of highlight as all three cities are engaged in this sector with highest emission reduction targets. In parallel, these cities also have joint M+A plans.

Bregenz, Mouscron, Agueda and Worms

This cluster comprises of small- sized cities where the population size ranges below 100,000 and similar city characteristics of relatively low GDP equivalent to their size are also identified. Likewise the cities are located in regions of low negative impacts of climate change and depict high adaptive capacity as well. The unemployment rates depict different scenarios with Agueda and Mouscron showing high rates where as Bregenz and Worms in contrast show low rates of unemployment. Although cities in this cluster show diverse involvement in different sectors, the notable commitment in emission reduction targets in the industry sector for small-sized cities is significant.

Amsterdam, Barcelona, Madrid and Valencia

Cities in this cluster are a group of metropolis with a large population size ranging from 1 million to a maximum of 6.5 million and retain significant GDPs equivalent to their sizes. The underlying element in this cluster is the Joint M+A plans that exist in all four cities in parallel to high index of climate change impacts of each city.

4.7 Inferential Statistics

Research Question: Which city characteristics (acquired and existing) explain the facilitation of these climate adaptation and mitigation measures in member cities in Europe?

4.7.1 Correlation analysis

Correlation analysis identifies associations between climate change plans and the different city characteristics; natural (existing) and acquired through membership to various transnational city networks in member cities across Europe.

4.7.1.1 Dependent variable: Total Action Plans

From the correlation matrix we infer that the dependent variables; Total action plans of different member cities were significantly correlated to a total of 8 different city characteristics.
2 Socio-economic and 1 environmental factor from existing city characteristics are the most influential predictors for the level of engagement in climate actions. Gross Domestic Product exhibited the highest positive correlation and is the most significant ($r = 0.328, p < 0.01$) .Likewise GDP per Inhabitant ($r = 0.237, p < 0.01$) and Combined adaptive capacity ($r = 0.277, p < 0.01$) also displayed similar results with positive correlation and high significance. This observation suggests that prosperous cities with better living standards regardless of the size indicate extensive employment in the overall number of action plans. Positive correlation with adaptive capacity suggests that city with better economic, infrastructural, technological and institutional capacity implement more action plans compared to other cities. It should be observed that predictors such as aggregated indices for climate change impacts or distance from the coast do not signify any correlation indicating that regions with higher risk to climate change do not necessarily result in additional actions in the member cities.

From the city characteristics acquired through membership to various TCNs, the total membership ($r = 0.239, p < 0.01$) to different TCNs was positively correlated and was statistically significant indicating that joining different networks is increasing climate action in cities. When the networks are examined individually, C40 cities and Euro-cities are the only 2 networks that displayed a significant correlation with total action plans suggesting that its members have implemented a higher number of climate actions(both mitigation and adaptation or Joint M+A) in comparison to the other networks.

The function of funding that a network provides to its member is the only variable from acquired city characteristics that exhibits a positive correlation and a statistically significant

value($r = 0.271, p < 0.01$) with the total number of actions. This indicates the predominant significance of acquiring financial resources especially for economically weaker cities with lower GDP who depend on external funding for implementing climate actions.
The Overall number of functions($r = 0.257, p < 0.01$) that a TCN provides also exhibits a positive correlation and high significance indicating the total number of climate actions employed are higher in member cities that acquire more functions from a TCN.

4.7.1.2 Dependent variable: Mitigation Action Plans

Mitigation action plans are negatively correlated with a large number of variables with Euro cities($r = - 0.224, p < 0.05$) depicting the most statistically significant value. Likewise total membership to different networks depicts a similar result of negative correlation ($r = - 0.192, p < 0.05$).
However this does not necessarily indicate that mitigating measures are non-existent for members of Euro cities and cities with higher number of memberships as there is a positive correlation in terms of Joint M+A plans. So it can be assumed that stand-alone mitigation plans are absent but most members have a Joint M+A plan instead.
Population size from the socio economic factor of a city also indicate a negative correlation($r = - 0.184, p < 0.05$), indicating large population in cities do act as a barrier for implementing mitigation action plans.

4.7.1.3 Dependent variable: Adaptation Action Plans

Adaptation action plan exhibits no correlation at all with any existing city characteristics, however a positive correlation and high significance can be identified with Funding ($r = 0.208, p < 0.05$), function acquired through membership. Member of C40 cities ($r = 0.208, p < 0.05$) also depict a similar result indicating that a high number of adaptation plans are present in members of C40 cities in comparison to other network members and indicating that acquiring funds plays a pivotal role in financing and implementing adaptation plans .

The Overall number of functions($r = 0.195, p < 0.05$) that a TCN provides also exhibits a positive correlation but a slightly lower statistical significance than total number of action plans. We can infer that adaptation plans are initiated more often in member cities that acquire a high number of functions through different networks.

4.7.1.4 Dependent variable: Joint M+A Action Plans

Similar to the earlier findings on Total number of action plans, 2 Socio-economic and 1 environmental factor from existing city characteristics are also the most influential predictors for Joint M+A as well. GDP of a city exhibited the highest positive correlation and is the most significant ($r = 0.321, p < 0.01$), followed by population size ($r = 0.279, p < 0.01$), and combined adaptive capacity ($r = 0.259, p < 0.01$). This result suggests that Joint M+A plans are mainly associated with Large-sized cities with strong economies supplemented with greater institutional, infrastructural and technological capacity.

In terms of city characteristics acquired through membership, Funding ($r = 0.252, p < 0.01$) again depicts a high significance and a positive correlation. Total membership, member to C40 cities and Euro cities show a similar result.

4.7.1.5 Dependent variable: Total Emission Reductions Targets

Total emission reduction targets in comparison to the other dependent variables depict the highest number of correlation. GDP ($r = 0.478$, $p < 0.01$) and Population ($r = 0.436$, $p < 0.01$) size again exhibit the highest positive correlation and high significance. This is followed by aggregated indices of climate change impacts which is negatively correlated ($r = -0.363$, $p < 0.01$) which indicates that larger cities that are located at regions with less risk are engaged with higher GHG emission reductions.

Funding ($r = -0.373$, $p < 0.01$) again displays high positive correlation and significance. This followed with Total number of membership and total number of functions acquired which also show a similar result. A distinctive result is the level of network ($r = -0.255$, $p < 0.01$) displaying a positive correlation indicating that members in higher levels of network which in this case are global networks have set higher emission reduction targets especially observed in megacities of C40 cities.

Summary

Overall evaluation of the correlation analysis identifies Gross Domestic Product of a city as the most significant variable that positively correlates with Total number of action, total emission reductions and Joint M+A action plans. This is followed by Population size and combined adaptive capacity which presents a similar result. From this observation we can deduce that larger cities with prosperous economies encompassing superior technology, infrastructure and institutions are well involved in both stand alone and Joint M+A measures.
In terms of city characteristics acquired through membership, the function of Funding can be identified as the most significant in all climate change response measures including adaptation, mitigation and Joint M+A plans.

Correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1. Total_Emission_Reduction	Pearson Correlation	1																	.[b]														
	Sig. (2-tailed)																																
2. Total_Action_Plans	Pearson Correlation	.326**	1																.[b]														
	Sig. (2-tailed)	.001																															
3. adaptation action plans	Pearson Correlation	.140	.719**	1															.[b]														
	Sig. (2-tailed)	.161	.000																														
4. mitigation action plans	Pearson Correlation	-.055	.202*	.120	1														.[b]														
	Sig. (2-tailed)	.584	.027	.194																													
5. mitigation and adaptation action plans(M+A joint measures)	Pearson Correlation	.296**	.424**	-.132	-.530**	1													.[b]														
	Sig. (2-tailed)	.003	.000	.154	.000																												
6. Member of International Solar Cities Initiative	Pearson Correlation	-.042	-.069	-.051	.031	-.058	1												.[b]														
	Sig. (2-tailed)	.676	.453	.581	.739	.529																											
7. Member of World Mayors Council on Climate Change	Pearson Correlation	-.043	-.102	-.120	-.166	.097	-.031	1											.[b]														
	Sig. (2-tailed)	.668	.269	.194	.071	.294	.740																										
8. Member of C40 Cities	Pearson Correlation	.373**	.271**	.208*	-.170	.252**	-.039	.171	1										.[b]														
	Sig. (2-tailed)	.000	.003	.023	.064	.006	.676	.062																									
9. Member of EuroCities	Pearson Correlation	.317**	.275**	.130	-.224*	.366**	-.077	.000	.308**	1									.[b]														
	Sig. (2-tailed)	.001	.003	.159	.014	.000	.400	1.000	.001																								
10. Member of Energy Cities	Pearson Correlation	.000	.024	.000	-.035	.053	-.059	.031	-.064	.015	1								.[b]														
	Sig. (2-tailed)	1.000	.797	1.000	.703	.567	.523	.740	.486	.867																							
11. Member of International Council for Local Environmental Initiatives	Pearson Correlation	.267**	.084	.035	-.063	.113	-.064	.184*	.306**	.244**	.103	1							.[b]														
	Sig. (2-tailed)	.007	.364	.707	.493	.220	.490	.044	.001	.007	.264																						
12. Member of Climate Alliance	Pearson Correlation	.128	.043	.164	.032	-.122	.143	-.092	-.013	-.170	-.089	.064	1						.[b]														
	Sig. (2-tailed)	.199	.644	.075	.726	.185	.120	.319	.889	.063	.333	.490																					
13. Member of Covenant of Mayors	Pearson Correlation	.054	.141	.103	.092	.015	.017	-.093	.078	-.031	.017	.030	.017	1					.[b]														
	Sig. (2-tailed)	.591	.127	.263	.318	.874	.854	.313	.397	.734	.854	.747	.854																				
14. Total_Memeberships	Pearson Correlation	.371**	.239**	.171	-.192*	.263**	.034	.331**	.561**	.524**	.375**	.684**	.284**	.161	1				.[b]														
	Sig. (2-tailed)	.000	.009	.063	.037	.004	.712	.000	.000	.000	.000	.000	.002	.079																			
15. Level_of_Network	Pearson Correlation	.255**	.091	.050	-.111	.140	.108	.394**	.497**	.314**	.015	.821**	-.022	-.031	.691**	1			.[b]														
	Sig. (2-tailed)	.010	.323	.592	.231	.129	.238	.000	.000	.000	.867	.000	.814	.734	.000																		
16. Intra-network Interactions	Pearson Correlation	.051	.069	.051	-.031	.058	.008	-.275**	.039	.077	.059	.064	.059	.494**	.117	-.108	1		.[b]														
	Sig. (2-tailed)	.613	.453	.581	.739	.529	.927	.002	.676	.400	.523	.490	.523	.000	.201	.238																	
17. Inter-network interactions(Partnerships/associations with other networks)	Pearson Correlation	.051	.069	.051	-.031	.058	.008	-.275**	.039	.077	.059	.064	.059	.494**	.117	-.108	1.000**	1	.[b]														
	Sig. (2-tailed)	.613	.453	.581	.739	.529	.927	.002	.676	.400	.523	.490	.523	.000	.201	.238	0.000																
18. Information exchange (Functions acquired through membership)	Pearson Correlation	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]	.[b]												
	Sig. (2-tailed)																																
19. Lobbying (Functions acquired through membership)	Pearson Correlation	.051	.069	.051	-.031	.058	.008	-.275**	.039	.077	.059	.064	.059	.494**	.117	-.108	1.000**	1.000**	.[b]	1													
	Sig. (2-tailed)	.613	.453	.581	.739	.529	.927	.002	.676	.400	.523	.490	.523	.000	.201	.238	0.000	0.000															
20. Funding (Functions acquired through membership)	Pearson Correlation	.373**	.271**	.208*	-.170	.252**	-.039	.171	1.000**	.308**	-.064	.306**	-.013	.078	.561**	.497**	.039	.039	.[b]	.039	1												
	Sig. (2-tailed)	.000	.003	.023	.064	.006	.676	.062	0.000	.001	.486	.001	.889	.397	.000	.000	.676	.676		.676													
21. Research (Functions acquired through membership)	Pearson Correlation	.051	.069	.051	-.031	.058	.008	-.275**	.039	.077	.059	.064	.059	.494**	.117	-.108	1.000**	1.000**	.[b]	1.000**	.039	1											
	Sig. (2-tailed)	.613	.453	.581	.739	.529	.927	.002	.676	.400	.523	.490	.523	.000	.201	.238	0.000	0.000		0.000	.676												
22. Target and plan provisions (Functions acquired through membership)	Pearson Correlation	.051	.069	.051	-.031	.058	.008	-.275**	.039	.077	.059	.064	.059	.494**	.117	-.108	1.000**	1.000**	.[b]	1.000**	.039	1.000**	1										
	Sig. (2-tailed)	.613	.453	.581	.739	.529	.927	.002	.676	.400	.523	.490	.523	.000	.201	.238	0.000	0.000		0.000	.676	0.000											
23. Monitoring and Certification (Functions acquired through membership)	Pearson Correlation	.054	.141	.103	.092	.015	.017	-.093	.078	-.031	.017	.030	.017	1.000**	.161	-.031	.494**	.494**	.[b]	.494**	.078	.494**	.494**	1									
	Sig. (2-tailed)	.591	.127	.263	.318	.874	.854	.313	.397	.734	.854	.747	.854	0.000	.079	.734	.000	.000		.000	.397	.000	.000										
24. Total_functions	Pearson Correlation	.274**	.257**	.195*	-.096	.198*	-.015	-.056	.697**	.229*	-.007	.241**	.027	.624**	.477**	.260**	.685**	.685**	.[b]	.685**	.697**	.685**	.685**	.624**	1								
	Sig. (2-tailed)	.005	.005	.034	.299	.031	.868	.545	.000	.012	.940	.008	.774	.000	.000	.004	.000	.000		.000	.000	.000	.000	.000									
25. Gross Domestic Product of the city in Million Euron (2016)	Pearson Correlation	.478**	.328**	.177	-.125	.321**	-.016	.190*	.592**	.342**	.027	.200*	-.003	.036	.446**	.411**	.[b]	.[b]	.[b]	.[b]	.592**	.[b]	.[b]	.036	.543**	1							
	Sig. (2-tailed)	.000	.000	.060	.185	.001	.862	.042	.000	.000	.775	.032	.971	.699	.000	.000	0.000	0.000		0.000	.000	0.000	0.000	.699	.000								
26. GDP_per_inhabitant in PPS (% of EU-28 avg.)	Pearson Correlation	.109	.237*	.157	.026	.126	-.004	-.021	.249**	.190*	-.041	.029	.108	.001	.186*	.180	.[b]	.[b]	.[b]	.[b]	.249**	.[b]	.[b]	.001	.223*	.728**	1						
	Sig. (2-tailed)	.289	.011	.094	.787	.181	.964	.825	.007	.042	.666	.755	.251	.990	.046	.054	0.000	0.000		0.000	.007	0.000	0.000	.990	.017	.000							
27. population size of the city	Pearson Correlation	.436**	.167	.053	-.184*	.279**	-.019	.083	.601**	.333**	.089	.364**	.043	.040	.529**	.377**	.070	.070	.[b]	.070	.601**	.070	.070	.040	.440**	.521**	-.053	1					
	Sig. (2-tailed)	.000	.069	.564	.046	.002	.840	.369	.000	.000	.332	.000	.644	.666	.000	.000	.447	.447		.447	.000	.447	.447	.666	.000	.000	.577						
28. unemployment rate of the city(% share of labour force aged 15-74)	Pearson Correlation	.001	-.047	-.087	.002	.022	-.080	.133	.073	.072	.182*	-.056	-.256**	-.160	.004	.030	-.080	-.080	.[b]	-.080	.073	-.080	-.080	-.160	-.045	.050	-.178	.290**	1				
	Sig. (2-tailed)	.995	.609	.346	.982	.813	.384	.148	.430	.435	.047	.541	.005	.080	.965	.746	.388	.388		.388	.430	.388	.388	.080	.627	.598	.057	.001					
29. Combined adaptive capacity to climate change: Combination of economic, infrastructural, technological, institutional capacity	Pearson Correlation	.133	.277**	.150	-.085	.259**	.075	.100	.079	.121	.123	.320**	.229*	.020	.358**	.279**	.[b]	.[b]	.[b]	.[b]	.079	.[b]	.[b]	.020	.078	.135	.271**	-.122	-.399**	1			
	Sig. (2-tailed)	.196	.003	.115	.370	.006	.430	.290	.407	.202	.193	.001	.014	.832	.000	.003	0.000	0.000		0.000	.407	0.000	0.000	.832	.411	.155	.004	.197	.000				
30. aggregated indices of climate change impacts: Combination of physical, environmental, social, economic and cultural impacts of climate change.	Pearson Correlation	-.363**	-.168	-.017	-.068	-.145	-.018	-.039	.005	-.060	-.015	.031	-.142	-.094	-.092	.082	.[b]	.[b]	.[b]	.[b]	.005	.[b]	.[b]	-.094	-.033	.032	-.055	.174	.272**	-.349**	1		
	Sig. (2-tailed)	.000	.076	.856	.477	.127	.850	.679	.956	.525	.878	.745	.135	.320	.331	.390	0.000	0.000		0.000	.956	0.000	0.000	.320	.729	.739	.564	.065	.004	.000			
31. distance from the coast in kilometers	Pearson Correlation	.101	-.029	.065	.013	-.106	.005	-.086	-.059	-.125	.005	-.052	.340**	-.022	.017	-.082	-.057	-.057	.[b]	-.057	-.059	-.057	-.057	-.022	-.074	-.040	.058	-.026	-.293**	.251**	-.269**	1	
	Sig. (2-tailed)	.311	.752	.480	.886	.250	.956	.351	.519	.173	.953	.574	.000	.813	.853	.373	.537	.537		.537	.519	.537	.537	.813	.420	.674	.538	.774	.001	.007	.004		
32. altitude above sea level in meters	Pearson Correlation	-.068	-.063	.047	.015	-.133	-.018	.049	-.088	-.219*	-.066	-.150	.108	-.018	-.149	-.093	-.035	-.035	.[b]	-.035	-.088	-.035	-.035	-.018	-.081	-.064	-.090	.055	.027	-.036	-.091	.473**	1
	Sig. (2-tailed)	.500	.495	.611	.867	.151	.848	.595	.339	.016	.477	.101	.241	.845	.104	.311	.703	.703		.703	.339	.703	.703	.845	.380	.498	.339	.549	.768	.701	.338	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

b. Cannot be computed because at least one of the variables is constant.

Table 8. Correlation analysis

4.7.2 Multiple Linear regression analysis

A multiple regression analysis is conducted to test a model to see mathematical expression of the relation between independent variables and dependent variable (Van Thiel, 2014).The total number of action plans and Total emission reduction are the dependent variables with a selection of different predictors as the independent variable.

The analysis explains how a single response variable (DV) depends linearly on a number of predictor variables (IV). It allows in determining the degree of variation in Total number of action plans and Total emission reductions and also explains the relative contribution of each independent variable to the total variance.

Certain assumptions are checked for the multiple regression analysis to be applicable. Linear relationship between the dependent and independent variables is observed when checked for linearity through the visual inspection of scatterplots and partial regression plots. Independence of residuals is observed using the Durbin-Watson statistic which presents a value between the two critical values of $1.5 < d < 2.5$, indicating no autocorrelation detected in the residuals. The absence of multi-collinearity is assumed in the model as most of the independent variables are not strongly correlated in the Pearson's correlation test earlier. Thus we proceed with the multiple regression analysis for Total number of action plans and Total emission reductions.

Figure 11. Multiple Linear regression analysis

Multiple Linear regression analysis

Dependent variable: Total Action Plans

Model 1 = C40 cities ($\beta = 0.348$, $p < 0.05$)
Euro cities ($\beta = 0.257$, $p < 0.05$)

Model 2 = function of Funding ($\beta = 0.399$, $p < 0.05$)

Model 3 = combined adaptive capacity ($\beta = 0.874$, $p < 0.01$)
Gross Domestic Product ($\beta = 0.000003$, $p < 0.01$)

Dependent variable: Total Emission Reduction

Model 1 = C40 cities ($\beta = 1375305.42$, $p < 0.01$)
Euro cities ($\beta = 785603.42$, $p < 0.05$)

Model 2 = Total memberships ($\beta = 557493.3$, $p < 0.01$)
Multilateral city networks ($\beta = \mathbf{-930094}$, $p < 0.05$)
function of funding ($\beta = 894461.686$, $\mathbf{p > 0.05}$)

Model 3 = climate change impacts($\beta = \mathbf{-2586902.25}$, $p < 0.01$)
Gross Domestic Product ($\beta = 17.35$, $p < 0.01$)

4.7.2.1 Dependent variable: Total Action Plans

The Regression analysis has been conducted in different models with different set of predictor variables to avoid autocorrelation and multicollinearity as well as to retain the model of best fit.

Table 9. Multiple regressions with Total Action Plans as the Dependent variable

MODEL 1

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.897	.279		3.214	.002
	Member of International Solar Cities Initiative	-.371	.542	-.061	-.685	.495
	Member of World Mayors Council on Climate Change	-.218	.169	-.118	-1.288	.200
	Member of C40 Cities	.348	.151	.224	2.310	.023
	Member of Euro Cities	.257	.108	.227	2.373	.019
	Member of Energy Cities	.050	.110	.041	.460	.647
	Member of International Council for Local Environmental Initiatives	-.041	.114	-.035	-.363	.717
	Member of Climate Alliance	.107	.112	.087	.955	.342
	Member of Covenant of Mayors	.368	.274	.119	1.342	.182

a. Dependent Variable: Total_Action_Plans

MODEL 2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
2	(Constant)	1.181	.715		1.650	.102
	Level_of_Network	-.150	.154	-.133	-.974	.332
	Network structure is a Multilateral City Network	.244	.168	.181	1.456	.148
	Network structure is a Institution-led City Network	.138	.674	.039	.204	.839
	Funding (Functions acquired through membership)	.399	.172	.256	2.314	.023
	Target and plan provisions (Functions acquired through membership)	-.162	.685	-.027	-.237	.813
	Monitoring and Certification (Functions acquired through membership)	.326	.561	.105	.581	.563
	Total_Memebers hips	.025	.082	.054	.299	.766

a. Dependent Variable: Total_Action_Plans

MODEL 3

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
3	(Constant)	1.309	.060		21.906	.000
	Gross Domestic Product of the city in Million Euron (2016)	2.863E-6	.000	.336	3.745	.000
	(Constant)	.709	.232		3.059	.003
	Gross Domestic Product of the city in Million Euron (2016)	2.591E-6	.000	.304	3.450	.001
	Combined adaptive capacity to climate change: Combination of economic, infrastructural, technological, institutional capacity	.874	.327	.236	2.674	.009

a. Dependent Variable: Total_Action_Plans

Model 1 is the first analysis conducted with *Enter method* where the different TCNs are the only predictor variables included for the total number of actions in a member city. The model explains 15.8% of the variance in the data (*$R^2 = 0.158$).*Among the 8 TCNs, C40 cities (*$\beta = 0.348$, $p < 0.05$*) and Euro cities (*$\beta = 0.257$, $p < 0.05$*) are observed as significant predictors influencing the total number of climate action in a positive manner. The unique variance of membership to C40 cities and Euro cities affirms that for every 1-unit increase in member, we will observe an increase of 0.35 and 0.26 action plans in member cities respectively.

Model 2 encompasses city characteristics acquired through membership to different networks as the independent variables. The linear regression in model 2 conducted with *Enter method* explains only 12.7% of the variance in the data (*$R^2 = 0.127$).* The Durbin-Watson *$d = 2.07$* value predicts no linear autocorrelation in the multiple regression data. The results from the Anova table stipulates that the regression model was a significant predictor of Total action plans of member cities (*$F (7, 111) = 2.30$, $p < 0.05$)* when acquired city characteristics are taken as a set of predictor.

The function of Funding acquired through membership is identified as the single significant predictor that influences the number of climate action a city implements (*$\beta = 0.399$, $p < 0.05$*). The Linear regression affirms that for every single function of funding acquired through membership to different TCNs, we will observe an increase of 0.399 action plans in member cities.

Model 3 encompasses natural (existing) city characteristics as the independent variables but *Stepwise method* has been selected to increase the significance value of the output. Model 3 explains only16.8% of the variance of the data (*$R^2 = 0.168$).* The Durbin-Watson *$d = 2.22$* value predicts no linear autocorrelation in the multiple regression data. The results from the Anova table stipulates that the regression model was a significant predictor of Total action plans of member cities (*$F (2, 109) = 10.98$, $p < 0.01$)* when natural city characteristics are taken as a set of predictor.

The combined adaptive capacity (*β = 0.874, p < 0.01*) is identified as the most significant predictor that influences the number of climate action a city implements. The Linear regression affirms that for every 0.1 unit increase in combined adaptive capacity, we will observe an increase of 0.874 action plans in member cities. This is followed by Gross Domestic Product (*β = 0.000003, p < 0.01*) which indicates a high significance value but the regression / *β coefficient* is considerably low.

As an overall summary, we can conclude that the combined adaptive capacity and GDP of a city's natural characteristics are significant predictors of total number of climate actions, a member city implements. Member cities with a strong economy accompanied with high technological, infrastructural and institutional capacity are highly engaged in both mitigation and adaptation measures, stand alone and Joint measures to address issues of climate change. While the function of funding is the only significant predictor identified from all the functions acquired through membership. We can deduce that regardless of the member city's high ambition in engaging local climate measures, the financial aspects of implementing such plans still plays vital role. Even though we identified a positive correlation between the total number of functions and total number of actions, actions in the member cities tend to increase with acquiring the functions of funding.

4.7.2.2 Dependent variable: Total Emission Reduction

Table 10. Multiple regressions with Total emission reductions as the Dependent variable

MODEL 1

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	120708.914	1074067.067		.112	.911
	Member of International Solar Cities Initiative	-516215.861	1471547.405	-.032	-.351	.727
	Member of World Mayors Council on Climate Change	-554287.726	506273.995	-.104	-1.095	.276
	Member of C40 Cities	1375305.426	467503.923	.290	2.942	.004
	Member of EuroCities	785603.428	311883.227	.244	2.519	.013
	Member of Energy Cities	-52884.952	312805.981	-.016	-.169	.866
	Member of International Council for Local Environmental Initiatives	388656.808	341834.270	.116	1.137	.258
	Member of Climate Alliance	553959.721	326547.462	.158	1.696	.093
	Member of Covenant of Mayors	-11704.773	1065822.811	-.001	-.011	.991

a. Dependent Variable: Total_Emission_Reduction

MODEL 2

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	586110.512	156828.772		3.737	.000
	Funding (Functions acquired through membership)	1767309.426	439292.867	.373	4.023	.000
2	(Constant)	-114647.016	356565.369		-.322	.748
	Funding (Functions acquired through membership)	1151107.859	515736.659	.243	2.232	.028
	Total_Memebers hips	305722.647	140309.607	.237	2.179	.032
3	(Constant)	-12456.594	354743.313		-.035	.972
	Funding (Functions acquired through membership)	894461.686	523482.610	.189	1.709	.091
	Total_Memebers hips	557493.323	185975.324	.433	2.998	.003
	Network structure is a Multilateral City Network	-930094.851	459866.941	-.250	-2.023	.046

a. Dependent Variable: Total_Emission_Reduction

MODEL 3

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	193521.844	192594.662		1.005	.318
	Gross Domestic Product of the city in Million Euron (2016)	17.579	3.333	.478	5.275	.000
2	(Constant)	938304.140	248984.419		3.769	.000
	Gross Domestic Product of the city in Million Euron (2016)	17.346	3.066	.472	5.658	.000
	aggregated indices of climate change impacts: Combination of physical, environmental, social, economic and cultural impacts of climate change.	-2586902.251	607739.349	-.355	-4.257	.000

a. Dependent Variable: Total_Emission_Reduction

Model 1 is the first analysis conducted with *Enter method* where the different TCNs are the only predictor variables included for the total emission reduction targeted by each member city. The model explains 24.3% of the variance in the data (*$R^2 = 0.243$).* Among the 8 TCNs, C40 cities (*β* = 1375305.42, *$p < 0.01$*) and Euro cities (*β* = 785603.42, *$p < 0.05$*) are observed again as significant predictors influencing the total emission reductions in a positive manner. The unique variance of membership to C40 cities and Euro cities affirms that for every 1-unit increase in member, we will observe an increase of 1375305 and 785603 million tonnes CO_2 reduction in member cities respectively.

Model 2 includes the functions and characteristics acquired through membership but a *stepwise method* is selected to increase the significance value. Model 2 explains 21.2% of the variance of the data (*$R^2 = 0.354$).* The Durbin-Watson *d = 2.03 value* predicts no linear autocorrelation in the multiple regression data. The results from the Anova table stipulates that the regression model was a significant predictor of Total emission reductions of member cities (*F (3, 98) = 8.76, $p < 0.01$)* when natural city characteristics are taken as a set of predictor.

Total memberships to different networks (*β = 557493.3, $p < 0.01$*) can be identified as the most significant predictor influencing emission reductions. We can infer that for every 1 membership to a network, we can observe an increase of *557493.3* million tonnes CO_2 reduction. This is followed by Multilateral city networks (*β = -930094, $p < 0.05$*) but has a negative influence of the emission reductions and significance is relatively low. Lastly, function of funding again depicts as a positive influence but the relation is not so significant as the *p value* is greater than 0.05. (*β = 894461.686, $p > 0.05$*)

Model 3 includes the natural (existing) city characteristics as the independent variables and a *stepwise method* is selected again to increase the significance value. Model 3 explains 35.4% of the variance of the data (*$R^2 = 0.354$).* The Durbin-Watson *d = 1.81* value predicts no linear autocorrelation in the multiple regression data. The results from the Anova table stipulates that the regression model was a significant predictor of Total emission reductions of member cities (*F (2, 93) = 25.5, $p < 0.01$)* when natural city characteristics are taken as a set of predictor.

The combined aggregated indices of climate change impacts (*β* = -2586902.25, *$p < 0.01$*) is identified as the most significant predictor that influences the Total emission reductions but in a negative manner. The Linear regression affirms that for every 0.1 unit increase in aggregated index of climate change impact, we will observe a decrease of 2586902.3 million tonnes CO_2 reduction in member cities. This is followed by Gross Domestic Product (*β = 17.35, $p < 0.01$*) which indicates a high significance value but the regression / *β value* is considerably low again. This indicates that for every 1 million euro increase in GDP, we observe an increase of 17.35 million tonnes CO_2 reduction in member cities.

In an overall summary, we can conclude that cities located in regions of high risk of climate change impacts are engaging less in mitigation efforts. While cities with a strong economy have set higher targets in CO_2 emission reductions. This does not necessarily suggest that cities with high negative climate change impact index are more active in adaptation measures as observed earlier in the case of Italian cities which depicted that 91.3% lack any adaptation plans and joint M+A measure are non-existent.

Among the city characteristics acquired through membership, though the function the funding again indicates a positive influence, it is not statically significant which indicates that regardless of acquiring funds from networks, most member cities engaged in mitigation efforts through their own financial resources. Total membership is the most significant influencer indicating that cities with more memberships have higher emissions reduction targets in comparison to cities with fewer memberships.

4.7.2.3 Dependent variable: Total Emission Reduction per Sector

Sector										
Local electricity Production	C40(β = 261057 , p < 0.01)	Climate Alliance(β = 261057, p < 0.01)	Eurocities(β = 139180, p < 0.05)	Funding(β = 312832, p < 0.01)	Climate Change Impacts (β = -488180, p < 0.01)	Population (β = 0.087, p < 0.01)				
Transport							Total Membership(β = 100545, p < 0.05)	GDP (β = 4, p < 0.01)		
Tertiary buildings	C40(β = 132156 , p < 0.01)		Eurocities(β = 76527, p < 0.05)		Climate Change Impacts (β = -257471, p < 0.01)	Population (β = 0.067, p < 0.01)	Total Membership(β = 45665, p < 0.01)			
Municipal buildings	C40(β = 123827 , p < 0.01)	Climate Alliance(β = 45608, p < 0.05)		Funding(β = 125049, p < 0.01)	Climate Change Impacts (β = -183244, p < 0.01)	Population (β = 0.043, p < 0.01)				
Public lighting	C40(β = 192024 , p < 0.01)	Climate Alliance(β = 68595, p < 0.05)		Funding(β = 193862, p < 0.01)	Climate Change Impacts (β = -247687, p < 0.01)	Population (β = 0.073, p < 0.01)				
Residential Buildings	C40(β = 399112 , p < 0.01)			Funding(β = 399112, p < 0.01)	Climate Change Impacts (β = -566362, p < 0.01)	Population (β = 0.169, p < 0.01)				
Industry	C40(β = 399112 , p < 0.01)	Climate Alliance(β = 94510, p < 0.05)	Euro cities(β = 92609, p < 0.01)				Total Membership(β = 56218, p < 0.01)		GDP per Inhabitant (β = 671, p < 0.01)	Level of Network (β = -109913, p < 0.01)
Local heat cold production	C40(β = 368638 , p < 0.01)			Funding(β = 368638, p < 0.01)	Climate Change Impacts (β = -514525, p < 0.01)			GDP (β = 3, p < 0.01)		

Table 11.Multiple regressions for different sectors

Multiple linear regressions have been conducted to identity the similar factors from each sector influencing the total emission reduction in all member cities. As illustrated in the above Table, C40 cities is the most influential network with its members depicting the inclusion of almost all sectors except transport, in its action plans. This is followed by the aggregated indices of climate change impacts but it influences in a negative manner signifying action plans of cities at high risk have lower emission targets in majority of the sectors. A notable observation can be seen where GDP per Capita and Level of Network is identified to influence only the industry sector. As indicated earlier, the industrial sector was the least incorporated component in the action plans with only 45 cities committed to implementing mitigation measures in industries. Similarly, the total emission reduction target also represents a low percentage of only 6%.This indicates that only cities with higher standards of living are engaged in reducing emissions in the Industry sector.

4.7.3 Binary Logistic Regression

Binary Logistic Regression has been used for its classification algorithm which can predict whether a member city has a mitigation/adaptation/Joint M+A measures (Yes/No) based on a set of independent variable(s). Similar to the earlier analysis, the set of independent variables have been conducted in three separate models. Model 1 comprises of the 8TCNs, Model 2 comprises of the different city characteristics acquired through membership and Model 3 comprises of existing (natural) city characteristics.

Figure 12. Binary Logistic Regression Analysis

Binary Logistic regression analysis

Dependent variable: Mitigation Action Plan	Dependent variable: Adaptation Action Plan	Dependent variable: M+A Action Plans
Model 1 = Euro cities *(β = **-1.57**, p < 0.05, Exp(β)= 0.209*) 79.1%	**Model 1** = C40 cities *(β = 1.3, p < 0.05, Exp(β)= 3.65*) 265% Climate Alliance *(β = 1.01, p < 0.05, Exp(β)= 2.75*) 175%	**Model 1** = Euro cities *(β = **1.517**, p < 0.01, Exp(β)= 4.56*) 79.1%
Model 2 = -------	**Model 2** = Multilateral City Networks *(β = 2.65, p < 0.05, Exp(β)= 14.14*) 1314% function of Funding *(β = 1.42, p < 0.05, Exp(β)= 4.12*)) 312%	**Model 2** = -------
Model 3 = --------	**Model 3** = ----	**Model 3 =** combined adaptive capacity *(β = **5.45**, p < 0.05, Exp(β)= 232.03*)

****Odds ratio = 1 same prob. Of event occurring between 2 situation**

Odds ratio > 1 prob. of event occurring with unit increase in IV higher than at original value of IV.

Odds ratio < 1 prob. of event occurring with unit increase in IV is lower than at original IV**

4.7.4 Dependent Variable: Mitigation Action Plan

A statistically significant result is observed only in Model 1. Nagelkerke's R^2 indicates that the model explains roughly 18% of the variation in the outcome. From the Hosmer & Lemeshow test we can infer that the model is a good fit to the data as *p=0.701* (*>.05*). The prediction is correct in 90.8% of the cases (100% correct where mitigation plan exists; 8.3% correct where no mitigation plan exist).

Membership to Euro cities can be identified as the important factor with a significant contribution to the model. For an additional member in Euro cities, the odds of having a mitigation plan is lower by a factor of 0.209 (79.1%)

4.7.5 Dependent Variable: Adaptation Action Plan

In Model 1. Nagelkerke's R^2 indicates that the model explains roughly 18% of the variation in the outcome. From the Hosmer & Lemeshow test we can infer that the model is a good fit to the data as *p=0.701* (*>.05*). The prediction is correct in 75.6% of the cases (14.3% correct where adaptation plan exists; 94.5% correct where no adaptation plan exist).

Membership to C40 and Climate Alliance cities can be identified as the important factors with significant contribution to the model. For an additional member in C40 cities and Climate alliance, the odds of having a adaptation plan is higher by a factor of 3.65 (265%) and 2.75 (175%)

In Model 2. Nagelkerke's R^2 indicates that the model explains roughly 19% of the variation in the outcome. From the Hosmer & Lemeshow test we can infer that the model is a good fit to the data as *p=0.882* (*>.05*). The prediction is correct in 76.5% of the cases (10.7% correct where adaptation plan exists; 96.7% correct where no adaptation plan exist).

Multilateral City Networks and Function of funding can be identified as the important factors with significant contribution to the model. For an additional member in Multilateral city network and acquiring the function of funding, the odds of having an adaptation plan is higher by a factor of 14.14 (1314%) and 4.12 (312%)

4.7.6 Dependent Variable: Joint M+A Action Plan

In Model 1. Nagelkerke's R^2 indicates that the model explains roughly 23% of the variation in the outcome. From the Hosmer & Lemeshow test we can infer that the model is a good fit

to the data as *p=0.455* (>*.05*). The prediction is correct in 714% of the cases (23.5% correct where mitigation plan exists; 91.4% correct where no mitigation plan exist).
Euro cities is again identified as the important factor with significant contribution to the model but in a positive manner. For an additional member in Euro cities, the odds of having a Joint M+A plan is higher by a factor of 4.56 (396%)

In Model 3. Nagelkerke's R^2 indicates that the model explains roughly 33% of the variation in the outcome. From the Hosmer & Lemeshow test we can infer that the model is a good fit to the data as *p=0.296* (>*.05*). The prediction is correct in 74.1% of the cases (33.3% correct where Joint M+A plan exists; 91.4% correct where no a Joint M+A plan exist).
Combined adaptive capacity is identified as the important factor with significant contribution to the model. For an additional unit in combined adaptive capacity, the odds of having a Joint M+A plan is higher by a factor of 232.03

Table 12. Binary Logistic Regression for Each Dependent Variable

MODEL 1: Mitigation action Plans (IV)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Int_Solar_cities	17.837	40192.969	.000	1	1.000	55808660.948
	W_Mayr_Cncl	-1.327	.838	2.506	1	.113	.265
	C40_cities	-.725	.764	.900	1	.343	.485
	Euro_Cities	-1.565	.760	4.243	1	.039	.209
	Energy_Cities	-.327	.697	.220	1	.639	.721
	ICLEI	.204	.711	.082	1	.775	1.226
	Cli_Alliance	-.247	.766	.104	1	.747	.781
	COM	1.185	1.276	.863	1	.353	3.271
	Constant	2.427	1.348	3.244	1	.072	11.330

a. Variable(s) entered on step 1: Int_Solar_cities, W_Mayr_Cncl, C40_cities, Euro_Cities, Energy_Cities, ICLEI, Cli_Alliance, COM.

MODEL 2: Adaptation action Plans(IV)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Int_Solar_cities	-20.384	40192.970	.000	1	1.000	.000
	W_Mayr_Cncl	-1.583	1.152	1.888	1	.169	.205
	C40_cities	1.294	.651	3.949	1	.047	3.647
	Euro_Cities	.574	.516	1.237	1	.266	1.775
	Energy_Cities	.213	.516	.169	1	.681	1.237
	ICLEI	-.272	.538	.256	1	.613	.762
	Cli_Alliance	1.011	.498	4.126	1	.042	2.749
	COM	19.734	19228.828	.000	1	.999	371685289.367
	Constant	-21.564	19228.828	.000	1	.999	.000

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Level_of_Network	-.522	.700	.556	1	.456	.593
	Multi_City_Netw	2.649	1.151	5.295	1	.021	14.144
	Insti_led_City_Netw	.622	49211.257	.000	1	1.000	1.862
	Online_activity	-.214	24605.676	.000	1	1.000	.807
	Funding	1.417	.735	3.719	1	.054	4.123
	Moni_Cert	19.980	40192.933	.000	1	1.000	475403865.280
	Total_Memeberships	-.193	.342	.320	1	.572	.824
	Constant	-22.092	40192.933	.000	1	1.000	.000

MODEL 3: Joint M+A action Plans(IV)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	Int_Solar_cities	-19.008	40192.970	.000	1	1.000	.000
	W_Mayr_Cncl	.613	.714	.738	1	.390	1.846
	C40_cities	.880	.604	2.125	1	.145	2.411
	Euro_Cities	1.517	.481	9.931	1	.002	4.557
	Energy_Cities	.310	.489	.402	1	.526	1.363
	ICLEI	-.120	.507	.056	1	.813	.887
	Cli_Alliance	-.336	.534	.396	1	.529	.715
	COM	.309	1.258	.060	1	.806	1.362
	Constant	-2.168	1.293	2.813	1	.094	.114

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1a	GDP	.000	.000	1.350	1	.245	1.000
	GDP_per_inhabitant	-.005	.006	.689	1	.407	.995
	population_size	.000	.000	.217	1	.641	1.000
	Unemplymnt_rate	.011	.067	.028	1	.868	1.011
	Adapt_capacity	5.447	2.164	6.334	1	.012	232.034
	Agg_ind_cli_chnge_imp	-1.859	1.305	2.030	1	.154	.156
	Dist_coast	-.003	.003	1.278	1	.258	.997
	Altitude	-.002	.003	.771	1	.380	.998
	Constant	-4.065	1.859	4.782	1	.029	.017

5.1 Conclusion and recommendations

As cities become key actors in addressing climate change, the local governments have gradually adopted the responsibility for the implementation of mitigation and adaptation measures around the world. In parallel to these commitments towards climate change responses, several Transnational city networks have emerged providing a global/regional platform for shaping local climate initiatives while instigating transnational relations. With this study focusing on the local level of urban climate measures, the aim was to contribute to the scientific understanding of the influence of transnational climate networks enabling cities to acquire certain characteristics and functions through their membership, resulting in the facilitation of climate change measures.

This study aimed to contribute in developing a better understanding of the effective roles played by various climate networks and provide insights for policy makers and network facilitators in directing more credible strategies to implement local climate policy against climate change.
The findings of this study can be utilized by local governments in aiding them with better understanding of the impacts that Climate networks can have on furthering the resilience of a city through resource acquisition for diffusion of local climate actions and its influential aspect in the progression of climate policy in the urban context.
In order to accomplish the research objective, the following questions are answered:

What are the City characteristics and functions acquired through membership to the different types of Transnational city networks?

The different attributes and functions of climate networks is identified by providing a classification of city to city networks based on their level of network/geographic spread, identifying the institutions and main stakeholders involved in the network structure, and analyzing the function that each specific network provide to their members (such as information exchange, lobbying, networking, standards and commitment provision, research, project financing, certification and monitoring). Among the 8 Transnational city networks selected based on its prominence in Europe, Covenant of Mayors encompasses majority of the cities in its membership and similarly offers the highest number of functions with only funding being absent. International solar cities and World Mayors Council on Climate Change offer the least with information exchange/networking being the single function available.

Information exchange/networking was the most prominent function provided by all 8 TCNs, while funding and monitoring/certification were the least provided functions.C40 cities is the only network that encompasses the function of funding and Covenant of Mayors is the only network that provides the function of monitoring and certification.

It is noteworthy to observe that while the level of network is equally distributed with 4 networks functioning at global scale and the other 4 networks functioning at regional scale (Europe), the network structure in contrast is prominent more towards Multilateral city networks with only 2 networks identified as institutional led city networks (ICLEI and COM).

While assessing the online activity status of the 8 TCN, we can observe that 6 networks displayed high online activity while 2 networks (International Solar Cities and World Mayors Council on Climate Change) displayed no events and news updated since 2014 and 2015. Through assessing its correlation between the different function a network provides and online activity, we can observe that TCNs with more advanced functions exhibit more active participation and interactions, while networks with only basic function of information exchange/networking are less likely to be active.

What are the Climate action plans (Adaptation and Mitigation) under implementation in European cities with membership in a Transnational city network? What are the emerging patterns of Climate action plans?

The overall distribution of Total number of climate action plans among 120 cities indicate that a high number of cities (60.8%) contain at least one climate response measure with a mitigation action plan being the general inclusion. 35 % of the member cities indicate having 2 action plans while a minor 2.5% with only 3 cities contained all 3 climate action plans (Berlin, London and Liverpool).This indicates that even though most cities show high level of engagement and commitment towards climate response measures ,majority of the cities include only mitigation action plans.

Despite the widely acknowledged leadership role of Europe in terms of environmental policy, climate change response measures depict a high disparity in its distribution with adaptation measures being significantly less in comparison to mitigation measures. Across the sample, only 23.3% have adaptation plans, while 89.2% have mitigation plans and 28.3% have a joint M+A plans.
The existence of plans differs noticeably across countries. Cities in United Kingdom depict an all-encompassing scenario with almost all British cities containing either both or Joint M+A plans. Likewise German cities also demonstrate high levels of activity both in terms memberships to different networks and in climate response measures including both mitigation and adaptation. Italian cities depict a contrasting scene with all 23 cities (100%) containing a mitigation action plan, but only 2 cities (8.7%) containing an adaptation plan and none of the cities contained a joint M+A action plan. Aggregated indices of climate change impacts indicate that most of the Italian cities are at probable risk settled in medium-highest negative impact regions (0.3-1).Yet Italian cities have prioritize mitigation efforts above adaptive measures as 91.3% lack any adaptation plans and joint M+A measure are non-existent.

What are the identifiable City characteristic Typologies with similar activities across different sectors in the member cities?

This research on climate action has resulted in a projected set of information on cities' characteristics and activities, from simple population and GDP statistics, to detail on the preferred sectors for climate action. Typologies of cities with similar characteristics and activities concerning climate actions with greenhouse gas emission reductions per sector have been identified. Identification of such a typology presents the potential for policy makers to exchange information from cities facing similar challenges and opportunity for attracting investors. The following are examples of such clusters:

Birmingham, Grand Lyon, Helsinki, Paris, Warsaw: Metropolis cities, low negative index of climate change impacts, high unemployment rate, high adaptive capacity, Significant emission reduction target in Transportation sector.

Berlin, Grand Lyon and Hamburg: Metropolis cities, low aggregated ndex of climate change impacts, highest emission targets in Industry sector, Joint M+A plans

Bregenz, Mouscron, Agueda and Worms: Small Sized cities, low GDP, low negative impacts of climate change, High emission reduction targets in the Industry Sector.

Amsterdam, Barcelona, Madrid and Valencia: Large Population Size, significantly high GDP, High aggregated index of climate change impacts, Joint M+A plans.

Which city characteristics (acquired and existing) explain the facilitation of these climate adaptation and mitigation measures in member cities in Europe?

5.1.2 Acquired City Characteristics through membership to TCNs:

Through correlation and multiple regression analysis, we could observe that **function of funding** has a statistically significant positive correlation and can be observed as significant predictors influencing the total action plans, adaptation and joint M+A action plans in a member city. This indicates the predominant significance of acquiring financial resources especially for economically weaker cities with lower GDP who depend on external funding for implementing climate actions. In contrast mitigation /emission reduction did not portray any significant correlation with funding indicating that majority of the member cities implemented mitigation measures regardless of acquiring the funding from networks.

When the networks are examined individually, **C40 cities and Euro-cities** are the only 2 networks that displayed a significant correlation and are significant predictors of total action plans suggesting that its members have implemented a higher number of climate actions(both mitigation and adaptation or Joint M+A) and higher emission reduction targets in comparison to the other networks. **Total number of membership** can also be observed as a significant predictor of total emission reduction indicating that cities with higher number of membership to different networks have higher emission reduction targets in comparison to other cities. **Multilateral city networks** can also be observed as significant predictor but in a negative manner indicating that majority of the members of this network has lower emission reduction targets in comparison to institutional led city networks.

Through Binary logistic regression we can observe that membership to **Euro cities** is a significant factor for predicting **mitigation and Joint M+A action plans**. The odds of having a mitigation plan are lowered with an additional member in Euro cities. However this does not necessarily indicate that mitigating measures are non-existent for members of Euro cities as there is a positive correlation in terms of Joint M+A plans. So it can be assumed that stand-alone mitigation plans are absent but most members have a Joint M+A plan instead as the odds are higher for M+A plans. For adaptation measures, we can identify that **C40 cities, Climate Alliance, Multilateral city networks and function of funding** are important factors having higher odds of implementing adaptation action plans.

5.1.3 Natural (existing) City Characteristics:

Through correlation and multiple regression analysis, we could observe that **Gross Domestic Product** and **Combined Adaptive Capacity** of a city was the most significant predictor for both the total number of action plan implemented and the total emission reduced. This observation suggests that prosperous cities with better institutional, technological, and infrastructural capacity regardless of the city size indicate extensive employment in the overall number of action plans. It is be observed that predictors such as aggregated indices for climate change impacts or distance from the coast do not signify any correlation indicating that regions with higher risk to climate change do not necessarily result in additional actions in the member cities.

The **aggregated indices of climate change impacts** is observed as significant predictor for **total emission reduction** but in negative manner indicating that cities located at high risk areas have lower emission reductions. This does not necessarily suggest that cities with high negative climate change impact index are more active in adaptation measures as observed earlier in the case of Italian cities which depicted that 91.3% lack any adaptation plans and joint M+A measure are non-existent.

Through Binary logistic regression we can observe that **Combined Adaptive Capacity** is a significant factor for predicting **Joint M+A action plans**. The odds of having a Joint M+A are higher with an Unit increase in combined adaptive capacity. The Economic, technological, infrastructural and institutional capacity of a city can be observed as significant factor for predicting the development of joint M+A plans.

As an overall summary, the results of the research indicate that despite the extensive engagement of cities in several Transnational city networks, disparity in the distribution of climate change response measures among member cities still exist with adaptation measures being significantly less in comparison to mitigation measures. The large numbers of memberships have mostly enabled in the facilitation of mitigation action plans only. This may be explained by networks such as Covenant of Mayors that require a member city to submit at least a sustainable energy action plan upon its admission. For instance earlier findings on Italy's high membership to TCNs does not reflect a similar outcome but a disparity in the dispersion of the total action plans can be identified with all 23 cities containing a mitigation action plan, but only 2 cities containing an adaptation plan and none of the cities contained a joint M+A action plan. The constraints for the implementation of climate actions are often asserted to the uncertainty of climate change impacts. Reckien, et al. (2015) had identified projected **exposure to future climate impacts** as a main factor in regards to city adoption of climate actions. However, Italian cities with only implementing mitigation measures indicates that verifiable information on climate change impacts and greater certainty do not necessarily result in additional and adaptive climate change actions.

(Milfont, et al., 2014) had identified distance **from the coast and altitude above sea level** being linked to climate change belief**,** however we observed that psychological acceptance of climate change and support for better regulation resulted in no significant correlation neither with the total number of action plans implemented or the total emission reduction.
Among the natural city characteristics that are identified for serving as a driver in the implementation of climate change actions, the significant factor was **Gross Domestic Product** of the city. Satterthwaite, et al. (2007) had identified vulnerability in an urban context as being dependent on its social and economic development. Buob and Stephan (2011) claimed a region's **income level** defines the adoption between mitigation and adaptation strategies .High income regions tend do both M+A measures while low income regions implement only mitigation actions stemmed by their limited resources. A comparable outcome can be identified in this study with prosperous cities with stronger economies indicating extensive employment in the overall number of action plans and targeting higher emission reduction.

Adaptive capacity is also identified as significant factor indicating that cities with greater economic, institutional, infrastructural, and technological capacity are implementing more action plans especially in terms of adaptation and Joint M+A action plans.

Regarding the institutions and stakeholders involved in a TCN, Lee et al. (2018) in his literature identified two different types of network structures,; multilateral and institution-led city networks. The results of the regression analysis demonstrate that **multilateral city networks** which are voluntarily instigated by city governments/ city leaders such as C40 cities, Euro cities …etc. are more engaged in terms of adaptation measures in comparison to institution led networks. This reason may be explained by the lack of resources and absence of predominant authority in an institution led network which limits the local government in implementing adaptation measures. As adaptation plans are resource extensive, if an institution is incapable of rendering sufficient resources required by member cities for implementing climate actions, effectiveness of a network diminishes.

Niederhafner, (2013) Bulkeley et al., (2012) and Lee and Koski,(2015) had identified different functions available from a variety of climate networks, however through our analysis we only observed the **function of funding** as the most significant influencer for the total number of action plans a member city implements especially regarding adaptation measures. We can deduce that regardless of the member city's high ambition in engaging local climate measures, the financial aspects of implementing such plans still plays a vital role.

Considering the time constraint and scope of the study, the research was dependent on a quantitative desk research method measuring most of the attributes and functions of the TCNs through a binary scale. Although this methodology contributes to a certain component of the knowledge gap, it does not give overall comprehensive deduction as in depth details of the how these functions operate are still absent. Further research into advanced functions such as Monitoring and Research may provide some key insights into a network's effectiveness in policy learning among cities while assessing their performance and progress.

As Transnational city networks comprise of vast numbers of members, a larger sample size would have been preferred but due the time constraint, only 306 memberships have been analysed. Other limitations with the recommendations for future research are discussed below.

5.1.4 Recommendations for future research

1. The scope of the study was delimited to only member cities in Europe. The results may provide valuable and insightful information into TCNs but cities from other parts of the world may depict differing results. Further research and a comparative study for member cities of TCNs from different part of the world are recommended.
2. In-depth research with interviews exploring the internal functioning for a transnational city network's effectiveness and explaining the different functions of TCN identified in this study.
3. Research involving case studies into specific countries such as the United Kingdom/Germany where the cities demonstrate high activity levels in terms of implementations of both mitigation and adaptation measures. Research into exploring the main factors acting as drivers, while barriers for implementation can also be studied in the case of Italian cities which represented an alarming trend where majority of the cities at high risk to climate change impacts lacked any adaptation measures.
4. Further research into individual network's working particularly C40 cities/ Covenant of Mayors can be explored. Research into the Operational aspects of a certain network's function rendering it more effective in comparison to other networks should be studied.

Bibliography

Albrechts, L., 2004. Strategic (spatial) planning reexamined. *Environment and Planning B : Planning and Design,* 31 (5), pp. 743-758. Available at: https://www.researchgate.net/publication/23541454_Strategic_spatial_planning_reexamined [Accessed 30-10-2015].

Amundsen, H., Berglund, F. and Westskog, H. 2010. Overcoming Barriers to Climate Change Adaptation—A Question of Multilevel Governance? *Environ Plann C Gov Policy,* 28 (2), pp. 276-289.

Bansard, J. S., Pattberg, P. H. and Widerberg, O. 2017. Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. *International Environmental Agreements: Politics, Law and Economics,* 17 (2), pp. 229-246.

Busch, H., Bendlin, L. and Fenton, P., 2018. Shaping local response – The influence of transnational municipal climate networks on urban climate governance. Available at: http://www.sciencedirect.com/science/article/pii/S2212095518300932 .

Davidson, F., 1996. Planning for performance:: requirements for sustainable development. *Habitat International,* 20 (3), pp. 445-462.

Fünfgeld, H., 2015. Facilitating local climate change adaptation through transnational municipal networks. Available at: http://www.sciencedirect.com/science/article/pii/S1877343514000839 .

Giest, S. and Howlett, M., 2013. Comparative Climate Change Governance: Lessons from European Transnational Municipal Network Management Efforts.

Gore, C. D., 2010. The Limits and Opportunities of Networks: Municipalities and Canadian Climate Change Policy. *Review of Policy Research,* 27 (1), pp. 27-46.

Hinkel, J., 2011. "Indicators of vulnerability and adaptive capacity": towards a clarification of the science–policy interface. *Global Environmental Change,* 21 (1), pp. 198-208.

Keiner, M. and Kim, A. 2007. Transnational City Networks for Sustainability. *European Planning Studies,* 15 (10), pp. 1369-1395.

Kona, A., Bertoldi, P., Monforti-Ferrario, F., Rivas, S., et al., 2018. Covenant of mayors signatories leading the way towards 1.5 degree global warming pathway. Available at: http://www.sciencedirect.com/science/article/pii/S2210670717314762 .

Kona, A., Melica, G., Rivas, S., Zancanella, P., et al., 2015. The Covenant of Mayors in Figures and Performance Indicators: 6-year Assessment.

Kulozu Uzunboy, N., 2019. Effect of transnational climate networks on climate experiments: the NilÃ¼fer Municipality, a case from Turkey. *Environment, Development and Sustainability,* .

Lee, T., 2018. Network comparison of socialization, learning and collaboration in the C40 cities climate group.

Lee, T. and Jung, H. Y., 2018. Mapping city-to-city networks for climate change action: Geographic bases, link modalities, functions, and activity. Available at: http://www.sciencedirect.com/science/article/pii/S0959652618303408 .

Milfont, T. L., Evans, L., Sibley, C. G., Ries, J., et al., 2014. Proximity to coast is linked to climate change belief. *PLoS One,* 9 (7), pp. e103180.

Niederhafner, S., 2013. Comparing functions of transnational city networks in Europe and Asia. *Asia Europe Journal,* 11 (4), pp. 377-396.

Perkins, R. and Nachmany, M. 2019. 'A very human business'—Transnational networking initiatives and domestic climate action. *Global Environmental Change,* 54 pp. 250-259.

Reckien, D., Flacke, J., Olazabal, M. and Heidrich, O. 2015. The Influence of Drivers and Barriers on Urban Adaptation and Mitigation Plansâ€"An Empirical Analysis of European Cities. *Plos One,* 10 (8), pp. e0135597.

Smeds, E. and Acuto, M. 2018. Networking Cities after Paris: Weighing the Ambition of Urban Climate Change Experimentation. *Global Policy,* 9 (4), pp. 549-559.

Sovacool, B. K. and Van de Graaf, T., 2018. Building or stumbling blocks? Assessing the performance of polycentric energy and climate governance networks. Available at: http://www.sciencedirect.com/science/article/pii/S0301421518301800 .

Tang, Z., Brody, S. D., Quinn, C., Chang, L., et al., 2010. Moving from agenda to action: evaluating local climate change action plans. *Journal of Environmental Planning and Management,* 53 (1), pp. 41-62.

Annex 1

City.	Mitigation Plan	Adaptation Plan	Joint M+A Plan
Oxford, UK	A Sustainability Strategy for Oxford (2011 – 2020)(M)		
Paris, France		Paris's adaptation strategy towards a more resilient city(A)	PArIS CLIMAtE AND ENErGy ACtIoN PLAN (M+A)
Municipality of Cerisano	COMUNE DI CERISANO (COSENZA)(M)		
City of Koprivnica	Sustainable Energy Action Plan(M)		
City of Bonn	Maßnahmen Klimaschutz Bonn(M)		
Geneva	STRATEGIC PLAN FOR THE SUSTAINABLE DEVELOPMENT OF THE CITY OF GENEVA(M)		
Copenhagen			Kobenhavns Klimaplan(M+A)
Stockholm	The Stockholm Environment Programme 2016-2019(M)		Stockholm action plan for climate and enegry 2010-2020(M+A)
Almada	Estratégia Local Para as Alterações Climáticas do Município de Almada Plano de Acção para a Mitigação(M)		
Barcelona city	The energy, climate change and air quality plan of Barcelona (PECQ 2011-2020)(M)		Barcelona Pla Clima 2018-2030(M+A)
City of Newcastle-Upon-Tyne			Citywide Climate Change Strategy and Action plan 2010-2020(M+A)
Municipality of Águeda	PLANO DE ACÇÃO PARA A ENERGIA SUSTENTÁVEL | PAES(M)		
City of Malmö	Energistrategi för Malm(M)		
Amsterdam	Sustainable Amsterdam(M)		New Amsterdam Climate(M+A))
Athens	SustainabilityPlan2018UpdateV1.1(M)	Athens_Resilience_Strategy_for_2030_Rede(A)	
Berlin	Energiekonzept 2020(M)	Anpassung an die Folgen des Klimawandels in Berlin – AFOK(A)	Berliner Energie- und Klimaschutzprogramm 2030 (BEK 2030)(M+A)
Heidelberg			Konzept für den Masterplan 100% Klimaschutz für die Stadt Heidelberg(M+A)
Lisbon	Plano de AcÃ§Ã£o para a Sustentabilidade EnergÃ©tica de Lisboa(M)	Lisbon's Strategy for Adaptation to Climate Changes (EMAAC)(A)	
London	Delivering London's Energy Future; The Mayor's CC Mitigation and Energy Strategy (2011)(M)	Managing risks and increasing resilience The Mayor's climate change adaptation	london_environment_strategy_2018(M+A)

		strategy(A)	
Madrid			City of Madrid Plan for the Sustainable Use of Energy and Climate Change Prevention 2008(M+A)
Milan	Sustainable Energy Action Plan of the City of Milan(M)	Climate Change Adaptation Strategy for the City of Oslo 2014-2030(A)	
Oslo	FUTURE CITYS for lower greenhouse gas emissions and better urban environment Action program for Oslo 2010 - 2014(M)		
Rome	Piano d'Azione per Kyoto (2004)(M)		
Rotterdam	Investing in sustainable growth Rotterdam Programme on Sustainability and Climate Change 2010 - 2014(M)	/Rotterdam Climate Change Adaptation Strategy 2013(A)	
Venice	PIANO DI AZIONE PER L'ENERGIA SOSTENIBILE - CITTA' DI VENEZIA(M)		
Warsaw	Sustainable Energy Action Plan for Warsaw.(M)	LIFE ADAPTCITY PL (A)	
Linz	50 (Plus-) Punkte für das Weltklima (2002)(M)		
Antwerp	KLIMAATPLAN ANTWERPEN(M)		
Gent	Ghent Climate Plan 2014-2019(M)	Ghent Climate Adaptation Plan 2016-2019(A)	
Brussels capital region	BRUSSEL Van ecogebouw tot duurzame stad(M)		
Zagreb	ACTION PLAN FOR ENERGY SUSTAINABLE DEVELOPMENT CITY OF ZAGREB(M)		SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN - SECAP2019(M+A)/
Helsinki	KestÃ¤vÃ¤n energiankÃ¤ytÃ¶n toimenpideohjelma(M)		
Hamburg			Master Plan for Climate Protection(M+A)
Berlin	Energiekonzept 2020(M)	Anpassung an die Folgen des Klimawandels in Berlin – AFOK(A)	Berliner Energie- und Klimaschutzprogramm 2030 (BEK 2030)(M+A)
Hannover	Klima-Allianz Hannover 2020 (2008)(M)	Climate Adaptation Concept for the Hannover Region(A)	
Budapest	Budapest Főváros Fenntartható Energia Akció Programja (SEAP)(M)		
Dublin	Dublin City Sustainable Energy Action Plan 2010 - 2020(M)		CLIMATE CHANGE STRATEGY FOR DUBLIN CITY(M+A)
Bristol	Climate Change and Energy Security Framework(M)		
Aberdeen City	ABERDEEN'S SUSTAINABLE ENERGY		

	ACTION PLAN(M)		
Milton Keynes	Milton Keynes A Sustainable Future- A low carbon Prospectus(M)/Low Carbon Action Plan 2012(M)		
Delft	Delft Climate Plan 2003 - 2012(M)	Waterplan Delft(A)	
Utrecht	Utrecht Energy Programme 2011-2014(M)		
Valencia			Plan de Adaptación al Cambio Climático de Valencia 2050(M+A)
Malaga	Sustainable Energy Action Plan(M)		
Modena	PIANO di AZIONE PER L'ENERGIA SOSTENIBILE (SEAP)(M)		
Parma	Comune di Parma PIANO D'AZIONE per L'ENERGIA SOSTENIBILE(M)		
Salerno	Piano di Azione per l'Energia Sostenibile Sustainable Energy Action Plan(M)		
Mantova	PIANO D'AZIONE per L'ENERGIA SOSTENIBILE(M)	Mantova Resiliente: le Linee Guida per l'adattamento climatico(A)	
Pordenone	PIANO D'AZIONE PER L'ENERGIA SOSTENIBILE (PAES)(M)		
Udine	Piano d'Azione per l'Energia Sostenibile(M)		
Namur	Plan Climat Energie de la Ville de Namur(M)		
Liège			
Mouscron	Plan d'Actions Energie Durable(M)		PAEDC 2018 Mouscron(M+A)
Vienna / Wien	Klimaschutzprogramm der Stadt Wien Fortschreibung 2010–2020(M)	/klimaschlau-bericht-2018-en(A)	
Stuttgart, Stadtkreis	Klimaschutzkonzepts Stuttgart (KLIKS)(M)	/Klimaanpassungskonzept Stuttgart KLIMAKS(A)	
Frankfurt am Main	Energie- und Klimaschutzkonzept für die Stadt Frankfurt am Main 2008(M)		
Freiburg im Breisgau	Freiburg GreenCity - Approaches to Sustainability (M)/Klimaschutz-Strategie der Stadt Freiburg (M)		
Aalst	Klimaatplan Aalst(M)		
Hasselt	Energiebeleid(M)/Gemeentelijk klimaatactieplan 2012-2020(M)		
Roeselare	/Klimaatneutraal Roeselare(M)	Green plan(A)	
Aachen	SEAP(M)	ANPASSUNGSKONZEPT AN DIE FOLGEN DES	

		KLIMAWANDELS IM AACHENER TALKESSEL(A)	
Düsseldorf	Klimafreundliches Düsseldorf Energie- und CO2-Bilanz 2007(M)/Szenario Düsseldorf 2050 Technologieoptionen und Pfade für ein klimaverträgliches Düsseldorf(M)		
Bremen	Klimaschutz- und Energieprogramm 2020(M)	Klimaanpassungsstrategie Bremen Bremerhaven(A)	
Nürnberg	Klimaschutzfahrplan 2010/2020 (2010)(M)	Handbuch Klimaanpassung Bausteine für die Nürnberger Anpassungsstrategie(A)	
Wolfsburg	CO2 - Bilanz und - Minderungskonzept der Stadt Wolfsburg(M)		
Münster	Klimaschutzkonzept 2020 für die Stadt Münster (M)	/KLIMAANPASSUNGSKONZEPT(A)	
Pforzheim	Aktionsplan für nachhaltige Energie“ (Sustainable Energy Action Plan – SEAP) der Stadt Pforzheim(M)		
Rostock	Klimaschutz Ein Rahmenkonzept für die Hansestadt Rostock(M)		
Worms	KLAK worms (A)/KLIK worms (M)		
Bottrop	City of Bottrop Climate Protection Concept(M)		
Oulu	Oulun kaupungin kestävän energiankäytön toimintasuunnitelmaSEAP(M)		OULUN KAUPUNGIN KESTÄVÄN ENERGIAN JA ILMASTON TOIMINTASUUNNITELMA SECAP(M+A)
Tampere	Tampereen kaupunki Pormestareiden ilmastositoumuksen Kestävän energiankäytön ohjelma(M)		Tampereen kau punkiseudun ilmastostrategia 2030(M+A)
Bordeaux			Plan Climat de la Cub (2011)(M+A)
Grand Lyon	Plan Energie Climat du Grand Lyon(M)		Agenda 21 Grand Lyon (2007)(M+A)
Essen			Integriertes Energie- und Klimakonzept der Stadt Essen (2009)(M+A)
Murcia	Plan de Acción de Energía Sostenible de Murcia(M)	Análisis de Vunerabilidad del Municipio de Murcia(A)	
Nijmegen	Duurzaamheid in uitvoering(M)		
Tilburg	Energievisie(M)/Klimaataanpak 2013-2020(M)		EERSTE KLIMAATPROGRAMMA TILBURG NAAR EEN KLIMAATNEUTRALE EN KLIMAATBESTENDIGE STAD (M+A)

Belfast			The Belfast Agenda - Community Plan for Belfast Strategic Environmental Assessment (M+A)
Birmingham	Sustainable Energy Action Plan(M)		Climate Change Action Plan 2010+ (2010)(M+A)
Cardiff			Carbon Lite Action Plan (2010)(M+A)
Edinburgh	Edinburgh's SEAP(M)	Edinburgh_Adapts_Adaptation_Action_Plan(A)	
Glasgow	The Energy and Carbon Masterplan(M)		Sustainable Energy Action Plan(M+A)
Leeds	Leeds City Council SEAP(M)		Vision for Leeds 2011 to 2030(M+A)
Leicester	Carbon reduction road mapSEAP(M)		Leicester's Sustainability Action Plan 2016 – 2019 (M+A)
Liverpool	Liverpool City Region Sustainable Energy Action Plan(M)	Climate Impacts and Vulnerabilities Framework for Liverpool City(A)	City of Liverpool Climate Change Strategic Framework: A Prospectus for Action(M+A)
Manchester			Manchester -a certain future- CC action plan (2009)(M+A)
Nottingham	Sustainable Energy Action Plan (M)		The Nottingham Community Climate Change Strategu 2012-2020(M+A)
Sunderland	CLIMATE CHANGE ACTION PLAN FOR SUNDERLAND(M)	Local Flood Risk Management Strategy(A)	
Bregenz	Sustainable Energy Action Plan (SEAP)(M)	Strategie zur Anpassung an den Klimawandel in Bregenz(A)	
Brugge	Energie Actieplan Brugge(M)		
Fürstenfeldbruck	Sustainable Energy Action Plan Fürstenfeldbruck(M)		
Landau in der Pfalz	Integriertes Klimaschutzprogramm Landau(M)		
Lörrach	Klimaneutrale Stadt Lörrach (M)	Strategie zur Minderung von Hochwasserrisiken in Baden-Württemberg(A)	
Thessaloniki	Sustainable Energy Action Plan of the Municipality of Thessaloniki(M)		ResilientThessaloniki(M+A)
Bologna	Piano d'Azione per l'Energia Sostenibile(M)	Allegato_Strategia di adattamento locale(A)	
Bergamo	Sustainable Energy Action Plan(M)		
Bolzano-Bozen	SEAP(M)		
Cagliari	Piano di Azione per l'Energia Sostenibile(M)		
Verona	Piano d Azione per l'Energia Sostenibile Patto dei Sindaci(M)		
Firenze/ Florence	Sustainable Energy Action Plan(M)		
Alessandria	Piano d'Azione per L'Energia Sostenibile (M)		
Livorno	Piano d'Azione per l'Energia Sostenibile Comune di		

	Livorno(M)		
Padova	Piano di Azione per l'Energia Sostenibile del Comune di Padova(M)		
Pesaro	S..E..A..P.. Pesaro PIIANO D'AZIIONE PER L'ENERGIIA SOSTENIIBIILE(M)		
Pescara	Piano D' Azione per l' energia sostenibile(M)		
Trieste	PAES Piano d'Azione per l'Energia Sostenibile del Comune di Trieste(M)		
Sassari	PIANO DI AZIONE PER L'ENERGIA SOSTENIBILE COMUNE DI SASSARI(M)		
Vilniaus	Vilnius city sustainable energy action plan(M)		
Kauno	Sustainable Energy Action Plan for the City of Kaunas(M)		
Alkmaar en omgeving	Actieplan voor energiebesparing en duurzame energie in de regio Alkmaar 2015-2020(M)		
Área Metropolitana do Porto	SEAP-Porto(M)	ESTRATÉGIA MUNICIPAL DE ADAPTAÇÃO ÀS ALTERAÇÕES CLIMÁTICAS(A)	
Braşov	SEAP Brasov 2010-2020(M)	Plan de acțiune privind adaptarea la schimbările climatice în Municipiul Brașov(2016)(A)	
Arad	PLANUL DE ACȚIUNE PRIVIND ENERGIA DURABILĂ ÎN MUNICIPIUL ARAD(M)		
Vaslui	Sustainable Energy Action Plan of Vaslui Municipality, 2011 - 2020(M)		
Córdoba	Sustainable Energy Action Plan of CORDOBA(M)		
La Rioja	Sustainable Energy Action Plan of Rioja(M)		
Durham	A Low Carbon Masterplan for County Durham(M)		DurhamClimateChangeDeliveryPlan(M+A)
Northumberland	SEAP(M)		
Cornwall Council / Konsel Kernow	Sustainable Energy Action Plan (SEAP)(M)		

Multiple linear regressions

Total action plans
Model 1

Model 1 Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.397[a]	.158	.096	.53220	.158	2.575	8	110	.013	2.219

a. Predictors: (Constant), Member of Covenant of Mayors, Member of Energy Cities, Member of Euro Cities, Member of International Solar Cities Initiative, Member of World Mayors Council on Climate Change, Member of Climate Alliance, Member of International Council for Local Environmental Initiatives, Member of C40 Cities

b. Dependent Variable: Total_Action_Plans

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.835	8	.729	2.575	.013[b]
	Residual	31.157	110	.283		
	Total	36.992	118			

a. Dependent Variable: Total_Action_Plans

b. Predictors: (Constant), Member of Covenant of Mayors, Member of Energy Cities, Member of EuroCities, Member of International Solar Cities Initiative, Member of World Mayors Council on Climate Change, Member of Climate Alliance, Member of International Council for Local Environmental Initiatives, Member of C40 Cities

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.897	.279		3.214	.002
	Member of International Solar Cities Initiative	-.371	.542	-.061	-.685	.495
	Member of World Mayors Council on Climate Change	-.218	.169	-.118	-1.288	.200
	Member of C40 Cities	.348	.151	.224	2.310	.023
	Member of Euro Cities	.257	.108	.227	2.373	.019
	Member of Energy Cities	.050	.110	.041	.460	.647
	Member of International Council for Local Environmental Initiatives	-.041	.114	-.035	-.363	.717
	Member of Climate Alliance	.107	.112	.087	.955	.342
	Member of Covenant of Mayors	.368	.274	.119	1.342	.182

a. Dependent Variable: Total_Action_Plans

Model 2

Model 2 Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.356[a]	.127	.072	.53943	.127	2.303	7	111	.031	2.079

a. Predictors: (Constant), Total_Memeberships, Target and plan provisions (Functions acquired through membership), Monitoring and Certification (Functions acquired through membership), Funding (Functions acquired through membership), Network structure is a Multilateral City Network, Level_of_Network, Network structure is a Institution-led City Network

b. Dependent Variable: Total_Action_Plans

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.692	7	.670	2.303	.031[b]
	Residual	32.300	111	.291		
	Total	36.992	118			

a. Dependent Variable: Total_Action_Plans

b. Predictors: (Constant), Total_Memeberships, Target and plan provisions (Functions acquired through membership), Monitoring and Certification (Functions acquired through membership), Funding (Functions acquired through membership), Network structure is a Multilateral City Network, Level_of_Network, Network structure is a Institution-led City Network

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.181	.715		1.650	.102
	Level_of_Network	-.150	.154	-.133	-.974	.332
	Network structure is a Multilateral City Network	.244	.168	.181	1.456	.148
	Network structure is a Institution-led City Network	.138	.674	.039	.204	.839
	Funding (Functions acquired through membership)	.399	.172	.256	2.314	.023
	Target and plan provisions (Functions acquired through membership)	-.162	.685	-.027	-.237	.813
	Monitoring and Certification (Functions acquired through membership)	.326	.561	.105	.581	.563
	Total_Memeberships	.025	.082	.054	.299	.766

a. Dependent Variable: Total_Action_Plans

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Intra-network Interactions	.[b]	.	.	.	.000
	Inter-network interactions(Partnerships/associations with other networks)	.[b]	.	.	.	.000
	Lobbying (Functions acquired through membership)	.[b]	.	.	.	.000
	Research (Functions acquired through membership)	.[b]	.	.	.	.000
	Total_functions	.[b]	.	.	.	.000

a. Dependent Variable: Total_Action_Plans

b. Predictors in the Model: (Constant), Total_Memeberships, Target and plan provisions (Functions acquired through membership), Monitoring and Certification (Functions acquired through membership), Funding (Functions acquired through membership), Network structure is a Multilateral City Network, Level_of_Network, Network structure is a Institution-led City Network

Model 3

Model 3 Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.336[a]	.113	.105	.53447	
2	.410[b]	.168	.152	.52012	2.175

a. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016)

b. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016), Combined adaptive capacity to climate change: Combination of economic, infrastructural, technological, institutional capacity

c. Dependent Variable: Total_Action_Plans

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.006	1	4.006	14.025	.000[b]
	Residual	31.422	110	.286		
	Total	35.429	111			
2	Regression	5.941	2	2.971	10.981	.000[c]
	Residual	29.487	109	.271		
	Total	35.429	111			

a. Dependent Variable: Total_Action_Plans

b. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016)

c. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016), Combined adaptive capacity to climate change: Combination of economic, infrastructural, technological, institutional capacity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.309	.060		21.906	.000
	Gross Domestic Product of the city in Million Euron (2016)	2.863E-6	.000	.336	3.745	.000
2	(Constant)	.709	.232		3.059	.003
	Gross Domestic Product of the city in Million Euron (2016)	2.591E-6	.000	.304	3.450	.001
	Combined adaptive capacity to climate change: Combination of economic, infrastructural, technological, institutional capacity	.874	.327	.236	2.674	.009

a. Dependent Variable: Total_Action_Plans

Dependent variable: total_emission_reduction
Model 1

Model 1 Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.493[a]	.243	.178	1438952.01361	2.085

a. Predictors: (Constant), Member of Covenant of Mayors, Member of International Solar Cities Initiative, Member of C40 Cities, Member of Energy Cities, Member of Climate Alliance, Member of World Mayors Council on Climate Change, Member of EuroCities, Member of International Council for Local Environmental Initiatives

b. Dependent Variable: Total_Emission_Reduction

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	61762595145463.500	8	7720324393182.938	3.729	.001[b]
	Residual	192564209465167.400	93	2070582897474.919		
	Total	254326804610630.900	101			

a. Dependent Variable: Total_Emission_Reduction

b. Predictors: (Constant), Member of Covenant of Mayors, Member of International Solar Cities Initiative, Member of C40 Cities, Member of Energy Cities, Member of Climate Alliance, Member of World Mayors Council on Climate Change, Member of EuroCities, Member of International Council for Local Environmental Initiatives

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		

1	(Constant)	120708.914	1074067.067		.112	.911
	Member of International Solar Cities Initiative	-516215.861	1471547.405	-.032	-.351	.727
	Member of World Mayors Council on Climate Change	-554287.726	506273.995	-.104	-1.095	.276
	Member of C40 Cities	1375305.426	467503.923	.290	2.942	.004
	Member of EuroCities	785603.428	311883.227	.244	2.519	.013
	Member of Energy Cities	-52884.952	312805.981	-.016	-.169	.866
	Member of International Council for Local Environmental Initiatives	388656.808	341834.270	.116	1.137	.258
	Member of Climate Alliance	553959.721	326547.462	.158	1.696	.093
	Member of Covenant of Mayors	-11704.773	1065822.811	-.001	-.011	.991

a. Dependent Variable: Total_Emission_Reduction

Model 2

Model 2 Summary[d]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.373[a]	.139	.131	1479519.67542	
2	.423[b]	.179	.162	1452551.60894	
3	.460[c]	.212	.187	1430395.80945	2.033

a. Predictors: (Constant), Funding (Functions acquired through membership)

b. Predictors: (Constant), Funding (Functions acquired through membership), Total_Memeberships

c. Predictors: (Constant), Funding (Functions acquired through membership), Total_Memeberships, Network structure is a Multilateral City Network

d. Dependent Variable: Total_Emission_Reduction

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35428957615653.090	1	35428957615653.090	16.185	.000[b]
	Residual	218897846994977.800	100	2188978469949.778		
	Total	254326804610630.900	101			
2	Regression	45446093123926.375	2	22723046561963.188	10.770	.000[c]
	Residual	208880711486704.530	99	2109906176633.379		
	Total	254326804610630.900	101			
3	Regression	53815651785741.940	3	17938550595247.312	8.767	.000[d]
	Residual	200511152824888.970	98	2046032171682.541		
	Total	254326804610630.900	101			

a. Dependent Variable: Total_Emission_Reduction

b. Predictors: (Constant), Funding (Functions acquired through membership)

c. Predictors: (Constant), Funding (Functions acquired through membership), Total_Memeberships

d. Predictors: (Constant), Funding (Functions acquired through membership), Total_Memeberships, Network structure is a Multilateral City Network

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	586110.512	156828.772		3.737	.000
	Funding (Functions acquired through membership)	1767309.426	439292.867	.373	4.023	.000
2	(Constant)	-114647.016	356565.369		-.322	.748
	Funding (Functions acquired through membership)	1151107.859	515736.659	.243	2.232	.028
	Total_Memeberships	305722.647	140309.607	.237	2.179	.032
3	(Constant)	-12456.594	354743.313		-.035	.972
	Funding (Functions acquired through membership)	894461.686	523482.610	.189	1.709	.091
	Total_Memeberships	557493.323	185975.324	.433	2.998	.003
	Network structure is a Multilateral City Network	-930094.851	459866.941	-.250	-2.023	.046

a. Dependent Variable: Total_Emission_Reduction

Model 3

Model 3 Summary[c]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.478[a]	.228	.220	1436595.45688	
2	.595[b]	.354	.340	1321310.78211	1.818

a. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016)

b. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016), aggregated indices of climate change impacts: Combination of physical, environmental, social, economic and cultural impacts of climate change.

c. Dependent Variable: Total_Emission_Reduction

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	57423696433384.690	1	57423696433384.690	27.824	.000[b]
	Residual	193997811632785.400	94	2063806506731.760		
	Total	251421508066170.100	95			
2	Regression	89056325055793.250	2	44528162527896.625	25.505	.000[c]
	Residual	162365183010376.840	93	1745862182907.278		

Total	251421508066170.100	95			

a. Dependent Variable: Total_Emission_Reduction

b. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016)

c. Predictors: (Constant), Gross Domestic Product of the city in Million Euron (2016), aggregated indices of climate change impacts: Combination of physical, environmental, social, economic and cultural impacts of climate change.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	193521.844	192594.662		1.005	.318
	Gross Domestic Product of the city in Million Euron (2016)	17.579	3.333	.478	5.275	.000
2	(Constant)	938304.140	248984.419		3.769	.000
	Gross Domestic Product of the city in Million Euron (2016)	17.346	3.066	.472	5.658	.000
	aggregated indices of climate change impacts: Combination of physical, environmental, social, economic and cultural impacts of climate change.	-2586902.251	607739.349	-.355	-4.257	.000

a. Dependent Variable: Total_Emission_Reduction

Binary logistics regression

Adaptation action plans

Model 1

Model 1 Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	114.928[a]	.118	.177

a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	5.519	8	.701

Contingency Table for Hosmer and Lemeshow Test

	adaptation action plans = NO		adaptation action plans = YES		Total
	Observed	Expected	Observed	Expected	

Step 1	1	12	11.694	0	.306	12
	2	6	5.302	0	.698	6
	3	22	19.822	1	3.178	23
	4	7	8.371	3	1.629	10
	5	9	9.632	3	2.368	12
	6	8	8.547	3	2.453	11
	7	5	5.911	3	2.089	8
	8	9	9.717	5	4.283	14
	9	8	7.701	5	5.299	13
	10	5	4.302	5	5.698	10

Classification Table[a]

			Predicted		
			adaptation action plans		Percentage
	Observed		NO	YES	Correct
Step 1	adaptation action plans	NO	86	5	94.5
		YES	24	4	14.3
	Overall Percentage				75.6

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Int_Solar_cities	-20.384	40192.970	.000	1	1.000	.000
	W_Mayr_Cncl	-1.583	1.152	1.888	1	.169	.205
	C40_cities	1.294	.651	3.949	1	.047	3.647
	Euro_Cities	.574	.516	1.237	1	.266	1.775
	Energy_Cities	.213	.516	.169	1	.681	1.237
	ICLEI	-.272	.538	.256	1	.613	.762
	Cli_Alliance	1.011	.498	4.126	1	.042	2.749
	COM	19.734	19228.828	.000	1	.999	371685289.367
	Constant	-21.564	19228.828	.000	1	.999	.000

a. Variable(s) entered on step 1: Int_Solar_cities, W_Mayr_Cncl, C40_cities, Euro_Cities, Energy_Cities, ICLEI, Cli_Alliance, COM.

Model 2

Model 2 Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	113.678[a]	.127	.191

a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	2.377	6	.882

Contingency Table for Hosmer and Lemeshow Test

		adaptation action plans = NO		adaptation action plans = YES		
		Observed	Expected	Observed	Expected	Total
Step 1	1	7	6.939	0	.061	7
	2	22	22.061	1	.939	23
	3	12	10.859	1	2.141	13
	4	8	9.657	4	2.343	12
	5	10	9.428	3	3.572	13
	6	22	22.056	11	10.944	33
	7	7	7.000	5	5.000	12
	8	3	3.000	3	3.000	6

Classification Table[a]

	Observed		Predicted		
			adaptation action plans		Percentage Correct
			NO	YES	
Step 1	adaptation action plans	NO	88	3	96.7
		YES	25	3	10.7
	Overall Percentage				76.5

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Level_of_Network	-.522	.700	.556	1	.456	.593
	Multi_City_Netw	2.649	1.151	5.295	1	.021	14.144
	Insti_led_City_Netw	.622	49211.257	.000	1	1.000	1.862
	Online_activity	-.214	24605.676	.000	1	1.000	.807
	Funding	1.417	.735	3.719	1	.054	4.123

Moni_Cert	19.980	40192.933	.000	1	1.000	475403865.280
Total_Memeberships	-.193	.342	.320	1	.572	.824
Constant	-22.092	40192.933	.000	1	1.000	.000

a. Variable(s) entered on step 1: Level_of_Network, Multi_City_Netw, Insti_led_City_Netw, Online_activity, Funding, Moni_Cert, Total_Memeberships.

Joint m+a action plans

Model 1

Model 1 Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	121.951[a]	.158	.226

a. Estimation terminated at iteration number 20 because maximum iterations has been reached. Final solution cannot be found.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	6.750	7	.455

Contingency Table for Hosmer and Lemeshow Test

		mitigation and adaptation action plans(M+A joint measures) = NO		mitigation and adaptation action plans(M+A joint measures) = YES		
		Observed	Expected	Observed	Expected	Total
Step 1	1	19	17.260	0	1.740	19
	2	5	6.122	2	.878	7
	3	20	19.899	3	3.101	23
	4	10	9.932	2	2.068	12
	5	7	8.531	5	3.469	12
	6	5	4.870	3	3.130	8
	7	6	6.979	6	5.021	12
	8	6	6.701	7	6.299	13
	9	7	4.707	6	8.293	13

Classification Table[a]

			Predicted		
			mitigation and adaptation action plans(M+A joint measures)		Percentage Correct
	Observed		NO	YES	
Step 1	mitigation and adaptation	NO	77	8	90.6

action plans(M+A joint measures)	YES	26	8	23.5
Overall Percentage				71.4

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Int_Solar_cities	-19.008	40192.970	.000	1	1.000	.000
	W_Mayr_Cncl	.613	.714	.738	1	.390	1.846
	C40_cities	.880	.604	2.125	1	.145	2.411
	Euro_Cities	1.517	.481	9.931	1	.002	4.557
	Energy_Cities	.310	.489	.402	1	.526	1.363
	ICLEI	-.120	.507	.056	1	.813	.887
	Cli_Alliance	-.336	.534	.396	1	.529	.715
	COM	.309	1.258	.060	1	.806	1.362
	Constant	-2.168	1.293	2.813	1	.094	.114

a. Variable(s) entered on step 1: Int_Solar_cities, W_Mayr_Cncl, C40_cities, Euro_Cities, Energy_Cities, ICLEI, Cli_Alliance, COM.

Model 3

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	106.680[a]	.229	.326

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	9.583	8	.296

Contingency Table for Hosmer and Lemeshow Test

		mitigation and adaptation action plans(M+A joint measures) = NO		mitigation and adaptation action plans(M+A joint measures) = YES		
		Observed	Expected	Observed	Expected	Total
Step 1	1	11	10.505	0	.495	11
	2	11	9.959	0	1.041	11
	3	11	9.670	0	1.330	11

4	8	9.160	3	1.840	11
5	9	8.704	2	2.296	11
6	6	8.149	5	2.851	11
7	6	7.907	5	3.093	11
8	8	6.955	3	4.045	11
9	5	5.502	6	5.498	11
10	4	2.489	9	10.511	13

Classification Table[a]

	Observed		Predicted		
			mitigation and adaptation action plans(M+A joint measures)		Percentage Correct
			NO	YES	
Step 1	mitigation and adaptation action plans(M+A joint measures)	NO	72	7	91.1
		YES	22	11	33.3
	Overall Percentage				74.1

a. The cut value is .500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	GDP	.000	.000	1.350	1	.245	1.000
	GDP_per_inhabitant	-.005	.006	.689	1	.407	.995
	population_size	.000	.000	.217	1	.641	1.000
	Unemplymnt_rate	.011	.067	.028	1	.868	1.011
	Adapt_capacity	5.447	2.164	6.334	1	.012	232.034
	Agg_ind_cli_chnge_imp	-1.859	1.305	2.030	1	.154	.156
	Dist_coast	-.003	.003	1.278	1	.258	.997
	Altitude	-.002	.003	.771	1	.380	.998
	Constant	-4.065	1.859	4.782	1	.029	.017

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