Urban Heat Adaptation Measures in Austria

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Vienna, 01 June 2025

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Signature

Abstract

As climate change continues to exacerbate the temperature extremes across the world, European countries are faced with longer and more intense heat waves, specifically in urban areas. The consequences of this include an increasing burden on human health. To reduce this impact, heat adaptation measures need to be implemented at faster rates and in more marginalised areas. The largest Austrian project coordinating this is KLAR! (Climate Change Adaptation Model Regions for Austria). Six KLAR! project managers were interviewed on their current projects and what factors they perceive in drivers or barriers to their success. The projects were organised using a categorisation developed by Keith et al. (2022). The research found that all KLAR! projects had measures which addressed heat management or mitigation, and that most of these proposed projects are being implemented successfully. The four main factors responsible for the outcomes were identified as (A) Technical Feasibility, (B) Money, (C) Politics, (D) Social Acceptance and (E) Priority Conflicts. Of these, Social Acceptance and Money were identified as being the most impactful, and Politics as the most positively experienced factor by managers. Social Acceptance is the aspect KLAR! managers should focus on for the successful expansion of their projects.

Key Words: climate adaptation, heat adaptation, heat management, heat mitigation, urban heat, Austria

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AEA - Austrian Energy Agency

AK - Austrian Chamber of Labour

APCC - Austrian Panel on Climate Change

BMK - Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology

BPIE - Buildings Performance Institute Europe

CAQDAS - Computer Assisted Qualitative Data Analysis

EU - European Union

e5 Programme - An Austrian rating for pioneer towns in clean energy transitions

KLAR! - Climate Change Adaptation Model Regions for Austria

NIMBY - 'Not in my back yard' phenomenon describing reluctance in adoption of more invasive projects

NÖ - Niederösterreich, Lower Austria

UHI - Urban Heat Island

UV – Ultraviolet radiation (short wave radiation emitted by the sun)

Introduction

1.1 The World is Heating Up

As our climate changes at unprecedented rates due to humanity's unstoppable desire for energy and expansion in a way that outstrips the natural pace of our planet, the world is faced with a heat-related health crisis. In the process of easing our own lives, humans have relied on the burning of fossil fuels to release unprecedented amounts of useful energy since the dawn of industrialisation. The pollution of our atmosphere with greenhouse gases was an unfortunate byproduct. Energy which could previously leave our Earth's system is now trapped, creating an imbalance in the form of heat, which further upsets other natural systems from global albedo to increased extreme weather events.

The most regularly experienced of those is the increase of temperatures by individuals on a global level, but it does not just make us sweat more – heat often has an indelible impact on people's health. Each new year is setting records regarding top temperatures and counts of consecutive tropical nights. With current trends pointing to a ten-time increase of heat-related deaths globally in the next 75 years, and heat already being placed fifth on the list of annual mortality risk factors (Vicedo-Cabrera, 2024), it is no wonder that health experts are increasingly sounding the alarm to highlight the dangerous trajectory we are on.

How can we find a solution to mitigate the impact on people's lives on a global level, and hopefully decrease their suffering?

1.2 Austria's Temperature Problem

Austria is projected to continue having an increasing temperature rate higher than the global average (Umweltbundesamt, 2020, page 6), which will have negative impacts on the health of plants, animals and humans. In 2023, a report of climate resilience of health for Austrian regions and municipalities (Horváth et al., 2023) heavily emphasised the growing need for attention to be given to human health. They visualised clear findings to indicate that extreme heat events are going to pose an increasing burden on both the health of the individual citizens throughout the country, as well as the healthcare system in and of itself. Even in 2019, in the Austrian Special Report on Health, Demography and Climate Change (Haas et al, 2019), experts already identified heat as the climate-induced phenomena with the largest future effect on health for the country. This team's estimate laid at 400 annual deaths by 2030, and even over a thousand by 2050 (page 16) if we continue with the business-as-usual scenario. This rivals the number of deaths by car accidents each year, which reached 403 casualties in 2023 (Statista, 2024). Consequently, avoiding these deaths should ideally be a national priority for the future.

1.3 State of the Art

Although interest in this topic is steadily growing, too little research and policy clearly establish the link between individual health and increased temperatures (Watts et al., 2018). Climate change is an all-encompassing, all-threatening dilemma, and it is more lucrative for research to be focused on the sectors which will be impacted financially. Examples of this are climate migration, crop failures and extreme weather scenarios such as storms or droughts. What these three foci have in common is they do not describe events which impact the average Austrian's daily lived experience, but rather the large-scale economics of the country and popular political talking points. Normal citizens are much more likely to complain about hotter summers and slowly accumulate negative health impacts as they are exposed to temperatures which they - and their direct lived environment - are not equipped to deal with. If the healthcare sector is mentioned, it is likely in the context of the sector's own contributions to CO_2 emissions (APCC, 2023), rather than by the influx of patients with heat-related ailments.

Moreover, as is the way of the world, money, research and developments concentrate around the most financially powerful centres of a country. Vienna hosts just over 2 million of the 9.12 million people in the country, most of its international residents and is the political centrepiece. When researching whether there are adaptations to mitigate the effect of heat, all studies which come up are regarding Vienna, or one of the capital cities of a federal state (World Bank, 2020; Oswald et al., 2022) and are never concerning themselves with life in smaller towns and municipalities. Therefore, these other urban areas end up under-researched and underrepresented within the greater Austrian climate adaptation dialogue.

One explanation for this oversight is that heat concentrates itself in larger urbanised areas, presenting as the Urban Heat Island Effect (UHI), and that Vienna is disproportionately affected by it due to its surface area. Nights have been found to be up to 12 degrees Celsius warmer in certain locations in the capital city in comparison to rural areas (City of Vienna, 2022b, page 18). However, this is an oversimplification, as there are many urban centres outside of the capital, and the urban heat island effect is not dependent on the size of the area (Santamouris, 2007). As of 2024, nearly 60% of Austria's population resides in urban areas (UN DESA, 2024), making them susceptible to increased heat exposure through their environments, regardless of their proximity to the capital city. These people should not be excluded from climate adaptation developments.

Finally, many government publications on heat mitigation and adaptation act as guidelines and recommendations for actions, a collection of ideas and useful concepts (City of Vienna, 2020 and 2022b), but do not paint a holistic picture of the in-progress measures and their strengths and failures.

Therefore, an analysis of the current progress of heat adaptation measures across Austria needs to be conducted to encourage an optimisation and acceleration in this field.

Within the scope of this research, actions which are taken by a municipality to reduce the negative impact of heat onto their constituents shall be referred to as **heat adaptation measures**.

1.4 Research Aim and Questions

This thesis aims to fill the research gap with focus on urban areas outside of Vienna, to collect insights that can productively inform decision makers as they work to protect citizens from the effects of ever worsening climate change.

This research will revolve around two main questions. Firstly, **what heat mitigation and management project plans exist in Austrian towns**? Secondly, **which factors affect the successful implementation of heat mitigation and management projects, and how**?

To answer the first question, heat management and mitigation projects must be defined and categorisable. Through this, a comparison can be made across a sample of Austrian municipalities, whether these categories of projects are familiar, relevant or even currently being implemented in their urban areas. This creates an impression of the status quo in Austria, as well as highlighting any interesting discrepancies. As there is no existing academic literature on this exact topic in this region, the knowledge of experts will be sourced through semi-structured interviews based on these categories. Creating an overview is necessary before developing recommendations, as it separates relevant from irrelevant. There is no point in proposing measures which are inappropriate or completely foreign to the local context and can be dismissed as impossible to implement. Additionally, when in comparison to internationally realized measures, it will be identifiable which project types are never proposed, from this a pattern can be deduced.

To answer the second question regarding the barriers and drivers facing these projects, the experts will be asked to elaborate on why certain projects succeeded, failed, or had to come to compromises. When combined with the patterns observed from the first question, it will be identifiable which projects are very standardised across the managers' experiences, in comparison to those who may be less consistent. As the goal is for the consistent implementation of as many measures as possible, especially this second category with its reasonings are interesting to become aware of. Which levers and actors have a large impact on their success, and what lessons can be learnt through that, to encourage more success in the future? These levers will be grouped and analysed, to create a conclusion which supports future decision-makers with more knowledge on avoiding pitfalls and finding sources of support. It is necessary to facilitate the making of decisions in a most informed manner, because as changes in an urban space are ideally permanent (Austrian Conference of Spatial Planning, 2021), care needs to be taken to ensure longevity and being future proof.

Literature Review

2.1 How Does Heat Affect People?

The consequences of heat on health are more complex than simple excess mortality or increased morbidity rates during the time span of a heat wave. As Horvath et al (2023) emphasised, the impacts are due to exposure in connection with existing vulnerabilities. Vulnerabilities are defined by Horvath et al. as the meeting point of any demographic factors which can increase susceptibility to climate related health impacts (See Figure 1 below). Identifying who is most susceptible in a society is a crucial step towards prevention of illness and mortality. This is also referred to as sensitivity to heat.

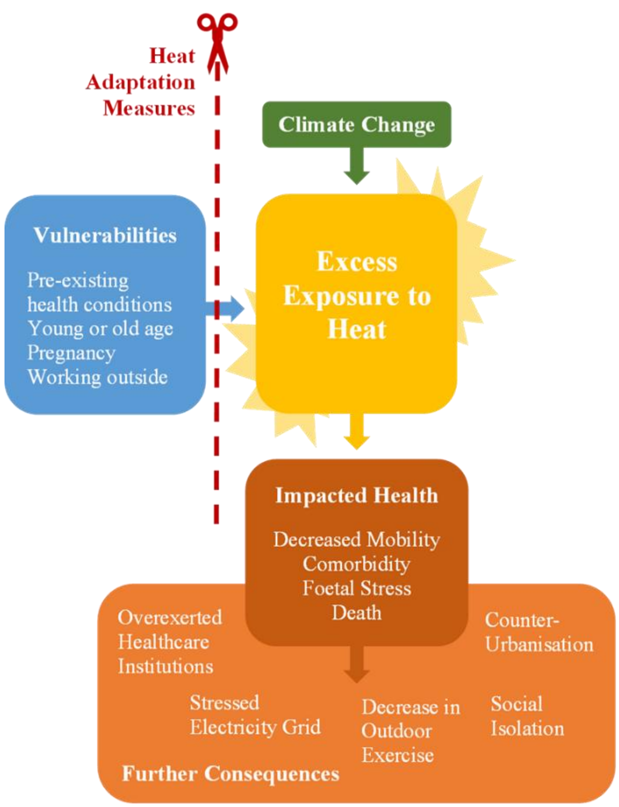

Figure 1: Climate Change, Vulnerabilities and Health Impacts, inspired by the U.S. Global Change Research Program (USGCRP, 2018).

Segments of the population most biologically vulnerable to heat include people under the age of 20, people above the age of 65 and people with chronic illnesses (including heart and blood pressure irregularities). Primarily, these people are most likely to be unable to properly regulate their body temperature to (close to) 37 degrees Celsius if exposed to higher temperatures. While unlikely that heat alone will lead to mortality or heat strokes, these populations may have pre-existing conditions which are exacerbated under stress (Vicedo-Cabrera, 2024).

Young children's ability to thermoregulate is still developing, as their surface area is in a higher ratio to their mass than in adults, and their ability to sweat enough to balance their internal temperature is still immature (Tsuzuki, 2023). Older people are found to be the most vulnerable group for similar reasons - their body's adaptive capabilities weaken with time and illness. Additionally to this, periods with higher temperatures may lead to avoidance of outdoor activities. These play a crucial role in vulnerable populations, as a source of regular exercise to maintain health, as well as being the facilitator of the maintenance of social connections (Balmain et al., 2018). Social connections in the advanced age groups are a core safety net during heat waves, as isolation of this population is high, and connections allow for early health warnings to be identified and supported, as well as allowing avoidance of exposure through support in daily outdoor tasks, like buying groceries or visiting the pharmacy (Orlando et al., 2021). Similarly, pregnant individuals experience more dangers from extended extreme heat events, both exhausting themselves and putting the foetus at risk of being stillborn, experiencing neonatal stress and having a decreased weight at birth (Kuehn and McCormick, 2017).

Pre-existing conditions are not limited to physical ailments. Mental illnesses and behavioural disorders are exacerbated during heat waves, and have been positively correlated to increased hospital admissions, and increased mortality specifically in the older demographics and in people with dementia (Hansen et al., 2008).

The second dimension of vulnerability lies in the magnitude (length of time) of the exposure to heat. The previously mentioned groups of seniors and chronically ill members of society are the most likely to be spending over 20 hours of their day inside their homes (Eurostat, 2020). In Austria, most homes have no air conditioning units, unlike hospitals or offices, leaving residents incapable of escaping the heat (Statistics Austria, 2023). The second main group exposed to heat for extended durations are workers in blue collar or agricultural jobs involving being outside, often on fields or roofs, for extended periods of time (Dong et al., 2019; Patel et al., 2022). In Austria, these workers are not yet fully legally protected from working during heat waves (AK - Austrian Chamber of Labour, 2024). All these people are excessively exposed to heat due to their limitations in adaptation through their employment, finances or physical independence.

Therefore, it is evident that increased temperatures do not only have immediate impacts, but rather damage health in the long term, by both producing new and exploiting existing vulnerabilities. When planning adaptation measures to reduce human health impacts, the measures must target the most vulnerable populations by prioritising the areas they spend most of their time in. For the elderly and less mobile, this is the cooling of their homes and immediate built environments, for children their schools and playgrounds. Other groups with more independent mobility should have the option of avoiding extreme heat. The sooner we address the problem, the more reduced the exacerbating pressure on the health system will be, to the benefit of all patients and medical professionals.

2.2 The Disproportionate Effect on Urban Spaces

The degree of urbanisation has been found to be a factor correlating with the magnitude of health impacts due to heat (Vicedo-Cabrera, 2024). This is due to heat stress being concentrated in those areas, with factors such as increased population density, lack of green spaces, UV index from buildings and ground sealing contributing to the urban heat island (UHI) effect (Oswald et al., 2022; Trimmel et al., 2020). The definition of this effect has developed over time to become more consistent (Stewart, 2011), and it is important to only consider the impact due to urban factors when using the term. This thesis aims to be more encompassing of all urban areas, regardless of the proven existence of this effect. Firstly, not every municipality has the interest or funds to define the UHIs within their perimeter, and this would limit the scope of the research areas greatly. Secondly, current increased temperatures already pose health risks without the specific added magnitude by the UHI effect. Lastly, heat in relation to health must consider all environments which people inhabit in their daily routines, including their homes, workplaces, public transportation and educational facilities, while UHI mainly concerns itself with public spaces. Therefore, the used term of urban heat is considered in the broader context as the increased stress experienced by populations residing in urban areas.

Urbanisation is a phenomenon driven by the concentration of productivity in certain locations as agriculture becomes more automated and secondary and tertiary sectors continue to grow. This concentration of people allows for many efficiencies in travel and access to services but also drastically changes the land use with the building of roads and houses, sealing ground and introducing many sources of anthropogenic heat with the cars and technology we use for our convenience. In Austria, by 2023, 59.5% of the population is residing in urban areas. While counter-urbanisation is an expanding phenomenon as working from home has accelerated, this is not a trend with enough momentum to cast doubt on the continued existence of urban areas as we know them in this country (Statistics Austria, 2024).

As touched upon, the characteristics of urbanisation, such as building density and lack of green spaces, create excess heat, or a higher surface energy balance (Oswald et al., 2022). The quickest way to decrease temperatures is through impeding the incoming UV radiation from the sun (Heris et al., 2020). If it cannot reach the ground, it cannot be absorbed and re-emitted as infrared waves, which we experience as heat.

As seen below (Diagram 2), urban characteristics influence the energy balance of the environment, creating more extreme microclimates. Asphalt and dark roofs absorb incoming UV radiation and emit heat. This warms the air which has difficulties escaping as the wind gets intercepted by buildings, creating hot, stagnant air pockets. Lack of greenery stops the natural interception of radiation (rays) at a stage before where humans are affected (Oswald et al., 2020 and 2021; World Bank, 2020).

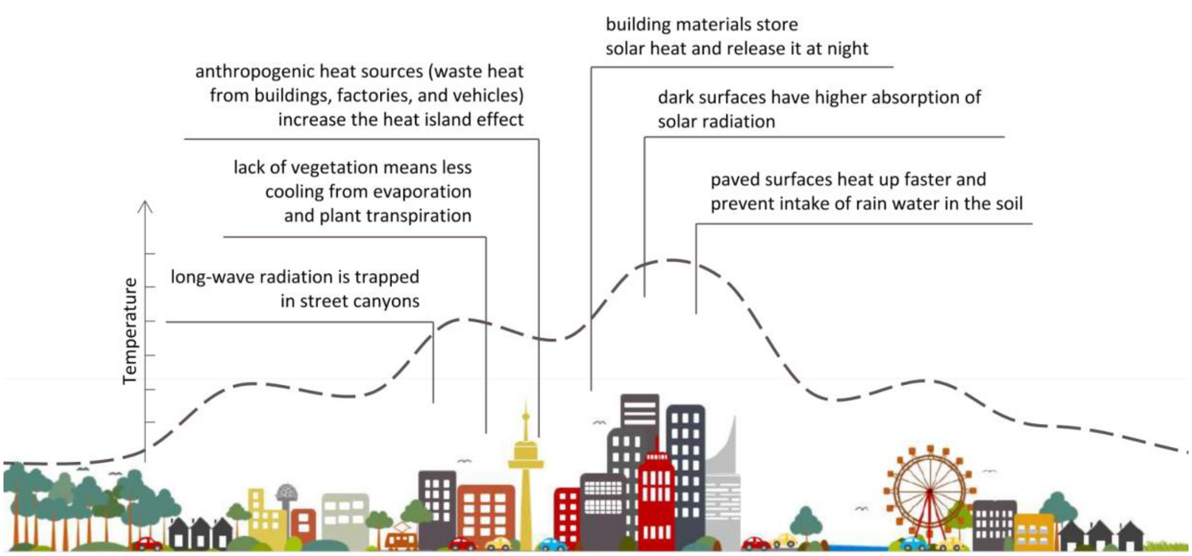

Figure 2: Urban Heat Island Effect (World Bank, 2020).

Secondly, heat cannot disperse in urban areas the same way it does on greenery or unpaved ground. Through the process of evaporation, water stored in soil and on the surface of plants absorbs heat, consequently cooling down the immediate area (Oswald et al., 2020; Trimmel et al., 2020). Sealed surfaces cannot store water and therefore do not have these same thermoregulatory qualities.

Lastly, sources of anthropogenic heat occur more intensely in densely urbanised areas. Industrial buildings, the heating and cooling processes of homes and workplaces and the concentration of cars and other motorised modes of transport all exacerbate the increased temperature (World Bank, 2020).

Urban spaces create a positive feedback loop for worsening environmental conditions for a growing number of people. Due to the density of living in urban areas, many more people are exposed to these increased temperatures on a regular basis in comparison to their more dispersed rural counterparts. Consequently, more vulnerable people will be impacted, creating an overall larger stress on the population's health than it otherwise would.

2.2.1 Urban Adaptation Possibilities

Adaptation to increased temperatures in urban spaces can be separated into two categories: **heat mitigation** and **heat management**. Heat mitigation tries to reduce the temperature of an area through methods such as land use planning, urban design, increased vegetation and waste heat reduction. This is the long term and forward-thinking approach. Heat management acts as a plaster over a wound - it acknowledges that there is already an issue with the current temperatures and works to reduce that impact on people through reliable cooling, public health interventions, emergency management and policies to reduce individuals' exposure to heat (Keith et al. 2020; 2022). Both categories are considered in this paper.

In essence, heat mitigation is the reduction of the amount of UV radiation being converted into long wave heat (radiation, which warms the air) that then collects in the spaces people exist in. To decrease this conversion, plants and water holding surfaces can use the incoming energy to create evaporation which absorbs the energy. Trees, green roofs and unsealed ground allow for this. More architectural options include shade structures and avoiding large south facing windows. To encourage heat dissipation, wind must be utilised. Urban planning plays a role here, by including wind corridors throughout a city to keep the air moving (World Bank, 2020).

The final type of mitigation measure is the reduction of other sources of heat. Better insulated buildings reduce the need for heaters and air conditioners (ACs). These measures can eliminate the need for heat-emitting motors and encourage more electricity-based modes of transport as alternatives to petrol- and diesel-powered vehicles.

The second side of the coin, management, largely relies on the knowledge of the population and their preparedness to react to extreme heat scenarios. This may be in daily life by avoiding sun-exposure during the midday heat for school children, in relation to reducing existing comorbidities as are common in the elderly population or in emergency scenarios though heat wave warning systems. Outdoor labourers should be protected against health risks by their unions and public transport systems need to be adapted to increasing temperatures as well.

2.2.2 The Effects of Heat on Austria

Austria is a country experiencing a large impact on its environment as climate change progresses, due to its location in the northern hemisphere as a landlocked country with diverse ecosystems (Umweltbundesamt, 2020). This is most conspicuously demonstrated by the melting of the permafrost and glaciers (WWF Austria, 2024) and the drying out of large lakes.

Although Austria prides itself on its sustainable and progressive image, the direct effects of climate change are perceived as uncertain and thereby has reduced the enthusiasm for more proactive long-term measures (Federal Ministry of Agriculture, Forestry, Environment and Water Management, 2012).

Austria's healthcare system is being progressively overloaded with an ageing population and the omnipresent divide between public and private healthcare, leaving many patients facing either long waiting times or high out-of-pocket costs (Braunisch, 2024). Renner (2020) analysed avoidable hospitalisation across Austria from a spatial perspective, considering more than just heat-related maladies. She found that the strongest indicator of increased avoidable hospitalisations (in-patient care) was a lack of accessible preventative (out-patient) care, a stronger indicator than education or economic status of the region. Avoidable hospitalisations describe cases where an illness has progressed to an extent where immediate care is necessary and the individual is in more danger, but earlier care could have safely managed the issue in most cases. Consequently, avoiding hospitalisations from heat-related conditions through reducing people's exposure in their urban environments is both necessary and beneficial to the overall medical sector.

2.3 Approaches to Addressing Urban Heat

To address the consequences of increasing temperatures, the causes, methods and impacts of addressing these need to be outlined in a clear enough way for all stakeholders to understand. When pushing for change, clear communication is essential to gain cooperation from policymakers, technical experts and the impacted communities. Urgent actions cannot be expected if the problem is not perceived as pressing and the solutions as within our control and capabilities.

2.3.1 Identifying the Urban Environment as a Space for Climate Adaptation

Adaptation to climate change impacts, in a way which maintains and improves upon the status quo, if possible, falls under the umbrella term of urban climate resilience. As mentioned in the introduction, heat impacts are under-researched, even in this field, with much research being focused on flooding events instead (Tong, 2021). Furthermore, heat-related issues are often presented in conjunction with a wider plan, such as a smart city concept or climate adaptation plan. Whether this is a benefit or a hurdle raises contrary opinions. By not explicitly mentioning heat as a focus, and dedicating undivided attention to it, the problem can stay vague and seem less possible to be managed. By overcomplicating proposals, individuals can be discouraged to take action on the local scale (Lim et al., 2022).

Contrarily to this, from the policy-maker perspective, embedding heat into solutions which simultaneously touch on other forms of sustainability is killing two birds with one stone. For example, new bus services can reduce the emissions of single-person vehicles, reduce social inequality by providing affordable transport options and save space in the inner city all at once, while also addressing heat by building bus shelters with green roofs. In opposition to Tong's (2021) more pessimistic conclusions, earlier research by Meerow et al. (2016) rather emphasised the need to view resilience holistically, instead of just finding quick fixes. Their justification is that resilience should be seen as an opportunity for positive progress, rather than maintenance of the status quo. Urban areas are developing and expanding, so the urbanisation process must be simultaneously addressing as many dangers as possible.

In a similar vein, it must be recognised that changes in an urban environment always have a wider impact than simply temperature. The APCC (2023) report synthesised research on which qualities a successful climate-considerate urban project should fulfil. They recommend that current urban planning process needs to be focused on climate adaptation as a goal consistently, stakeholders from various levels should be involved throughout the whole process, coordination of adaptation measures needs to be forced and prioritised, other sectors (transport, water, tourism, energy) and financing bodies (economic and for building) need to respect their impacts on the urban climate and this should always work in tandem with the clean energy transition.

These Austrian recommendations overlap with the BPIE (2023) paper in their advocacy for a just transition through ways of participation in decision-making processes, and that maladaptations should be de-financed and brought to light. However, the Austrian paper does not highlight vulnerabilities and disenfranchised communities. These more elaborate requirements of changes respect the impact which the lived urban environment has on the lives of its current and future inhabitants, aligning with the call to be careful emphasised in the latest report by the Austrian Conference on Spatial Planning (2021).

As increased temperatures, specifically the increased number of days with unusually high temperatures, continue to be faced by Austria, the individual exposure to heat must be reduced. If the exposure is reduced, then vulnerable populations are less likely to experience negative health effects, and the total number of people requiring acute healthcare will be reduced. This not only benefits that individual, but also reduces the stress on healthcare facilities, allowing for more thorough treatment of other patients in need.

2.4 Who is Responsible for Taking Action?

As with any transition, it is necessary to identify who will lead and also ensure that progress is being made. The last Austrian Panel on Climate Change (APCC) Report (2023, page 8) clearly states that the current national urban planning instruments are not capable of doing enough to encourage positive changes and halt negative trends regarding climate adaptation in this country.

Why not rely on Europe to guide this transition? As of 2024, the EU has yet to create a pan-European policy in regard to climate adaptation of the built environment. They touch on this topic in many climate-related and smart city papers but have not consolidated this knowledge into a form which can be used to keep countries accountable and guide them in a just transition. The EU acknowledges that Europe's current built environment is exacerbating climate risks for its inhabitants, and has started many initiatives, but these are non-binding and generally focus on selected pioneer regions, creating unequal progress on this front (BPIE (Buildings Performance Institute Europe), 2024).

Why not rely on the federal government? The main guidance document for spatial planning on a federal level is the ÖREK, the Austrian Spatial Development Concept. This lays the common ground for all the federal states on what their principles and objectives should be for the next 10-year period, most recently from 2021 to 2030 (Austrian Conference on Spatial Planning, 2021). It is not a law or policy document which can penalise changes that do not conform to its expectations. The second main law is each state's building regulations, or Bauordnungen. There are nine across Austria, which largely overlap but are still separate documents (BKA - Federal Chancellery of the Republic of Austria, 2024). Although it now includes regulations on solar panels and insulation, it does not represent a holistic approach to urban heat management, especially in regard to any aspect of urban planning outside of individual buildings.

Austria mirrors most European countries in its reliance on the political bodies of municipalities and regions to evaluate the impact of heat, and implement measures to combat this (Leitner et al., 2023, page 40). To facilitate this progress, supporting both financially and through knowledge sharing structures, the 'Climate Change Adaptation Model Regions for Austria - KLAR!' were brought to life on a national level. This project combines the need for a centralized oversight of the heat adaptation measures, with the understanding that Austrian urban planning occurs as the most local of levels.

KLAR! is the 'Climate Change Adaptation Model for the Regions of Austria' project. Initiated by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) in 2016, individual municipalities in Austria, regardless of size, location or magnitude of heat stress, can elect a manager and create a proposal of 10 adaptation measures in a span of 12 months which they aim to implement in the next 2 years (KLAR!, 2025). Their main requirement is a minimum population of 3000 within the chosen area. KLAR! funds the managers and 75% (Interviews 1 and 2) of the projects, organises multiple annual conferences to allow knowledge sharing across the managers and follows up on the progress and completion of each project.

The strength of having a centralised point of contact for all managers and municipalities is manifold. A study recently conducted in the United States of America (Stults and Woodruff, 2017), where there is no similar unified body, found that individual cities' climate adaptation plans, although present, were very varied and leant towards being excessively vague, making the implementation of actual measures inconsistent and the meeting of any targets difficult to assess. A reasoning for this is the realisation that no clear entity is ever responsible for heat, so there is plausible deniability in taking no actions (Keith et al., 2020, page 21). One unified body with a clear purpose of addressing heat, such as KLAR!, ensures plans are actionable and followed through on.

Initiatives such as KLAR! also allow for a non-top-down approach to progress. While laws and regulations are powerful tools, there is no one-size-fits-all answer to reducing heat, nor can any individual be held accountable for the severity of local urban microclimates. The meeting of bottom-up and top-down approaches is recommended for its ability to both see the greater picture and finance it, as well as ensuring that projects suit the region and will be accepted by the residing population (Kyprioanou et al., 2023, pg 10).

Completely restructuring the current processes of funding and management to create a singular institution is a large task. Interestingly, the APCC (2023) findings do want to touch on restructuring of both governance and consumerist culture, but do not make either of these points very strongly.

They highlight that climate adaptation issues should be pressed to the forefront and approached with more bravery, but do not argue for new structures of processes or institutions. By working within the current framework, processes can be initiated more immediately.

A note must be made that this panel's brief is mainly intended to guide policymakers or politicians, who would be sceptical of any large-scale restructuring, both due to the large percentage of conservatives in power, where environmental issues are not their priority (Nehammer, 2024), as well as the logistical and financial ordeal it would represent.

Methodology

3.1 Methodology Overview

The chosen method uses semi-structured interviews, as there are specific criteria that were necessary to address consistently across all interviewees, but as the reasoning behind choices and limitations (Research Question 2) is a more varied question, and each region has implemented different measures, follow-up questions allowed for the flexibility to react to unanticipated morsels of information. This second part relies on the principles outlined by Grounded Theory (Charmaz, 2006). In the following section, justifications for choosing these methods are outlined, as well as precautions taken to avoid potential biases or ethical issues.

Interviews are the decided-upon method for two (2) main reasons. Firstly, when considering the qualitative data needed to answer both research questions, public reports on the KLAR! and local municipality websites fell short of the detail and perspective necessary. Direct contact to the KLAR! managers was the natural progression. Secondly, due to the volume of questions asked as well as the focus on personal experiences rather than undescriptive numbers, speaking with the chosen experts rather than written communication through an emailed questionnaire was the preferred option to ensure completion and comprehension by both the interviewer and interviewee. The human element should not be underestimated. By allowing the participants to directly (even if via e-conference call) interact with the researcher, they were more likely to open up, as they became aware of the want for their opinions and perspectives on the situation (Knott et al., 2022).

To guide questions on possible adaptation measures, a list of current and possible urban heat adaptations needed to be sourced independent of the KLAR! website. A checklist by Keith et al. (2022) was found through an online literature search using the keywords ‘heat’, ‘urban’, ‘plan’ and ‘evaluation’, with the added criteria of a well elaborated methodology, clear criteria and evidence of previous successful applications. A further paper reporting its applications in Tucson, Arizona the following year was also identified (Keith et al., 2023). Although this research stemmed from Arizona, it does not heavily rely on specific local context such as urban planning or political structure which would limit its applicability to Austrian adaptations. On the contrary, Keith’s (2022) proposed list of measures overlaps largely with Austrian recommendations by the health sector in reduction of climate-induced effects. For example, the 2019 Special Report on Health (Haas et al., 2019) mentions reduction of the UHI effect, increased greenery, air circulation (which all fall under mitigation methods in the chosen methodology) while also touching on the necessity of heat warning systems (a management method under Emergency Preparedness).

Keith et al. (2023) created two (2) groups of adaptation measures, heat mitigation and heat management, each with four (4) categories, which then had one (1) to five (5) more specific subcategories. These are organized as shown in the table below (Table 1).

Table 1: Categories of heat mitigation and management methods, based on Keith et al. (2023)

Category	**Subcategories**
Heat Mitigation	
Waste Heat	Building Waste Heat Reduction Programs
	Vehicle Waste Heat
	Cool Roofs and Walls
Urban Greening	Vegetated Parks and Open Spaces
	Green Roofs and Walls
	Urban Forestry

	Water Features
Urban Design	Built Shade Structures
	Cool Pavements
	Building Shape and Massing
	Building and Street Orientation
Land Use	Ventilation Corridors
	Land Conservation
	Urban Development Patterns, Roadways and Parking Lists
Heat Management	
Energy	Indoor Cooling
	Grid Resilience
	Accessible and Affordable Energy
Personal Heat Exposure	Transit System Operations
	Parks and Trails Operations
	School Operations
	Occupational Safety Operations
Public Health	Education and Awareness
Emergency Preparedness	Early Warning Systems
	Heat Response Plan
	Cooling Centres and Resilience

These categories build the base for answering the first research question on what heat mitigation and management projects have been and are currently being undertaken in Austria. The interview structure ensured the experts were asked about each possible urban heat adaptation measure.

Keith et al. (2023) is an American research paper. Although the websites of many Austrian and Viennese authorities and ministries report on climate friendly urban development and provide information on plans, none of them yielded a compendium of measures which were as clear as this one. Additionally, documents such as (City of Vienna, 2022b) contain lists of completed or approved projects, which do not give any insight into failed or unexplored options. Using only such documents as a guide would only result in a confirmation bias, implying that Austria is taking all possible actions to adapt to heat in urban areas.

3.1 Rigour of Research

To ensure the quality of the research, the two factors of main concern are **validity** and **reliability**. As emphasised by (Grossoehme, 2014, page 111-112), the validity ensures how trustworthy the findings can be. No research will ever fully replicate the truth, but the closer we can get through rigorous research methods, the more relevant and impactful our findings may be. One way in which **validity** was encouraged is through having researched the topic ahead of time, allowing the interviewees to speak more freely. This is also a process which improved throughout the interviews, as repeating concepts were now familiar to the interviewer.

One example of these repeated topics was the understanding of how the KLAR! funding proposals are submitted and approved of. This process is not obvious to an outsider and is an important context to the limitations some plans are facing. As this process is the same across all interviewees, this question then did not need to be repeated once insight had been gained and allowed for more time spent on the objective-relevant questions, and for these questions to become more specific over time. The flexibility of semi-structured interviews permitted this.

On the other hand, such changing interview structures may cause inconsistencies. To avoid the analysis being impacted by when the interview was held, two precautions were taken. Firstly, the coding groupings were broad enough and based on the 8 predetermined categories of measures (Table 1). Regardless of interview, the given information always reflected this. If new categories emerged over time due to the inductive nature of the reasoning-based questions, these were then added to, when the first interviews were looked over a second time. The used CAQDAS (Computer Assisted Qualitative Data Analysis Software) software package Nvivo (Version 14) allows this flexibility.

Additionally, Grossoehme (2014) also mentions that this inductive approach consolidates validity as well, since, as in Grounded Theory, the participants guide the direction of the information, thereby reducing possible biases the outsider researcher may have. My definition of public and social acceptance changed as the interviews progressed, for example. This factor was initially considered within the context of public participation; if projects are presented ahead of time or voted on. It soon came to light that the way in which this was expressed was rather after the implementation, where faults or oversights in the projects readily led to lawsuits from the affected members of the public. This development gave more depth to the understanding of this code.

The second aspect is **reliability**, which is closely linked to replicability. Throughout the process of the research, decisions were constantly kept track of, as well as questioned by myself and my academic supervisor. Critically, full replicability is not the goal in qualitative or mixed methods research; this measurement of validity was initially developed for quantitative methods (Maher et al., 2018). To further enhance reliability, having more research partners or co-writers, as is usually common in academia, would have been a strength, allowing for more interactive reflection.

Another way in which having research partners would have been advantageous is within the analysis of the interviews themselves. One of the strengths of the inductive approach is a researcher which picks out nuances and then builds questions for further investigation, and having more people inherently multiplies the capability to do so (Grossoehme, 2014, page 114). To replicate this effect within the existing capabilities, I applied an iterative process during the encoding and analysing of interviews. Through Nvivo, any newly developed codes were immediately available to older interviews, and I went back into those and encoded further if relevant quotes could be identified.

When focusing specifically on the inductive section of the interviews, aspects of the Grounded Theory approach were adopted. Qualitative research relies on samples, raising the issue of knowing when the amount of people interviewed is acceptably representative of the overall relevant population. One solution to this through Grounded Theory is the concept of 'saturation' (Morse, 1995), where enough interviews have been completed that the interviewer has become familiar with each of the topics raised, to the extent that they may become bored. This was applied in this research through self-reflection; evaluating to what extent novel information was given as I progressed towards the end of the thus-planned interviews. It could not be applied to its full and intended extent, as research was limited due to time and simply a limited number of possible research partners, but it was evident that by Interview 5 the main justifications had already been mentioned previously. This supported the judgement that the findings on this topic had been thoroughly researched, to the point of saturation. This resulted in the confidence to claim the research as reliable. Using this approach has allowed for the natural lack of knowledge I had going into this to be compensated through establishing a structured learning process.

Further criteria that scientific research should follow are credibility, transferability, dependability and confirmability, as proposed by Guba and Lincoln (1989).

Credibility refers to research measuring that which is intended. This is ensured by choosing only those interview partners who have a clear understanding of this topic. Providing them with additional precise information on the direction (intent) of the questions beforehand and using an interview structure solely focused on the topic relevant to the two research questions. The precise definition of measures as provided by Keith & Meerow (2023), allow for accurate and consistent encoding of the collected data.

The **transferability** of this research is limited as the purpose of is to give an insight into this specific area and not develop any universal theories, axial coding and not the theoretical in the appropriate method. There it's applicability of results is focussed on other KLAR! projects, presenting them with results gathered from their peers.

Dependability is defined as a clear enough methodology for other researchers to be confident in their ability to replicate the work. As an individual researcher, the best practice is a constant notation of each decision in note format, to ensure details remain unforgotten and the logic behind them is examined. Further dependability is limited to proof reading by superiors and voluntary peers.

The last of these additional criteria is **confirmability**, working to reduce own bias within the research process. Although I am limited in my work as a sole researcher, I consulted an Austrian expert in the health field at the beginning of my process to guide my research questions and aim. Through an informal conversation with them, insight was gained on the value of examining this research gap, as the impact of heat on health was much more significant and complex than was initially assumed.

3.3 Analysis and Coding

After completion of each interview the information was encoded in an iterative process. To answer the first research question, Keith et al.'s (2022) criteria were strictly adhered to, with every mention of a KLAR! project which impacts climate adaptation in the municipalities being counted, based on the definitions provided by this paper (See Appendix C). To answer the second question, concerning drivers and barriers in the completion of heat adaptation projects, an inductive approach was utilized with repeated keywords being into themes progressively. After the complete encoding, these groups of quotes were re-read, and key repeated themes were identified alongside any specific anomalies or contrasting perspectives.

These emerging topics were either given sub-codes, such as C1_Geography, or collected separately to build collections of further contextual knowledge. One example of this is code D6 "Other Groups", under which 'evidence of the influence of stakeholders/actors such as the federal state, a clean energy initiative (Austrian Energy Agency, 2024) or universities were mentioned. The involvement of these varies between each KLAR! municipality and can therefore not be used to create any generalisations but needs to be noted as a reason why some projects succeeded in some areas, while other KLAR! managers had some aspects of heat management taken off their hands in terms of responsibility. Overall, the coding used to answer the second research question regarding the drivers and barriers implements a focused coding approach (Grossoehme, 2014, page 114) to develop the main categories of factors by combining them by type and then axial codes (page116) are subcategories / sub-codes which build more detail and explain each barrier and driver further.

3.4 Participant Ethics

To both ensure the comfort of the participants as well as creating a space in which the interviewees can talk as freely as possible, the ethics of the research design were considered.

3.4.1 Topic Sensitivity

The topic of the KLAR-plans and their relative strengths and weaknesses are related to the interviewees' jobs, as well as being something they personally pride themselves in as managers. It is significantly less sensitive than research into psychology or personal demographics, so the main concern was ensuring their comfort to be able to respond to questions in ways which might be critical of the KLAR! plans, rather than concerning myself with extremely confidential data.

To encourage these more critical responses, the communication with all potential interviewees was commenced with an explanation of the purpose of the research, informing them that the aim was not to criticise KLAR!, but rather to identify weaknesses and their sources in hopes of this information being useful to improving the existing system, and encouraging better heat adaptation capabilities.

Furthermore, by interviewing the managers of each regional project, they do not need to ask for permission from a superior and know which information they can share with a researcher. This eases the flow of the communication as no third party must be involved.

Lastly, comfort is also encouraged through the method of one-on-one interviews. Although this was largely due to making scheduling easier, it allows the interviewees to talk uninterrupted, for the interviewer to ask more focused follow-up questions, and to have a sense of competition in the conversation. In comparison, focus groups could put pressure on the participants to provide responses which present them in a better light than what the reality of the situation is (Grossoehme, 2014, page 120).

3.4.2 Confidentiality

All participants were provided with a consent form before the commencing of their respective interviews (see Appendix A for a German and Appendix B for an English version).

Due to the limited size of the population, which was studied, as well as the public and online presence of KLAR!, the confidentiality offered is limited to ensuring direct quotes are never accredited to any specific people, and that no names are mentioned throughout this thesis.

Transcribing and coding are done on a local computer by only the researcher, and none of the files are shared with any further parties. After the completion of the thesis, all files including the initial recordings are permanently deleted.

Participants can remove their consent while the writing of the thesis is still in progress but cannot influence the work after it has been submitted and made public.

3.5 Justifications for Sampling

The research conducted to answer the research questions involves managers of the Austrian KLAR! projects from municipalities across most of Austrias states. The choice to focus on KLAR! managers results from researching the progress of Austria's heat adaptation and concluding that this project is on the forefront of the transition of the urban areas which are outside the states' capitals. The nexus point for the knowledge on the progress are the local managers of each of the participating municipalities or group of municipalities. Additionally, as KLAR! is a national initiative, all samples and participants are located within the borders of Austria.

On a personal level, by choosing this scope, all documents, websites and interviews were in German or English, allowing understanding without reliance on a translation service. This reduces time, possible service costs and allows for direct communication as well as flexibility during interviews and e-mail communications.

The final criteria is the exclusion of municipalities with less than 100.000 (one hundred thousand) residents. The justification for this is that larger municipalities have a broader range of experience with projects and more financial means. Furthermore, they will have a plurality of perspectives and needs within their population.

Twenty-two (22) currently active KLAR! projects fulfilled the criteria. Of these, I reached out to sixteen (16), resulting in six (6) interviews, one of which resulted in an additional interview with a second expert from that town.

Results

The six interviews were held over the span of 2 months via Zoom, a free online conferencing tool. They naturally ended up being between 40 and 55 minutes long; the longest one featured an additional second expert on sustainability from the region, which was useful for inputs and also extended the overall discussion. After the encoding process, the mentioned projects were organised by category and subcategory, following Keith et al.'s (2023) typology. These are collected in the table below (Table 2) and represent the first stage of answering Research Question 1.

Table 2: Categories of heat mitigation and management methods, based on Keith at al. (2023), applicable to research question 1, with codes and amount of projects where they are implemented.

Category	**Subcategory**	**Code**	**Number of Projects (out of 6)**
Heat Mitigation			
Waste Heat	Building Waste Heat Reduction Programs	A1_A	4
	Vehicle Waste Heat	A1_B	1
	Cool Roofs and Walls	A1_C	1
Urban Greening	Vegetated Parks and Open Spaces	A2_A	3
	Green Roofs and Walls	A2_B	3
	Urban Forestry	A2_C	6
	Water Features	A2_D	0
	Green Stormwater Infrastructure	A2_E	1
Urban Design	Built Shade Structures	A3_A	4
	Cool Pavements	A3_B	0
	Building Shape and Massing	A3_C	1
	Building and Street Orientation	A3_D	0

Land Use	Ventilation Corridors	A4_A	1
	Land Conservation	A4_B	1
	Urban Development Patterns	A4_C	1
	Roadways and Parking Lists	A4_D	4
Heat Management			
Energy	Indoor Cooling	B1_A	1
	Grid Resilience	B1_B	2
	Accessible and Affordable Energy	B1_C	0
Personal Heat Exposure	Transit System Operations	B2_A	0
	Parks and Trails Operations	B2_B	0
	School Operations	B2_C	0
	Occupational Safety Operations	B2_D	0
Public Health	Education and Awareness	B3_A	5
Emergency Preparedness	Early Warning Systems	B4_A	0
	Heat Response Plan	B4_B	1
	Cooling Centres and Resilience	B4_C	0

Each KLAR! municipality can only be marked down once for each project subcategory. For example, if one manager facilitates the planting of trees in 3 different areas of the city, this will still only get marked down once in the category of ‘Urban Forestry’ (A2_C). There are two reasons for this. Firstly, KLAR! itself perceives and counts this as one of the municipality’s 10 approved projects, as each of these are required to be different to be greenlit. Secondly, this allows for a total count of six (6), a number clearly describing the feasibility of this project type across municipalities, highlighting whether they are towns which have failed to complete any project of a certain category, and then allowing for an analysis to be made for the reasons why (Research Question 2).

Research Question 2 requires data on the factors which help or hinder the completion of projects. As seen below (Table 3), five factors were established throughout the research process as the drivers or barriers which KLAR! projects are dependent on for success.

Table 3: Categories of justifications for the successes and failures of projects with their codes and subcategories.

Category	**Subcategory**	**Code**	**Number of Mentions**
Technical Feasibility	Positive	C1	4
	Negative		4
* Geography	Positive	C1_Geo	1
	Negative		2
Money	Positive	C2	9
	Negative		26
Politics	Positive	C3	18
	Negative		10
Social Acceptance	Positive	C4	12
	Negative		24
Priority Conflicts	Positive	C5	10
	Negative		21

These codes evolved throughout the encoding process. The section 'Technical Feasibility' (C1) was initially named 'Geography', as the first found justifications for successes or failures in a project were justified by the physical environment. For example, more densely populated towns were more accepting of lectures on heat presented by managers in comparison to ones with more rural characteristics (Interview 1). As interviewees began mentioning the complications faced when creating physical changes, this categorisation had to expand to issues like difficulties in connecting to water sources, limitations in planting the desired number of trees and lack of access to appropriate technology to gain the needed results.

To count the number of justifications, the number of mentions is used, rather than the number of interviews. This is to allow for overall impressions of the magnitude of influence a factor has across all types of projects. No two KLAR! regions submit the same list of projects, so a direct comparison between them is not necessary when looking at drivers and barriers.

One standout topic, which was not explicitly contained in Keith et al.'s (2022) criteria is the unsealing of land. This is mentioned by each interviewee, highlighting its relevance to the current Austrian understanding of climate adaptive urban development. Instead, mentions of these projects had to be grouped under either Land Use or Urban Greening, depending on the measure's involvement of plants.

The purpose of a simple quantitative summary of the mentioned reasonings is to give an impression of what topics the interviewees themselves found important to highlight. Throughout the interviews, explanations for successes and failures were asked for in open ended questions, allowing for any possible direction in the answer. More pointed follow-up questions were only asked if the interviewee strayed from the intended purpose of the question.

4.1 Research Question 1: Patterns

The first research question asks to identify which heat mitigation and management projects or project plans currently exist in Austrian municipalities. This statistic draws solely on the information given by the interviewed managers in the 6 cases. The diagram below (Figure 3) is a composite bar chart illustrating how many projects of each main category were completed across the interviewed municipalities.

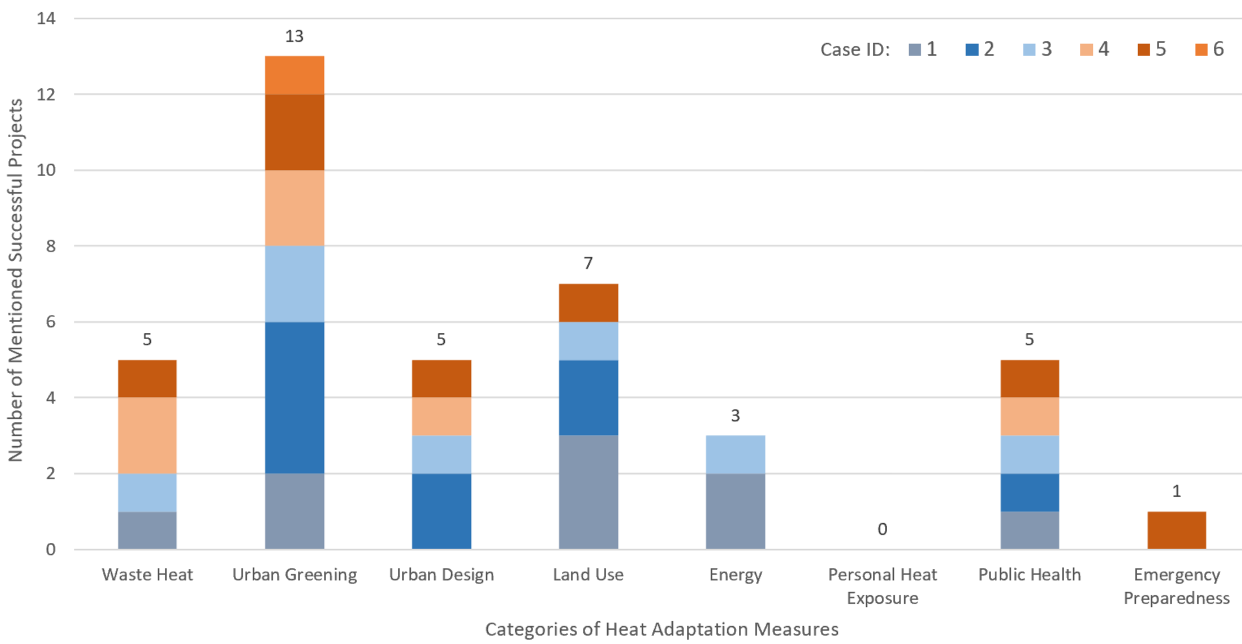

Figure 3: Number of Heat Adaptation Projects completed by the 6 interviewed KLAR! Cases, divided into 8 Categories defined by Keith et al. (2022)

The category with the most identified measures is ‘Urban Greening’ (A2) with 13 Projects, with a minimum of 1 project in each area, but an average of 2. This value is nearly double that of the next most common category of ‘Land Use’ with its 7 projects. ‘Urban Greening’ is also the only category to be present in all 6 interviews.

‘Waste Heat’ (A1), ‘Urban Design’ (A3) and ‘Land Use’ (A4) each contain projects from 4 cases, with interviews (cases) 3 and 5 having projects in every one of the A-section of the heat adaptation measures. A1 to A4 are all 30 heat mitigation measures. In comparison, there is only a sum of 9 projects across all heat management (B1-4) measures. Of this section the most successful is ‘Public Health’ (B3), where 5 of 6 cases had projects.

Summarily, heat mitigation projects are more popular than heat management projects within KLAR! municipalities. Urban greening is happening in all cases, with urban forestry being the main choice. The least populated section, with no projects is the ‘Personal Heat Exposure’ a category which includes the operations of transit systems (B2-A), Parks and Trails (B2-B), Schools (B2-C) and Occupational Safety (B2-D).

A noticeable trait for all the data was that the different municipalities displayed a large range of the relevant number of completed heat adaptation projects. The **average** number of relevant projects was 6.33. The **lowest** value with just 1 project was case number 6, a clear outlier. The most successful cases were 1 and 2 with the **highest** number of projects with 9 projects each.

Each KLAR! Region proposes 10 projects for each 3-year cycle. Although they are the Climate Change Adaptation Model Regions for Austria, their understanding of adaptation is broader than Keith et al.’s (2022) heat- and urban-specific categorisations. To take case 6 as an example, where ‘Urban Greening’ is the single categorized heat adaptation measure, other projects in that municipality focus on flood prevention and plant biodiversity (KLAR!, 2024). They adapt to consequences of climate change outside of raised temperatures.

4.1.1 Reflections on the Scope of KLAR!

The results highlight many gaps in the potential progress for heat adaptation projects in urban areas in Austria. Before analysing why some projects were more or less successful within the interviewed municipalities, the overall scope of KLAR!'s abilities must be defined further. Thereby, the discussion concentrates on factors which can be influenced, creating a more results-focused outcome.

It is presumptuous to believe that KLAR! managers' actions are the sole barrier to the implementation of certain project types. Projects range from the expensive and invasive unsealing of town squares to information sharing through lectures for retirement homes; KLAR!'s soft power does not always have equal weight. It must also be acknowledged that municipalities have their unique needs. Some have had projects like green roofs on public buildings for years before KLAR! had even come to fruition, or education for hospital staff on the effect of heat waves. Others may not need a certain measure due to their geography or it being a matter of law rather than urban development.

4.1.2 Measures Outside of KLAR!'s Control

To narrow down factors within KLAR!'s control, a brief analysis of project types within Keith et al. (2023)'s criteria which none of the cases chose to implement is made. The existence of examples can indicate that this category may be outside of KLAR!'s abilities, but this assumption must be assessed precisely. If true, then these projects are of no further concern within the current scope of this research.

Table 4 highlights the categories this concerns. As mentioned earlier (Table 2), criteria bearing the codes A1 to A4 are heat mitigation measures, and codes B1 to B4 are heat management measures. Only 3 mitigation measures found no application within the used cases, in comparison to the 7 types of management measures.

Table 4: Table of measures highlighting projects which no case successfully implemented.

Category	**Subcategory**	**Code**	**Number of Projects (out of 6)**
	Heat Mitigation		
Urban Greening	Water Features	A2_D	0
Urban Design	Cool Pavements	A3_B	0
	Building and Street Orientation	A3_D	0
	Heat Management		
Energy	Accessible and Affordable Energy	B1_C	0
Personal Heat Exposure	Transit System Operations	B2_A	0
	Parks and Trails Operations	B2_B	0
	School Operations	B2_C	0
	Occupational Safety Operations	B2_D	0
Emergency Preparedness	Early Warning Systems	B4_A	0
	Cooling Centres and Resilience	B4_C	0

A2_D: Water Features

Water Features are an established heat management method within large Austrian cities (City of Vienna, 2022c). New public drinking fountains and water sprays to cool the immediate surroundings can fall into the scope of KLAR's abilities. The failure of these projects is attributed to various internal barriers, further touched on in the coming discussion chapter.

A3_B: Cool Pavements

Keith et al. (2023) defined Cool Pavements as the application of coatings and materials in public spaces and roads to increase the reflection of incoming UV radiation. This is not a concept which any of the municipalities (Interview 1 to 6) were familiar with. Even Vienna's plan of actions against UHIs (City of Vienna, 2018), while mentioning albedo and cooling pavements, does not recommend any coatings or changes in used materials. Their preferred strategy is the unsealing of land to create more porous surfaces (page 37). Therefore, the limitations faced by this project are likely within KLAR!'s sphere of influence.

A3_D: Building and Street Orientation

Keith et al. (2022) defined this as changes to or new plans for solar, wind and drainage. This was never met with any interest by the interviewees due to Austria's municipalities' characteristics of low-rise and pre-existing buildings. These cannot be moved, instead their climate appropriate renovations are significantly more pressing (Interviews 1, 4 and 5), nor do they create as intense of an UHI effect as Kieth is used to from the sprawling Arizonian metropoles. Regardless of KLAR! managers' efforts, this is likely to remain unchanged

B1_C: Accessible and Affordable Energy

This heat management strategy is targeted at vulnerable and socio-economically disadvantaged populations. It describes the provision of grants and technical assistance for financing heating and cooling in homes. When asked about energy in the interviews, the KLAR! managers often referred to the e5 experts in their areas. Both KLAR! and the e5 programme (Austrian Energy Agency, 2024b) are supported by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and act in similar ways, offering expertise to interested municipalities in their transitions to sustainability and climate adaptations. It is evident that this project type falls outside of KLAR!'s jurisdiction. Progress is occurring without their involvement being necessary.

B2: Personal Heat Exposure

Many of the management strategies were less likely to be feasible within the KLAR! sphere of influence as it currently stands, in comparison to mitigation strategies. The management of 'Personal Heat Exposure', which includes Transit System Operations, Parks and Trails Operations, School Operations and Occupational Safety Regulations, was mentioned the least of those latter four categories. Amongst these measures, transit systems were mentioned the most, regarding creating shade and cooling through plants at bus stops, but the vehicles themselves do not seem to be part of any KLAR! plans. Whether this is because of finances; new vehicles are very expensive investments, or the prioritisation of expansion of systems over upgrading, or simply that these changes are managed by entirely separate governing bodies to the ones which interact with KLAR!. It is unlikely that future KLAR! proposals will have the ability to involve themselves directly in these topics.

Furthermore, roofers were identified as a vulnerable group in Interview 6. Occupational safety falls under the jurisdiction of the Austrian Chamber of Labour (AK), as they oversee and ensure worker's rights. Regarding extreme or enduring heat, they only have a legal basis for construction workers in situations where the temperature of the air exceeds 32,5 degrees Celsius (AK - Austrian Chamber of Labour, 2024). This does not encompass any other professional activities which are exposed outside, such as within agriculture or self-employed individuals. More concerningly, the use of air temperature at official stations cannot be considered accurate to the experienced temperature when enacting a job, as roofs, floors and miscellaneous used materials can radiate even higher temperatures after exposure to the sun, skewing the heat-derived mortality experienced by the labourers even higher (Dong et al., 2019). This concern is not one which KLAR! has any influence over, it is decided on a political level. An interesting further development could be the sharing of information on this issue, as KLAR! concerns itself with other vulnerable populations, like the elderly and children in kindergartens.

B4_A: Early Warning Systems

In Austria, early warning systems are a concern of the state level governments. They largely rely on sirens or public broadcasting via radio and television. The current expansion into app-format is being developed by the Ministry of Interior on a national but voluntary scale. Nevertheless, both the current and the future do not consider heat waves as being an immediate enough threat to require this. KLAR! and their municipal-level managers do not have any influence on these decisions.

B4_C: Cooling Centres and Resilience

According to Interview 4, KLAR! is still in the process of defining what cool centres are within the Austrian context. Their future involvement is likely the mapping of such places to provide this information to the local population and tourists in summer. KLAR! does not have the capability to independently buy or build spaces specifically for this purpose, rendering this category of project obsolete.

4.2 Research Question 2: Patterns

The second research question asks why some projects and areas are successful, while others are not. Each mention of a reason was encoded into 5 main topics: Technical Feasibility (C1), Money (C2), Politics (C3), Social Acceptance (C4) and Priority Conflicts (C5). Within these groups, the mentions got split into positives and negatives. In other words, whether they were barriers of drivers in each of the many projects. The visualisation of this pattern is seen in Figure 4 below.

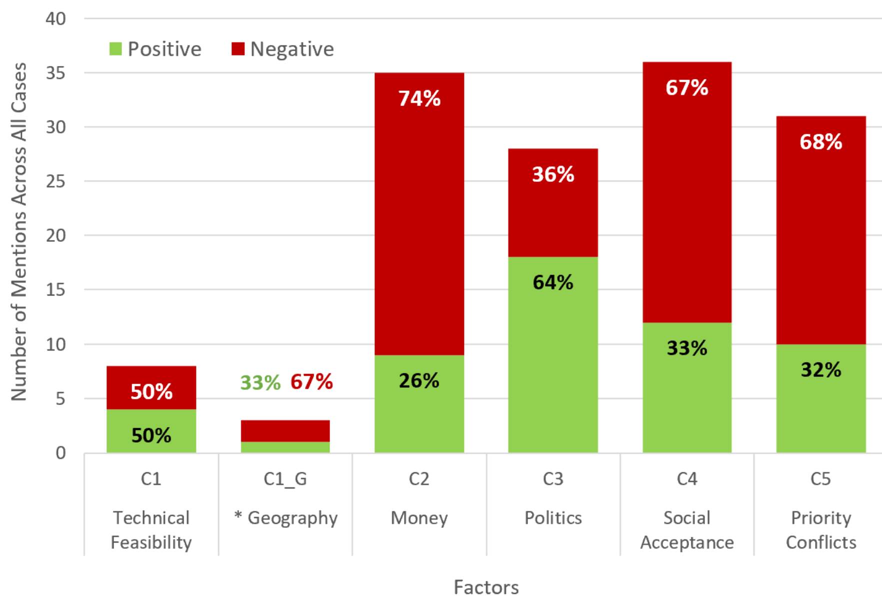

Figure 4: Total Number of Mentions of each Factor, split into Positives (Drivers) and Negatives (Barriers)

Geography (C1_G) was split from technical feasibility during the later iterations of the encoding process. Technical Feasibility quotes mostly encompassed very spatially or time focused issues, such as developments in green roofs or drone-based heat imaging (Interview 5), which may postpone projects until technology progresses or becomes more affordable. The 'Geography' category collects mentions which encompass the enduring physical qualities of the entire municipality, which cannot be avoided or changed.

As seen in Diagram 4, the most mentioned factors are Social Acceptance (36 mentions) and Money (35 mentions), closely followed by Priority Conflicts (31 mentions) and Politics (28 mentions). The least mentioned was Technical Feasibility (8 mentions) and its offspring code Geography (3 mentions). Thereby it is concluded that social acceptance and the financing of projects are perceived as the most relevant factors in relation to KLAR! projects overall.

The second aspect depicted in the chart (Diagram 4) is the relation between the positive mentions of a factor (drivers) in comparison to the negative mentions (barriers). This visualizes the areas which need to be improved upon to support the completion of more heat adaptation projects.

The only factor which had more positive mentions than negative ones, with 18 comparisons to 10 mentions, respectively, is 'Politics' (C3). Nearly two thirds of the remarks were positive, with managers interpreting the political structures in their municipality or on a federal scale as a driver for the success of their projects. Technical Feasibility (C1) was mentioned equally positively and negatively. All other factors were mentioned negatively at least two thirds of the time throughout the interviews. The factor with the most negative-leaning ratio as well as the largest overall number of mentions as a barrier, was Money (C2).

4.2.1 Factors as Drivers

In these two following bar charts (Diagrams 5 and 6), the factors are further split up into either being mentioned as drivers or as barriers, and the multiple bars show the number of mentions for each case.

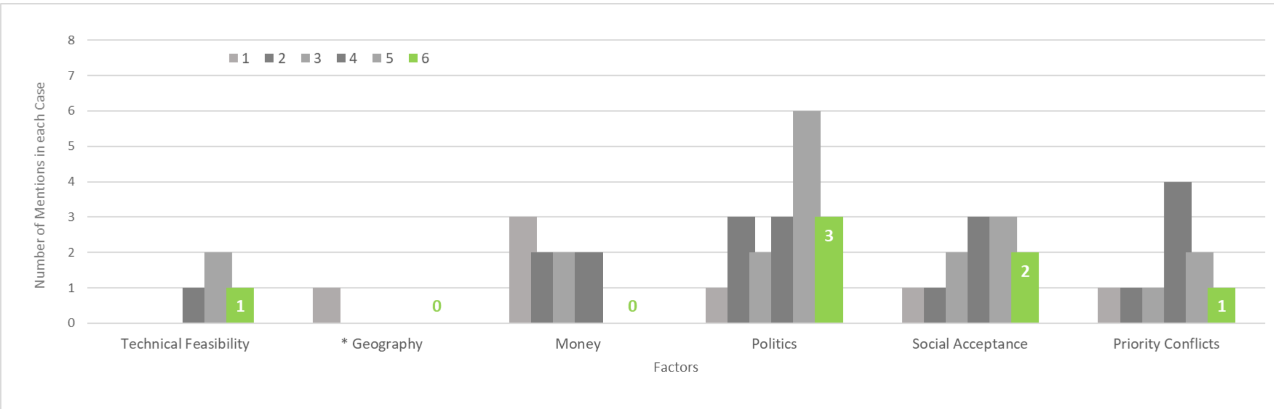

Figure 5: Number of Positive Mentions of each Factor (Drivers), split into Cases with Interview 6 highlighted.

By separating the interviewed KLAR! municipalities, connections can be drawn between their overall successes with heat adaptation projects and their perceived drivers or factors supporting their progress.

All 6 cases mention 'Politics' (C3), 'Social Acceptance' (C4) and 'Priority Conflicts' (C5) positively at least once. The least positively mentioned factors are 'Technical Feasibility' (C1), including 'Geography'(C1_Geo).

Case 5, the case with the 3rd most successful projects, mentioned Politics as a driver the most, with 6 separate collected quotes. This is the most focus on any single factor as a driver within the sample.

The most unsuccessful case (6) had no positive mentions of factors ‘Geography’ or ‘Money’. While only one case mentioned ‘Geography’ as a driver, making this a generally unpopular factor. Money is mentioned positively by 4 of the other cases, at least twice each. Therefore, the perceived lack of money is identified as a clear barrier in Case 6. Overall, Case 6 mentioned any of the factors positively 7 times, which is the same as for Cases 1, 2 and 3, falling into a secure medium and mode value.

The most successful heat-adaptation focused cases are 1 and 2, with 9 projects of their ten being identifiable within Keith et al.’s (2022) criteria. Neither of them displayed an unusually high number of positive mentions of any factors, as well as being the lowest in identifying Social Acceptance as a Driver.

4.2.2 Factors as Barriers

This final bar chart (Diagram 6) collates the negative mentions of each factor by case. Apart from Case 5, every interview mentioned more factors as barriers than as drivers (see Appendix E).

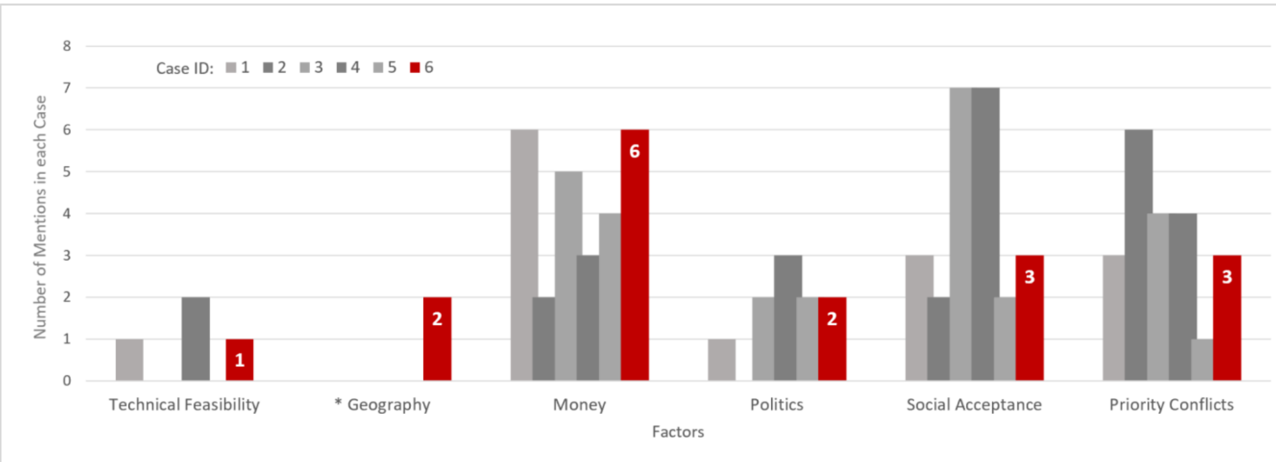

Figure 6: Number of Negative Mentions of each Factor (Barriers), split into Cases with Interview 6 highlighted.

The most often referenced barrier across all interviews in 'Money' (C2), with a total of 26 negative mentions. This is closely followed by 'Social Acceptance' with 24 negative mentions. These two factors, alongside 'Priority Conflicts' were each mentioned at least one in every interview, conveying their universality in the context of KLAR!.

Meanwhile Geography was only described as a limitation by case 6, on 2 separate occasions. The second least mentioned was Technical Feasibility, by half of the interviewees and only at most twice in one conversation. Politics is an occasional barrier for all the municipalities except one.

Case 6, as previously identified, is the least successful in realising the urban heat adaptation focused projects. They are unique amongst this sample in their identification of all 6 factors as barriers, as well as facing issues in relation to the town's geographies (C1_G). The latter is the factor that is most difficult for a sole KLAR! manager to change, unfortunately. Their most common complaint, however, are the 6 statements made on the lack of financial means (C2) to support their projects. As identified in the previous sections (see Factors as Drivers) these are the same factors where the manager gave no positive mentions.

The most successful cases, 1 and 2, each mentioned barriers more often than drivers, following the overall trend of all interviews apart from Case 5. Case 1's most common barrier with six quotes is Money (C2), and they mentioned every barrier other than Geography (C1_G) at least once. Case 2 had the largest issue with Priority Conflicts (C5), but no negative references were made of Technical Feasibility (C1), Geography (C1_G) or Politics (C3). It is the only case which does not identify Politics (C5) as a barrier in progressing with heat adaptation measures.

Discussion

To fully understand the factors acting as drivers or barriers for Austrian heat adaptation projects, it is necessary to break them down with examples and context. As previously mentioned in the Results Chapter, these main factors are Technical Feasibility (A), Money (B), Politics (C), Social Acceptance (D) and Priority Conflicts (E).

The following discussion chapter outlines each of these five factors, and how they affect the KLAR! programme, positively or negatively. The subsections are the specific concerns the interviewees brought up which could be grouped under these umbrella-terms.

A. Technical Feasibility

Heat mitigation and management methods are developing simultaneously across the world, but access to the innovations is not equal when the technology has not yet diffused fully (Stoneman and Battisti, 2010). This can be observed in whether the scale of the innovation has been sufficiently minimised to accommodate all locations (A.1), whether it has been implemented previously to let the contractors gain experience in completing the adaptation measure (A.2) as well as having convinced stakeholders of their success (A.3). Overall, Technical Feasibility is the least mentioned factor by the interviewees.

A.1 Physical Scale of the Measure

Any changes to existing infrastructure come with their own widespread complications. To complete a heat adaptation measure requiring a physical location, managers must find such a space, ensure it is free to use and meets all the logistical requirements the project has. This space is the main barrier to large-scale aspects of mitigating heat in urban areas, specifically in the category A3: Land Use. Changing already-set layouts of towns is an unfeasible intervention into a municipality's identity, finances and constituent's private property. One manager explained that although heat is a pressing topic in their area, it is not perceived as important enough to necessitate the redesign of their whole town (Interview 6).

Similarly, another Interviewee (Case 6) noted that one barrier to the implementation of water features (A2_D) was the reliance on either existing water infrastructure or the necessity for invasive pipe-laying. The perceived positive impact of cooling sprays does not justify such an extensive construction process in the eyes of their municipality's population.

Although generally supported, it was noticeable that the addition of greenery sometimes came with mixed support from levers such as public or financial support. To make sense of this, categories outlined by Snep et al. (2020) can be used to group projects into either No-Tech, Low-Tech or High-Tech. The first group would be simple spaces for natural grasses or other flora to grow, where no artificial watering or extensive gardening is necessary. Such measures are not mentioned by KLAR! managers, as they are not intense enough to make significant impacts on the surrounding microclimates in dense urban settings. The Low-tech category projects are the most popular within KLAR!'s portfolios, where trees and green spaces are put where intense urbanisation exists. This often involves the loss of parking spaces, changes to the accessibility to storefronts and the unsealing of asphalted ground. It is an undertaking of a much larger scale than initially assumed. Therefore it faces barriers in regard to Social Acceptance (D) and Priority Conflicts (E), similarly to the water features.

A.2 Lack of Expertise

Measures require either internal or external expertise to be brought to fruition. The internal expertise is the KLAR! manager themselves, as well as the resources they gain through their network. Adaptation measures which KLAR! managers can complete independently are the Education and Awareness events for heat management, in the category B3: Public Health. As previously found in the Results Chapter, apart from one municipality (Interview 6), all questioned KLAR! managers have completed projects of this type. Examples of these projects are classes on greenery and plants for interested community members (Interview 1) and lectures on the health impacts of increased heat exposure to nurses in hospitals (Interviews 2 and 5). The completion of so many of these projects demonstrates how success is likely when little planning or collaboration are needed.

In contrast to this, all other heat mitigation and management methods as defined by Keith et al. (2022) are more heavily reliant on further stakeholders and entities.

External contractors are the actors which build and/or maintain any physical project, and the implementation hinges on these individuals' understanding and cooperation. Their opinion must therefore be consulted before proposals can be seen as feasible and submittable for financing requests. For building projects, local contractors are used due to the importance of proximity (e.g.: for moving material, site visits, access to machinery) limiting the possible contractors to ones which meet these criteria (Interview 3).

Similarly, smaller projects also require materials or accessible set-ups, like structures for greening walls and green roofs, sails and awnings for increased shade or even liquid coatings for Cool Pavements (A3_B). Such products can encourage individuals to contribute to their own heat mitigation measures (Eurostat, 2020). Unfortunately, negative experiences have been made, where these products are underrepresented and lacking in options at local construction companies (Interview 3). The managers' understanding is that the builders are lacking in information on this topic and will therefore not recommend it to their clients. Expanding general awareness and acceptance of these tools is one way to gradually improve on this lack of interest. This hopefully encourages more bottom-up adaptation measures.

On the other hand, the field of climate adaptation is a constantly expanding one, with technology often existing long before it is finally put into full use. The standout example of this was one municipality's development of a 3D-render using drones to understand how heat interacts with the city's architecture and greenery (Interview 5). It is the most modern mechanism of measuring the positive cooling impact of any implemented heat adaptation measure thereby giving KLAR! municipalities a way to verify and justify their changes. This can have a positive impact on Social Acceptance (D).

Guided drone flights and instruments measuring environmental conditions are not new, but their combination and application for the purposes of KLAR! are. Case 4 used the BOKU University's capabilities to conduct their own drone flight and heat-mapping of the city. This demonstrates the usefulness of external partnerships in expanding technical capabilities.

A.3 Differences in Opinion

The third interview touched on reasonings for the rejection of a sponge-city concept for their municipality. The sponge-city concept is a rather new one, involving rainwater being collected below ground to slowly water trees planted into specific substrate layers, using water which would have otherwise simply seeped away (Guan et at., 2021). Some of the sponge city based projects were categorised into Urban Greening when they involved the planting of trees.

Rather than criticism from the side of politics or the public, it was that of the town's urban planner. Their reasoning was that this concept, although it increases the total number of trees, continues to facilitate the excessive amount of ground sealed with asphalt and concrete, rather than the open green patches they want to facilitate.

This aspect echoes the later factor Priority Conflicts (E). Their separation into two categories is justified; as they come to play at different stages in the process, the planner nipping the idea in the bud before any formal proposal can be laid on the table, or the project failing along the way due to specific actions creating disputes amongst the public.

Technical Feasibility Conclusions

- *Large scale building projects are outside of KLAR!'s control.*
- *The most successful projects only involve the managers' efforts.*
- *The true driver is knowledge of and support for heat adaptation technologies amongst involved parties such as urban planners and construction companies.*
- *To improve Technical Feasibility (A),* ***Social Acceptance*** *(D) and* ***Priority Conflicts*** *(E) must be worked on.*

B. Money

The three stages where money plays a central role are during construction (see section B.1), throughout the maintenance (B.2) and as insurance if the project causes damages (B.3).

Progress in urban climate adaptation is more likely to occur when there are set financial instruments to support and incentivise this progress, and subventions are removed for projects which are harmful to the climate (APCC, 2023). Both the literature and these interviews support the understanding that money is one of the most important levers in creating a transition to climate-adapted urban areas. Within the case studies, it was the most referenced barrier, with 62 negative mentions by the managers. It is the second most common factor overall.

B.1 Costs of Construction

At the point at which a project proposal is complete, it has been looked over and approved by the local government and by KLAR! as being justifiable and within the available financial means. A core tenet in the establishment of KLAR! is to provide financial aid to projects which would otherwise fall outside of the scope of a municipality's budget. Therefore, it is emphasised (by the experts) that none of the projects assessed within this research would have come to fruition at all, or within such a short time frame, without the financial support contributed by KLAR! covering 75% of the projects' costs. This money is a one-time payment, mainly used in the construction phase of a heat adaptation measure.

However, nearly three-quarters (74%) of the occasions where money was mentioned as a factor in the interviews, it was referred to negatively. In comparison to other factors, this is the most negatively skewed ratio of them all. A frustration with the availability of money is undeniably a major barrier to many projects. Interviews 5 and 6, which represent very different municipalities in their quantity of successful heat adaptation projects, both noted the difficulty for local governments in dedicating enough money to invest into projects at their beginnings. They explained that the full project costs can initially fall on the municipality and KLAR! reimburses them the 75% at a later point in time. This discourages some projects, even if the final costs may be manageable to the municipality.

On a grander scale, money flows where interest lies. This can be the interest of the singular town, or the interest of a federal state, whose position has a more birds-eye view of the priorities in all of Austria. One example of this is the Bodenbonus, a financial incentive for urban projects which aim to unseal ground in larger dimensions (Landesregierung NÖ, 2024). Although these projects are rare (Interview 3), it allows for more radical heat mitigation measures without depleting the local councils' finances. This, however, is not a KLAR! initiative, but rather one of Lower Austria from now until 2025. KLAR! municipalities within this federal state can use their respective managers to facilitate grant proposals to gain this 30-50% financing of their projects, but initiatives outside of this state do not have the same benefits. This is once again where these aspects overlap, in this case Politics (C) and Priority Conflicts (E).

A second critique of financial grants such as this, is that through their criteria of supporting only larger projects, it excludes most smaller or less financially strong towns (Interview 3). Paying 25% of such projects may simply not be in their budget, or they do not have areas large enough to qualify. Projects in larger municipalities, regarding population size, are more likely to find diverse sources for funding, such as 90% of the drone project being covered (Interview 4).

B.2 Costs of Maintenance

Long term financial commitments are made to two things: resources (water and energy) and people. Water is the most needed resource for temperature mitigation, due to its inherent environmental cooling during evaporation (i.e. water fountains or sprays, water features in kindergartens) as well as its involvement in all greenery projects. The cost of the water was not mentioned by any interviewees as a source of concern regarding the support of a project. The priority was rather on whether the use would be wasteful or not.

Sufficient and consistent water is necessary to ensure the new greenery does have an impact on the heat, as a large factor is the soil moisture creating a cooling effect through evaporation (Trimmel et al., 2020). This proved to be a main hurdle in the success of the bus stops with green roofs (Interview 3), due to the Technical Feasibility (A) being limited. A way in which this cost can be avoided is by reliance on collected precipitation (Interview 3). Water collection from roofs as well as slowing the seepage through soils allows for a decrease in artificial watering of greenery. Furthermore, this reduction of water leaving private properties may result in reduced drainage maintenance costs for the proprietors.

Sustainable energy usage is a repeated theme, and one in which finances play a large role as well. With the conflict in the Ukraine, the energy prices in Austria have seen a steep increase since 2022 (Austrian Energy Agency, 2024a). Although this has levelled out, it is still far outside the normal relation to energy usage and therefore expensive for the individuals using it. Most heat adaptation measures are not reliant on electricity for their positive impacts, making this concern less relevant.

The main financial burden due to maintenance is the cost of skilled people, the main category being gardeners. As Urban Greening is the most popular measure, this cost falls on all municipalities to carry and was therefore mentioned by multiple managers as a concern (Interviews 1 and 2). However, it does not seem to slow down the majority of the greening projects as the Social Acceptance (D) is overwhelmingly positive.

B.3 Insurance

This subcategory was a surprising revelation early in the interviewing process. One manager (Interview 1) mentioned an aversion to planting trees in public spaces in their area due to multiple negative experiences when the public took the municipalities to court for endangering their health or property damage. Two named examples were the falling of chestnuts or similar heavy fruits onto cars in the parking spaces below, resulting in scratches or dents, and fallen leaves on pavements turning into slipping risks when it rains. On public land, the municipality is liable for these damages. Consequently, the support for these projects on the side of the governing actors in the municipality is reduced, with a preference for supporting tree plantings in private areas (i.e. gardens and inner courtyards). This is not a reality which can be changed by this manager, but it seems not to be a universal problem amongst KLAR! municipalities.

Money Conclusions

- *Without KLAR!'s financing, most of these projects would not currently exist.*
- *The smallest municipalities are still not able to carry the financial burden and are therefore being left behind.*
- *Additional funds and KLAR! paying for costs upfront would always be beneficial.*
- ***Politics** (C) on state level can influence which projects are possible.*

C. Politics

Although democratically elected political structures, such as the ones found within councils and mayorships of Austrian towns, are there to represent the needs of the people, Politics do constitute a different category than Social Acceptance in their relation to the KLAR! projects in two main ways.

Firstly, the involvement of politicians begins at an earlier stage. A KLAR! project must be proposed with 10 initiatives that fall underneath the organisation's goals and are feasible in the specific region, which includes a commitment to financing the 25% of all undertakings by the local government. Considering these criteria, all interviewed regions have a baseline level of political support, as otherwise there would be no KLAR! managers situated there.

Secondly, politics can prioritise long term goals and commitments to plans more complex than just the individual building or tree. One recurring example of this was the e5-Regions with their energy efficient goals for individual involved municipalities. It is a certification with quality controls in a 4-year cycle, the results of which are given in grades from one to five 'e's, alongside awards once the third tier is reached (Austrian Energy Agency, 2024b). There are multiple ways to improve energy sustainability, from personal solar panels on roofs, to exchanging heating systems in public buildings or swapping older buses for electric alternatives.

Politics lies comfortably in the middle of the factors in relation to how often they were mentioned by the managers in interviews. It is unique in it being the only factor mentioned more often as a driver (positively) than as a barrier (negatively). Moreover, Case 2, one of the most successfully heat adaptation focused municipalities, had no mentions of Politics as a hindrance at all.

C.1 Political Change

The mayors and local councils in towns are voted for in elections every 6 years. In 5 of the chosen cases, the KLAR! projects were new enough to have not yet experienced a change in political leadership. As Interviewee 3 explains, they have a contract for the next phase of KLAR! which has been approved, which stands regardless of the if there are changes. The funding cycle for KLAR! is 3 years long.

Although the opinion that choosing to establish a KLAR! municipality is influenced by the local political majority was evident amongst some managers, once KLAR! is settled somewhere, it is safe for the duration of the contract. Additionally, many KLAR! projects are extended for a second phase. Whether this pattern continues is only visible with time, as most municipalities are still too new to the initiative.

KLAR! can influence their longevity through yielding clear positive results. Case 1's manager called having good projects to show off an advantage for the current politicians. By having elicited a positive change, their Social Acceptance (D) is increased, leading to a likelihood of re-election.

C.2 Top-Down Politics

Only two experts (Interviews 1 and 5) mentioned the politics of the federal state in which their municipality lies. On the municipal scale which KLAR! acts on, these situations are seldom directly relevant to urban heat adaptation projects. The two measures in which the state becomes relevant are Building Waste Heat Reduction Programs (A1_1) and Early Warning Systems (B4_A). The former is due to the influence of the state-developed building regulations (as mentioned in section 2.4) such as limiting the percentage of privately land being sealed (Interview 5) or renovations requiring improved insulation and energy efficiency. The latter, a heat management method, involves access to personal data such as phone numbers to alert of any incoming emergencies (as mentioned in section 4.1.2). These are aspects of heat adaptation outside of KLAR!'s capabilities. However, their effect can be replicated partially through educational events (B3_A), such as providing affordable consultations for building renovations (Interviews 1, 4 and 5) and lessons on how to avoid the negative health impacts of excess heat for the general population (Interviews 1, 2, 3, 4, 5 and 6). Due to a lack of top-down pressure, these are only optional.

KLAR! can apply some pressure on its municipalities. With their reliance on funding from an external source comes a binding contract and time frame (Interview 5). Once a project has been approved, it needs to be completed within that phase of the KLAR! programme, to whichever level of success. This pressure catalyses change. Projects running on private finances can be postponed at the will of the individual, depending on their finances (B) or current Priority Conflicts (E).

Having an application-based system strengthens the meeting of top-down and bottom-up, as communities can get together to discuss what they specifically need, before formally involving KLAR! at all (Interview 5). The proposals are written by the locally residing managers, approved by the local governmental structure, and then only sent to approval from a national-level structure. This ensures much more autonomy than blanket laws or one-size-fits-all initiatives allow.

Politics Conclusions:

- *Established KLAR! projects are unthreatened by politics and can positively impact politicians' reputations.*
- *There is power in top-down decisions or organisations, as it puts pressure on adaptation measures to meet standards. This reduces the barriers caused by private **Money** (B) or **Priority Conflicts** (E).*
- *KLAR! cannot fully imitate this power on a project-level.*

D. Social Acceptance

Social support is important because KLAR! functions at the meeting point of top-down and bottom-up practices (Interview 3). They do not have the power to implement any projects without local political and social support. In the context of this research, social acceptance is defined as the individual attitudes of the population within the municipality. Much of the land in urban areas is privately owned, and similarly, most of the public areas, such as squares and roads, need to serve the perceived needs of the local population. The prioritisation of this factor is underlined by it being the most mentioned of all the factors, with an average of 6 times per interviewed manager.

Social Acceptance is particularly crucial for larger projects in public areas, as these changes will influence the image of the current political leadership (Interview 2). To avoid discontent, intensive participation methods such as a referendum can be used. If found to not suit the image or priorities of the municipality, KLAR! has had the experience of large-scale projects being put on hold due to rejection from the public (Interview 3).

D.1 Fear of the Unfamiliar

A main cause of missing support from the public is apparently lack of knowledge on climate adaptation measures, leading to a fear of negative consequences. As research into heat adaptation measures evolves, so do the options for projects. Lack of familiarity with a new idea can be a hurdle to social acceptance and thereby to the greenlighting of a project. Due to a wide range of measures, there are various initial responses.

The benefits of some projects are perceived as obvious, such as trees and their shade cooling an area (Oswald et al., 2021), and don't even require feedback on whether they are successful, as that is accepted as common sense. These assumptions are not necessarily accurate. For example, Oswald at al., 2020 states that increased albedo on roofs is more effective in combating heat than trees, and that greenery is only effective once it reaches a certain size. They also warn against the energy input necessary to maintain manicured lawns. Similarly, Meili et al. (2020) studied how trees on narrow roads can inhibit reduced temperatures at night by blocking air flow. When it comes to social support as a driver for projects, reputation trumps any academic research. A better choice could be applying coatings for cooler pavements and roadways (A3_B).

Some projects need examples set by other regions. This is one of the purposes of having a KLAR! where managers can exchange ideas and successful projects. If a project worked in one place, then this can be adopted in a new region with more confidence. One example of this is the drone scans (Interview 1) measuring the current state of increased heat or the impacts of the completed measures, which can be applied to other municipalities as well.

The third category is projects which will not be accepted without successful examples within their own local urban area. The most mentioned examples of this are trees in the economic centres of urbanised areas and the renovation of old houses to increase their resilience to temperature changes and reduce waste energy.

What this third category has in common, is that these projects rely on social acceptance, or acceptance from the public, as they generally exist on private property. The planting of new trees in commercial areas takes away parking spaces in front of shops, which the owners fear would negatively impact their sales (Interview 3). An additional fear is inner areas of a town becoming less accessible by individual motorised transport, leading to an increase in empty buildings and the dying of the core. In Austria, the vacancy rate is nearly 5% and has shown a slight increase in the past years (NÖ ORF, 2024). This vacancy rate can similarly be linked to the resistance against heat adapted renovations, due to the immense financial burden these place on the individual owners. Unless their personal benefit of more trees or improved homes is proven, resistance is common.

In simpler terms, people need to be familiar with a change to accept the benefit in it, and the more exposed they are to various successful projects, the more likely it will be that they see beyond their fears of economic loss. This shift is constantly happening with the increase in education on heat management methods in schools (Interviews 1, 3 and 4).

Pilot projects in the public seem to be more easily accepted, an example of this being some moss-covered bus stops with the aim of doubling the immediate cooling for users of public transport through both shadow and the plants' transpiration processes (Interview 3). This project ultimately proved to be ineffective, as the water needed to sustain the moss evaporated too quickly to maintain the effect continuously. This failure to meet the set expectations was not commented on negatively at all and rather seemed to be an accepted part of the process of learning. This is a strength regarding the Technical Feasibility (A) of measures. However, this acceptance is not generalisable to the previously mentioned projects, since it doesn't require public approval to be greenlit, unless an intensive participation process is endeavoured, but rather just needs to fit the political agenda of the local area. Projects such as these bus stops, educational sessions or the adaptation of the town square do not infringe upon private property and do not result in a fear of an economic loss for individuals. It is evident that people accept failure less when it applies to their private property.

D.2 Urban in Comparison to Rural

An interesting distinction was made by an interviewee (Interview 3) when asked about how urgently the public saw the issue of climate change, specifically regarding temperature increase. To answer, they compared the stance of their town's population to that of the surrounding farmers. In their experience, people involved with agriculture had a much more acute understanding of the issue, and were more likely to push for changes which would mitigate the impacts of the changing climate. This remark strongly underlines the idea that people are more likely to prioritise an issue if it affects their own livelihoods.

Social Acceptance Conclusions

- *The barriers to Social Acceptance (D) closely mirror those of* ***Technical Feasibility*** *(A).*
- *Social Acceptance is strongly linked to the perceived personal impact of either the increasing heat or the adaptation measures on the population. This is the NIMBY effect.*
- *Projects using public spaces and with positive existing examples are most likely to face less resistance.*

E. Priority Conflicts

Priority Conflicts describe the points where the other goals of the municipality either support or clash with the progress of heat adaptation. In sum, interviewees mentioned this factor as a barrier (21 mentions) twice as often than as a driver (10 mentions). When assessing what the experts identified as conflicts of interest found by the public, three main ones came to light, two specific and one concerning general heat management.

E.1 Water Usage

Firstly, water can play a role in cooling features such as sprays or fountains in hotspots, like Vienna has (City of Vienna, 2022a). This is to alleviate immediate heat stress and has been an ever-expanding feature in the capital city over the last years as the days with extreme heat continued to grow. Water, similarly to green spaces or energy, is a resource where sustainable management is a priority when the supply is limited. Although Austria is a very self-sufficient country regarding a clean potable water supply, with advancing climate change and increasing droughts, more regions are expected to face shortages by 2050. Greenpeace (2024) found that the most impacted areas are Lower Austria, due to their distance from alpine water reserves and large areas of flatland. This report also highlights at-risk areas in Styria, Tyrol and a small group of municipalities in Upper Austria. Two of the interviews were conducted with at-risk municipalities, one falling into the worst category with a potential future water usage of 114% (Interview 3), and the other in a lower, but still stressed, group at 82,5% of the water supply being used (Interview 5). However, the level of water insecurity was not found to be an influential factor within the sample, as none of the municipalities propose any water features as heat mitigation measures. These measures are not met with Social Acceptance (D) as they seem unsustainable to the public (Interview 6).

E.2 Energy Usage

Secondly, energy usage was found to be a core concern on both individual (Interview 1) and regional levels, as can be seen by multiple of the KLAR! managers working in places which also identify as e5 regions (Austrian Energy Agency, 2024b). Therefore, under the wider umbrella of sustainability, energy wastage through products such as air conditioners is an immediately rejected idea (Interview 2). This decision is supported by the concept of the anthropogenic heat feedback cycle (World Bank, 2020, page 25), described as increasing temperatures leading to increasing numbers of air conditioners, which in turn release waste heat right into densely populated urban areas, exacerbating the already uncomfortable amounts of heat, as well as being a large use of energy. Becoming reliant on air-conditioning rather than taking overall measures to mitigate heat would be a maladaptation to climate change (BPIE, 2023).

An additional perspective on the prioritisation of long-term adaptations regarding buildings is the encouragement for improved insulation within renovations (Interviews 1 and 5). Due to Austria's cold winter months, this aids in reducing heating costs, hence further incentivising this heat adaptation measure. This makes energy waste reduction a clear example of positively overlapping priorities.

The topic of energy and regulations regarding to saving it within buildings overlaps with perspectives discussed in the section on Money (B) and Politics (C). KLAR!'s goals generally align with those of the Austrian state governments, and they are useful in enforcing these changes with more pressure. These conditions are not within the KLAR! managers' control to change.

E.4 Incompatible Priorities

The third conflict is the complete disregard for the health implications of extreme temperatures in lieu of the strengthening economic benefits due to climate change. One manager described their struggles in getting widespread social support due to their region being very tourism-dependent; as temperatures increase, more Austrians look for holiday spots to cool off in without having to leave the country, and their region has been experiencing a boost through this (Interview 6). They describe that climate change seems to be a problem that only exists outside of their bubble. The priority is current financial profit over long-term adaptations to a problem which is not perceived as particularly harmful.

Furthermore, a surprising account (Interview 3) touched on some nursing staff in the area being unreceptive to freely given information or training on the topic of heat-related health complications. Although these are professional medical staff, there seems to be a disconnect between them and information on the impacts of climate change. One situation cannot be generalised to all Austrian towns, of course, but it should be highlighted, as these professions are at the nexus of heat and the health issues related to it. In contrast to this, other managers report successful information-sharing, whether through courses (Interviews 1, 4 and 5) or multi-lingual pamphlets (Interview 2), that medical staff, especially ones at retirement homes, had a solid understanding of heat management for their more heat-susceptible patients. An explanation for the lone case's incongruence was the lack of medical personnel and nurses overall, and that their priority must then be immediately responding to the current needs of their patients, rather than spending time on voluntary further education (Interview 3).

In a contrasting perspective, prioritising other topics need not be detrimental to progress, as heat mitigation does not have to be at odds with other tenets of sustainability or urban planning. As mentioned by both academic literature (Kyprianou et al., 2023) and policy documents (City of Vienna, 2022c), heat and health are commonly just small aspects under these umbrella terms. They are both proponents of the idea that if proposed projects contribute to more than just heat management, they will be implemented more easily. The golden child here is increased greenery in public spaces, due to it being a champion for both human and environmental health (Interviews 1, 2, 3, 4, 5 and 6). That increases familiarity and understanding of widespread benefits of its implementation, regardless of knowledge on heat, resulting in high Social Acceptance (D). Additionally, energy use reduction and the transition to renewables is a social and Political (C) topic due to Austria's continued reliance on Russian gas (Interview 6).

Although this accidental support of heat mitigation methods allows for some levels of progress, managers found it to be a missed opportunity when the focus of heat was not being publicised properly, as this is a useful way of building knowledge and understanding amongst the local inhabitants (Interview 4). They believe that emphasis on heat would be a benefit in increasing Social Acceptance (D) for future projects. A study by Dare (2019) of North American city plans underlines this conclusion, finding that more explicit mentions of urban heat would increase the number of funded projects which target this issue specifically.

Case 5 (very positive) had least negative Priority Conflicts (E) and the most positive Politics (C) mentions. Therefore, an positive correlation can be identified between those two factors. The more politics stands behind climate adaptation, the less KLAR! must compete with other goals.

Priority Conflicts Conclusions

- *Water usage is an example of* ***Social Acceptance*** *(D) creating a conflict based on impression rather than actual drought risk.*
- *Energy use reduction regulations overlap with KLAR!'s goals but are not a measure which KLAR! can control.*
- *People prioritise short-term benefits or goals over investing in long-term heat adaptation unless* ***Politics*** *(C) demands otherwise.*

Conclusion

This final section consolidates the gained insights through the interviews, literature and critical discussion thereof. The results are summarised into data highlights for Research Question 1, and 3-level recommendations for actions to be taken by KLAR! for Research Question 2. These satisfy the **research aims** to the best of the scope's ability, as they do fill a research gap on urban heat adaptation measures found outside of Vienna or other wealthier state capitals, as well as being a collection of insights which the relevant decision makers, the KLAR! managers, can realistically apply to increase their successes with projects protecting their citizens' health.

6.1 Answering Research Question 1

What heat mitigation and management project plans exist in Austrian towns?

This question centred on the collection of quantitative data of projects, alongside an understanding of who the current drivers of this progress are. The leading role of KLAR! was identified through the literature review and initial research, then consolidated by the perspectives of the six interviewed managers. KLAR! is a government-initiated structure which supplies interested but financially limited municipalities with expertise and financial support for projects tackling climate adaptation measures. It is non-political and aspires to minimise bureaucracy for the local population through its mechanism of a manager per area, alongside a strict three-year timeline for project completion. These projects must be justified as reducing the negative impacts of climate change for the inhabitants. Their definition is more expansive than simply heat mitigation and management.

Through a categorization using Keith et al.'s (2022) criteria on urban heat adaptations, a statistic was completed for the chosen sample of 6 municipalities (see Results Chapter). The first main finding is the significantly larger number of mitigation projects, 30 within the chosen cases, in comparison to the management projects which only counted 9 overall. This imbalance is also echoed in the range of heat adaptation project categories which KLAR! implements. There are more managements without a single successful example than of mitigation measures.

Secondly, the most prevalent project was urban greening. Every interviewed manager had a project regarding the planting of trees, and 5 of the 6 had multiple. These are long term mitigation measures. In contrast to this, the category Personal Heat Exposure (B2), a type of heat management, yielded no examples. This would include transit systems, part operations, school operations and occupational safety (Keith et al., 2022).

Lastly, not all heat adaptations are within the current scope of KLAR!'s influence. This is the main factor behind the lack of heat management projects. Examples include the approval of early warning systems of the efforts to make energy accessible and affordable to all people. Therefore, these categories need not be regarded when advising KLAR! managers' on improving their actions, as is encouraged by the second research question.

In summary, KLAR! is the largest organised collection of urban heat adaptation projects in Austria, disregarding any capital cities. Most of its measures are appropriate for fulfilling the purpose of reducing the impacts of heat on human health. The managers focus more on long-term heat mitigation than immediate management measures, as that is where they have more influence.

6.2 Answering Research Question 2

Which factors affect the successful implementation of heat mitigation and management projects, and how?

To answer the second question, an inductive approach was used to interpret positive and negative justifications for the choice of measures from the interviews' transcripts. When collected and visualised alongside each municipality's respective projects, connections are drawn between factors and outcomes. These five (5) main factors were then analysed using context from the interviews and external literature, forming the sections of the Discussion Chapter; Technical Feasibility (A), Money (B), Politics (C), Social Acceptance (D) and Priority Conflicts (E). At the end of which short summaries were recorded. These summaries have been re-structured in the three (3) following sections to create a list of recommended actions for KLAR! managers to take, organised by who the recipient of the changes should be.

6.2.1 Manager-to-KLAR! Management

KLAR!'s power lies in its ability to financially support small municipalities which often cannot fund measures for heat adaptations on their own. Their commitments are generous and reliable. Unfortunately, the remaining 25% are still burdensome to the local governments. Nearly ¾ of the mentions of Money (B) are in relation to there being a need for more, the most unbalanced ratio of any of the analysed factors. Commitments of additional funds by governments would alleviate some stress.

The drawbacks of state government involvement, however, are manifold. The largest being the involvement of a new player with a large amount of political power and their own long-term agenda. By involving them, the bottom-up communication cultivated by KLAR! is further undermined, possibly betraying their aim of tailoring each measure to the specific municipality and the local governments vision. The growing awareness of KLAR!'s positive impacts and progressive addition of more municipalities should instead snowball into **growing support for the initiative from the existing financial sources**. This is the Austrian Climate and Energy Fund, belonging to the Austrian federal government.

The second barrier less wealthy municipalities face regarding Money (B) is the system of their needing to initially fund 100% of the measure, before KLAR! steps in and repays them the 75% at a later point in time. Two managers (Interviews 5 and 6) mentioned this on separate occasions as an issue. An option for amelioration is **creating a secondary financing system** for such cases, where a larger percentage of the costs are covered by KLAR! from the beginning.

<u>Manager-to-KLAR! Management Recommendations</u>

- *KLAR! must continue to expand through supporting new municipalities, without disregarding the poorest ones*
  - *Need for increased funding should result in further reliance on existing sources rather than involving more investors with top-down approaches to development.*
    - » Advertise and Present Successes using Comprehensible Data
  - *KLAR! should pay up front for the most disenfranchised municipalities*
    - » Create Mechanism to Allow Financial Security for All Parties

6.2.2 Manager-to-Manager

A repeated theme was **the need for pilot projects to encourage trust** from the local governments (Politics (C)), contractors (Technical Feasibility (A)) and the public (Social Acceptance (D)). Using the KLAR! infrastructure, managers can contact each other regarding expertise with similar projects. Contact details are readily accessible online, as well as a listing of all their current and past heat adaptation measures. Through the interviews, the impression arose that this is not being taken advantage of outside of the bi-annual meetings and special award events.

One proposal to encourage more peer-to-peer communication when problem-solving is creating an **internal database where each manager has a listing of their experiences based on a Barrier and Driver structure** as used in this paper. For example, a manager can define how positively or negatively they experienced local politics to be or whether they received a lack or surplus of social support for their proposed developments. This would require a high level of discretion as well as vulnerability from the managers, but the benefit would be in easily finding counterparts who have succeeded in overcoming issues they are currently facing. A large amount of KLAR!'s work focuses on situations not unique to specific measures or municipalities.

Furthermore, existing projects can be translated into the context of new municipalities if working together becomes more common. Projects such as **the drone-mounted heat scanner** took a lot of time and financial investments from that municipality. Transferring this project to other KLAR! areas would reduce costs for them and give these managers experience to fall back on.

Lastly, the measure **Cool Pavements** (A3_B) was never used by any KLAR! municipalities within this sample. Adding this to the repertoire might lead to positive results, as its drivers and barriers are still unknown.

Manager-to-Manager Recommendations

- *New pilot projects must be created for all possible relevant adaptation measures*
    - *Increased and more detailed sharing of experiences and data about specific projects between managers*
        - » Online Secure Database of Projects Tagged by Barriers and Drivers
    - *Transfer of existing projects (or their plans) to new municipalities*

New Projects

- *Drone-Aided 3D Heat Mapping in further KLAR! municipalities*
- *New Cool Pavements Attempts*

6.2.3 Manager-to-Public

Social Acceptance (B) lies at the centre of the success of most heat adaptation projects, as is underlined by it being the overall most-mentioned factor across the interviews (see Diagram 4). Its central role is further highlighted when considering that the least successful of the interviewed municipalities had a distinct lack of Social Acceptance (Interview 6, Diagram 6). The core justification was not a fear of change or encroachment upon private property (NIMBY), but rather the public's lack of understanding of negative impacts worsening heat waves would have on health.

Luckily, KLAR!'s entire premise is to connect municipalities with progress on an eye-level basis through their local managers. Most of the work my interviewees complete is related to communicating with stakeholders on specific measures and educating the public on the negative health impacts of excess heat exposure. The main framework for increasing Social Acceptance has been established.

As elaborated on in the introduction, the impacts of heat waves are difficult to quantify due to their interactions with pre-existing conditions as well as the lack of immediate changes. KLAR! investing into concise and impactful educational resources of the existing research, including data from the local Red Cross' increased emergency calls received during heat waves, is recommended to **translate the urgency to act** to the community.

The other approach to this is **gathering quantifiable data on successes**. KLAR! reports the number of municipalities and projects it has completed but is less clear on the positive impacts they create. Measuring the 'thermal sensation' (City of Vienna, ed. 2022b), albedo and wind flow before and after the implementation of a measure allows for a clear understanding of the benefits. Reporting positive results adds legitimacy to projects, persuading the public's opinion of changes positively. This is most important for more controversial or unfamiliar measures. Ideally, data from other municipalities can be used as positive examples for new projects elsewhere.

A failure to do such measurements is often noticeable in Greenery projects in Vienna. The recent addition of a few trees to the previously fully sealed Michaelerplatz in the 1st district has been faced with much criticism (Kurier, 2024). The trees are currently small and were bare during the winter months. The scepticism of any cooling impacts was noticeable online. Such opinions could halt similar projects in smaller municipalities where individuals' voices are more directly impactful.

A new project category which may emerge if communication improves are Water Features. Water usage, although not the most significant barrier, consistently came up in different contexts, from being a renewable resource in need of protection, to an expendable one when rainwater can be utilised effectively. It had an impact on whether a project was Socially Acceptable (D). With clarity and context on the municipality's actual drought risk, information shared with the public can be used to assuage assumptions of non-sustainable actions. As both surface water bodies and groundwater are highly protected by the Austrian Water Right Act (BKA - Federal Chancellery of the Republic of Austria, 1959) potential expansions in this field should target rainwater and grey-water for irrigation of new greenery. Water Features may become a more widespread heat adaptation measure wherever KLAR! managers find it appropriate to implement.

Manager-to-Public Recommendations

- *Social Acceptance is the most important factor to concentrate on, as it has evidently created barriers to Technical Feasibility (A), Politics (C) and Priority Conflicts (D).*
    - *Managers must emphasise the urgency to act to the public through more consistent and attention-grabbing educational events*
        - » Public Speaking Courses and Standardised Presentation Materials
    - *Managers must communicate successes of their own and other municipalities' successful measures using quantifiable data*

New Projects

- *Water Features in municipalities with low drought risk*

6.3 Limitations of the Research and Further Development Opportunities

6.3.1. The Sample

The interviewed parties are all privileged by being a part of a larger supportive structure with funding and expertise, and located in municipalities which, as a baseline, are very interested in improving their local urban climate adaptation. A further extension into this research would be to find similarly sized municipalities, where no KLAR! project has yet been either attempted or approved, and evaluate their plans for heat mitigation and management. Results of this can lead to comparisons with KLAR! projects, allowing for an indication of how impactful KLAR! is as a catalyst to implement adaptive measures.

Still, KLAR! was the most accessible choice as an entry point into this field within Austria due to it's spanning across all states and standardisation of reporting and managerial roles. This is the largest organised database of heat adaptation measures of municipalities outside of capital cities which is publicly accessible for research.

The results of Research Question 1 are quantitative. Therefore, to increase the reliability of the findings, a larger sample size is necessary. As of 2025, there are over 100 registered KLAR! municipalities, and 6 is a statistically unrepresentative sample. The sample size limitation was more dependent on Research Question 2, as its methodology required distinctively more effort per case to analyse the primary data thoroughly.

A vulnerable group which was only mentioned a single time were the homeless populations in the urban areas (Interview 2). These members of society are vulnerable to heat related health impacts due to combinations of social and environmental factors. They are more exposed to the urban heat island effect, often have pre-existing medical conditions and are less likely to have social contacts to care for them in case of emergencies, similarly to the pattern of isolated old people who pass away in heat waves without quick enough interventions. Further research into how this demographic can be best supported through the continuously heating summers would therefore be apt. Austria has many initiatives focusing on protecting unhoused people from the cold in winter, and the reverse should therefore become more obvious as our awareness of the dangers related to heat increase.

6.3.2 The Methodology

Firstly, there is no one single person responsible for all aspects of heat adaptation in each municipality, so measures such as 'Personal Heat Exposure' and 'Emergency Preparedness' could not be sufficiently analysed by solely relying on KLAR! managers, whose focus is urban planning and development. While encoding the interviews, difficulties arose when certain measures were mentioned without reference as to whether they were directly KLAR!-funded projects. Some of the managers have additional jobs within their municipality, as well as being involved as generally interested citizens. Therefore, when asked about climate adaptations in their municipality, information was often given on non-KLAR!-funded projects. This complicated the encoding, as statements needed more context to be identifiable as relevant projects, but was amended with repeated cross-checking of the quotes in the process of collating the final statistics. Furthermore, the list of KLAR!-sanctioned projects are public for every municipality and were referred to at any point of unclarity.

Secondly, by using preset categories, there is a limitation to the detail of the diversity of the projects which are being implemented. Some categories are clearly specific, i.e. Urban Forestry (Code A2_C) as a part of Urban Greening (Code A2), where all projects here involved the planting of trees. Meanwhile, categories like Education (Code B3_A) within Public Health (Code B3) allowed for projects from flyers to school projects and lectures for medical professionals. A municipality may have been good at implementing one of these, while facing large barriers in pushing for the other, and this is not clearly represented with this methodology of counting the number of cases (Research Question 1). Making generalisations here regarding why they were successful or not is therefore limited at times.

However, there were also clear benefits to the chosen use of clear categories based on Keith et al. (2023). Across 6 interviews, with so many standardised questions, quantifying allowed for a more immediate comparative overview of the given answers. Although notes were taken while conducting the interview, it was clear that the tone and body language of the experts impacted the interviewer's impression of the successes of their initiatives. This contrast is particularly stark in Case 6, where the handwritten notes were overwhelmingly positive, while the later encoded results showed many struggles and barriers.

Bibliography

AK - Austrian Chamber of Labour. 2024. 'Working in the Heat'. Arbeiterkammer. 2024. https://www.arbeiterkammer.at/beratung/arbeitundgesundheit/Arbeitsumfeld/Arbeiten_bei_Hitze.html.

Akbari, H., C. Cartalis, D. Kolokotsa, A. Muscio, A.L. Pisello, F. Rossi, M. Santamouris, A. Synnefa, N.H. Wong, and M. Zinzi. 2016. 'Local Climate Change and Urban Heat Island Mitigation Techniques - The State of the Art'. *Journal of Civil Engineering and Management* 22 (1): 1–16. https://doi.org/10.3846/13923730.2015.1111934.

APCC. 2023. *APCC Special Report: Strukturen für ein klimafreundliches Leben*. Edited by Christoph Görg, Verena Madner, Andreas Muhar, Andreas Novy, Alfred Posch, Karl W. Steininger, and Ernest Aigner. Berlin, Heidelberg: Springer Spektrum: Berlin/Heidelberg. https://doi.org/10.1007/978-3-662-66497-1.

Austrian Conference on Spatial Planning. 2021. 'Austrian Spatial Development Concept - ÖREK 2030 in Brief - Need for Transformation'. Office of the Austrian Conference on Spatial Planning (ÖROK). : www.oerek2030.at.

Austrian Energy Agency. 2024a. 'Energiepreisindex: AEA - Österreichische Energieagentur'. 2024. https://www.energyagency.at/fakten/energiepreisindex.

———. 2024b. 'Zertifizierung Und Auszeichnung: E5-Gemeinden'. Programm Für Energieeffiziente Gemeinden. 2024. https://www.e5-gemeinden.at/e5-programm/zertifizierung-und-auszeichnung.

Balmain, Bryce N., Surendran Sabapathy, Menaka Louis, and Norman R. Morris. 2018. 'Aging and Thermoregulatory Control: The Clinical Implications of Exercising under Heat Stress in Older Individuals'. *BioMed Research International* 2018 (August):8306154. https://doi.org/10.1155/2018/8306154.

BKA - Federal Chancellery of the Republic of Austria. 2024. 'Baurecht und Bauordnungen'. oesterreich.gv.at - Österreichs digitales Amt. 1 January 2024. https://www.oesterreich.gv.at/themen/bauen_und_wohnen/bauen/Seite.2260200.html.

BPIE (Buildings Performance Institute Europe), ed. 2024. 'Towards a Climate Resilient Built Environment: A Discussion Paper on Opportunities and Priorities for Climate Adaptation in the EU'. https://www.bpie.eu/publication/towards-a-climateresilient-built-environment-a-discussion-paper-on-opportunities-and-priorities-for-climateadaptation-in-the-eu/.

Braunisch, Stefanie. 2024. 'Ärztemangel: Wie man die Wahlarztlücke schließt'. Materie. 24 April 2024. https://materie.at/a/aerztemangel-wie-man-die-wahlarztluecke-schliesst/.

Charmaz, Kathy. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. SAGE.

City of Vienna. 2018. ‘Urban Heat Island Strategy’. https://www.wien.gv.at/umweltschutz/raum/uhi-strategieplan.html.

———. 2020. ‘Klima-Checkliste zur Umsetzung der klimarelevanten Leitziele für Stadtentwicklung, Gestaltung und Projektierung’. Presented at the 60.STEK, Vienna, June 16.

———. 2022a. ‘Öffentliche Nebelduschen und Wasserspiele’. 13 June 2022. https://www.wien.gv.at/umwelt/cooleswien/coole-plaetze.html.

———, ed. 2022b. ‘Vienna Climate Guide - Towards a Climate-Friendly City’. Vienna City Administration. https://www.wien.gv.at/spezial/klimafahrplan/.

———. 2022c. ‘Wiener Hitzeaktionsplan’. Vienna: Magistrat der Stadt Wien. https://www.wien.gv.at/umwelt/cooleswien/hitzeaktionsplan.html.

Dare, Robert. 2019. ‘A Review of Local-Level Land Use Planning and Design Policy for Urban Heat Island Mitigation’. *Journal of Extreme Events* 06 (03n04): 2050002. https://doi.org/10.1142/S2345737620500025.

De Genaro Chiroli, Daiane Maria, Maria Gabriela Menezes, Fernanda Cavicchioli Zola, Franciely Veloso Aragão, Rafael Dezotti de Almeida, and Sergio Mazurek Tebcherani. 2023. ‘Integrating Resilience and Sustainability: A Systematic Analysis of Resilient Cities Using ISO 37123’. *International Journal of Disaster Risk Reduction* 96 (October):103960. https://doi.org/10.1016/j.ijdrr.2023.103960.

Dong, Xiuwen Sue, Gavin H. West, Alfreda Holloway-Beth, Xuanwen Wang, and Rosemary K. Sokas. 2019. ‘Heat-Related Deaths among Construction Workers in the United States’. *American Journal of Industrial Medicine* 62 (12): 1047–57. https://doi.org/10.1002/ajim.23024.

Eurostat. 2020. ‘Harmonised European Time Use Surveys’. 2020. https://ec.europa.eu/eurostat/web/microdata/harmonised-european-time-use-surveys.

Federal Ministry of Agriculture, Forestry, Environment and Water Management. 2012. ‘The Austrian Strategy for Adaptation to Climate Change, Part 1 - Context’. Vienna: lebensministerium.at. https://climate-adapt.eea.europa.eu/en/metadata/publications/national-adaptation-strategy-austria.

Global Consortium on Climate and Health Education. 2024. ‘Session 2: Extreme Temperatures’. February 13. https://www.youtube.com/watch?v=F-J5_YZ74jY.

Greenpeace. 2024. ‘Greenpeace-Analyse: Über 470 Gemeinden zukünftig von Wasserknappheit bedroht’. 18 July 2024. https://greenpeace.at/presse/greenpeace-analyse-ueber-470-gemeinden-zukuenftig-von-wasserknappheit-bedroht-grafik/.

Grossoehme, Daniel H. 2014. ‘Overview of Qualitative Research’. *Journal of Health Care Chaplaincy* 20 (3): 109–22. https://doi.org/10.1080/08854726.2014.925660.

Guan, Xin, Jiayu Wang, and Feipeng Xiao. 2021. 'Sponge City Strategy and Application of Pavement Materials in Sponge City'. *Journal of Cleaner Production* 303 (June):127022. https://doi.org/10.1016/j.jclepro.2021.127022.

Guba, Egon G., and Yvonna S. Lincoln. 1989. *Fourth Generation Evaluation*. SAGE.

Haas, Willi, Hanns Moshammer, Raya Muttarak, and Olivia Koland. 2019. 'Austrian Special Report Health, Demography and Climate Change - Summary for Policymakers'. Verlag der Österreichischen Akademie der Wissenschaften. https://doi.org/10.1553/asr18_summary.

Hansen, Alana, Peng Bi, Monika Nitschke, Philip Ryan, Dino Pisaniello, and Graeme Tucker. 2008. 'The Effect of Heat Waves on Mental Health in a Temperate Australian City'. *Environmental Health Perspectives* 116 (10): 1369–75. https://doi.org/10.1289/ehp.11339.

Heris, Mehdi P., Ariane Middel, and Brian Muller. 2020. 'Impacts of Form and Design Policies on Urban Microclimate: Assessment of Zoning and Design Guideline Choices in Urban Redevelopment Projects'. *Landscape and Urban Planning* 202 (October):103870. https://doi.org/10.1016/j.landurbplan.2020.103870.

Horváth, Ilonka, Jennifer Delcour, Astrid Krisch, and Andrea E. Schmidt. 2023. 'Nationaler Klimaresilienz-Check Gesundheit für Gemeinden und Regionen. Grundlagenbericht'. Monograph. Wien: Gesundheit Österreich. 2023. https://jasmin.goeg.at/2824/.

Keith, Ladd, Sara Meerow, Philip Berke, Joseph DeAngelis, Lauren Jensen, Shaylynn Trego, Erika Schmidt, and Stephanie Smith. 2022. *Plan Integration for Resilience Scorecard™ (PIRS™) for Heat: Spatially Evaluating Networks of Plans to Mitigate Heat (Version 1.0)*. American Planning Association. https://repository.arizona.edu/handle/10150/666313.

Keith, Ladd, Sara Meerow, Malini Roy, Shaylynn Trego, Erika Schmidt, Jack Haskins, and Bryan Leyba. 2023. 'Plan Evaluation for Heat Resilience: City of Tucson, AZ', October. https://repository.arizona.edu/handle/10150/669877.

Keith, Ladd, Sara Meerow, and Tess Wagner. 2020. 'Planning for Extreme Heat: A Review'. *Journal of Extreme Events* 06 (03n04): 2050003. https://doi.org/10.1142/S2345737620500037.

KLAR! 2024. 'KLAR! Region » KLAR! Bad Ischl - Ebensee'. KLAR! Climate Change Adaptation Model Regions for Austria. November 2024. https://klar-anpassungsregionen.at/regionen/klar-bad-ischl-ebensee.

———. 2025. 'FAQs'. KLAR! Climate Change Adaptation Model Regions for Austria. 2025. https://klar-anpassungsregionen.at/service/faqs.

Knott, Eleanor, Aliya Hamid Rao, Kate Summers, and Chana Teeger. 2022. 'Interviews in the Social Sciences'. *Nature Reviews Methods Primers* 2 (1): 1–15. https://doi.org/10.1038/s43586-022-00150-6.

Kuehn, Leeann, and Sabrina McCormick. 2017. 'Heat Exposure and Maternal Health in the Face of Climate Change'. *International Journal of Environmental Research and Public Health* 14 (8): 853. https://doi.org/10.3390/ijerph14080853.

Kurier, ed. 2024. 'Umbau Am Wiener Michaelerplatz: Kritik Ebbt Nicht Ab'. *Kurier*, May. https://kurier.at/chronik/wien/umbau-am-wiener-michaelerplatz-kritik-ebbt-nicht-ab/402899615.

Kyprianou, Ioanna, Georgios Artopoulos, Anna Bonomolo, Timothy Brownlee, Rita Ávila Cachado, Chiara Camaioni, Vladan Đokić, et al. 2023. 'Mitigation and Adaptation Strategies to Offset the Impacts of Climate Change on Urban Health: A European Perspective'. *Building and Environment* 238 (June):110226. https://doi.org/10.1016/j.buildenv.2023.110226.

Landesregierung NÖ. n.d. 'Blau-gelber Bodenbonus | NÖ Umweltbericht'. Accessed 3 June 2024. https://www.umweltbericht.at/blau-gelber-bodenbonus/.

Leitner, Markus, Katie Johnson, Andrea Carosi, Eugenio Sini, Francesca Brusa, Wolfgang Lexer, Anna Lipsanen, Johan Munck Af Rosensköld, Wouter Vanneuville, and Angelika Tamasova. 2023. 'Is Europe on Track with Climate Resilience? – Status of Reported National Adaptation Actions in 2023'. European Topic Centre on Climate change adaptation and LULUCF (ETC/CA). https://doi.org/10.25424/CMCC-5P8Y-VD45.

Lim, Theodore C., Bev Wilson, Jacob R. Grohs, and Thomas J. Pingel. 2022. 'Community-Engaged Heat Resilience Planning: Lessons from a Youth Smart City STEM Program'. *Landscape and Urban Planning* 226 (October):104497. https://doi.org/10.1016/j.landurbplan.2022.104497.

Maher, Carmel, Mark Hadfield, Maggie Hutchings, and Adam de Eyto. 2018. 'Ensuring Rigor in Qualitative Data Analysis: A Design Research Approach to Coding Combining NVivo With Traditional Material Methods'. *International Journal of Qualitative Methods* 17 (1): 1609406918786362. https://doi.org/10.1177/1609406918786362.

Meerow, Sara, Joshua P. Newell, and Melissa Stults. 2016. 'Defining Urban Resilience: A Review'. *Landscape and Urban Planning* 147 (March):38–49. https://doi.org/10.1016/j.landurbplan.2015.11.011.

Meili, Naika, Gabriele Manoli, Paolo Burlando, Jan Carmeliet, Winston T. L. Chow, Andrew M. Coutts, Matthias Roth, Erik Velasco, Enrique R. Vivoni, and Simone Fatichi. 2021. 'Tree Effects on Urban Microclimate: Diurnal, Seasonal, and Climatic Temperature Differences Explained by Separating Radiation, Evapotranspiration, and Roughness Effects'. *Urban Forestry & Urban Greening* 58 (March):126970. https://doi.org/10.1016/j.ufug.2020.126970.

Morse, Janice M. 1995. 'The Significance of Saturation'. *Qualitative Health Research* 5 (2): 147–49. https://doi.org/10.1177/104973239500500201.

Nehammer, Karl. 2024. 'Österreichplan: Das Programm - Stabilität für Österreich'. Österreichische Volkspartei. https://www.karl-nehammer.at/das-programm.

NÖ ORF. 2024. 'Innenstädte kämpfen gegen hohen Leerstand'. noe.ORF.at. 16 March 2024. https://noe.orf.at/stories/3249288/.

Orlando, Stefano, Claudia Mosconi, Carolina De Santo, Leonardo Emberti Gialloreti, Maria Chiara Inzerilli, Olga Madaro, Sandro Mancinelli, et al. 2021. 'The Effectiveness of Intervening on Social Isolation to Reduce Mortality during Heat Waves in Aged Population: A Retrospective Ecological Study'. *International Journal of Environmental Research and Public Health* 18 (21): 11587. https://doi.org/10.3390/ijerph182111587.

Oswald, Sandro M., Brigitta Hollosi, Maja Žuvela-Aloise, Linda See, Stefan Guggenberger, Wolfgang Hafner, Gundula Prokop, Alexander Storch, and Wolfgang Schieder. 2020. 'Using Urban Climate Modelling and Improved Land Use Classifications to Support Climate Change Adaptation in Urban Environments: A Case Study for the City of Klagenfurt, Austria'. *Urban Climate* 31 (March):100582. https://doi.org/10.1016/j.uclim.2020.100582.

———. 2021. 'Supporting Climate Adaptation Measures in Small- to Medium-Sized Austrian Cities Using Climate Modelling'. In *Advanced Studies in Efficient Environmental Design and City Planning*, edited by Ferdinando Trapani, Nabil Mohareb, Federica Rosso, Denia Kolokotsa, Sreetheran Maruthaveeran, and Mahmoud Ghoneem, 405–13. Advances in Science, Technology & Innovation. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-65181-7_32.

Oswald, Sandro, Maja Žuvela-Aloise, Michael Avian, and Chris Schubert. 2022. 'Future Climate Projection of Heat Indices for Austrian Major Cities: Strengthening Urban Resilience and Meeting User Needs'. Edited by ZAMG and TU Wien. *Ilmastokatsaus* 4 (1). https://doi.org/10.35614/ISSN-2341-6408-IK-2022-08-RL.

Patel, Lisa, Kathryn C. Conlon, Cecilia Sorensen, Samia McEachin, Kari Nadeau, Khyati Kakkad, and Kenneth W. Kizer. 2022. 'Climate Change and Extreme Heat Events: How Health Systems Should Prepare'. *NEJM Catalyst* 3 (7). https://doi.org/10.1056/CAT.21.0454.

Renner, Anna-Theresa. 2020. 'Inefficiencies in a Healthcare System with a Regulatory Split of Power: A Spatial Panel Data Analysis of Avoidable Hospitalisations in Austria'. *The European Journal of Health Economics* 21 (1): 85–104. https://doi.org/10.1007/s10198-019-01113-7.

Santamouris, Mat. 2007. 'Heat Island Research in Europe: The State of the Art'. *Advances in Building Energy Research* 1 (January):123–50. https://doi.org/10.1080/17512549.2007.9687272.

Snep, Robbert PH, Joris GWF Voeten, Gerben Mol, and Tim Van Hattum. 2020. 'Nature Based Solutions for Urban Resilience: A Distinction Between No-Tech, Low-Tech and High-Tech Solutions'. *Frontiers in Environmental Science* 8. https://www.frontiersin.org/articles/10.3389/fenvs.2020.599060.

Statista. 2024. 'Road Deaths in Austria in 2023'. Statista. 26 June 2024. https://www.statista.com/statistics/1342461/traffic-crashes-fatally-injured-austria/.

Statistics Austria. 2023. 'Sanierungsmaßnahmen und Anzahl der Klimaanlagen in Österreich – Juli 2020 bis Juni 2022'. Spreadsheet. https://www.statistik.at/fileadmin/pages/100/10SanierungsmassnahmenKlimaanlagen20212022.ods.

———. 2024. ‘Austria: Urbanization from 2013 to 2023’. Statista. 1 October 2024. https://www.statista.com/statistics/455779/urbanization-in-austria/.

Stewart, I. D. 2011. ‘A Systematic Review and Scientific Critique of Methodology in Modern Urban Heat Island Literature’. *International Journal of Climatology* 31 (2): 200–217. https://doi.org/10.1002/joc.2141.

Stoneman, Paul, and Giuliana Battisti. 2010. ‘Chapter 17 - The Diffusion of New Technology’. In *Handbook of the Economics of Innovation*, edited by Bronwyn H. Hall and Nathan Rosenberg, 2:733–60. Handbook of the Economics of Innovation, Volume 2. North-Holland. https://doi.org/10.1016/S0169-7218(10)02001-0.

Stults, Missy, and Sierra C. Woodruff. 2017. ‘Looking under the Hood of Local Adaptation Plans: Shedding Light on the Actions Prioritized to Build Local Resilience to Climate Change’. *Mitigation and Adaptation Strategies for Global Change* 22 (8): 1249–79. https://doi.org/10.1007/s11027-016-9725-9.

Tong, Peihao. 2021. ‘Characteristics, Dimensions and Methods of Current Assessment for Urban Resilience to Climate-Related Disasters: A Systematic Review of the Literature’. *International Journal of Disaster Risk Reduction* 60 (June):102276. https://doi.org/10.1016/j.ijdrr.2021.102276.

Trimmel, Heidelinde, Philipp Weihs, Jürgen Preiss, Michael Revesz, Imran Nadeem, Kristofer Hasel, and Herbert Formayer. 2020. ‘Auswirkung von Klimawandel und Stadtentwicklung auf thermische Belastung während Hitzewellen in Wien’. 28. CCCA Factsheet. Graz: CCCA - Climate Change Centre Austria. https://ccca.ac.at/wissenstransfer/themenaufbereitungen/hitze-duerre.

Tsuzuki, Kazuyo. 2023. ‘Effects of Heat Exposure on the Thermoregulatory Responses of Young Children’. *Journal of Thermal Biology* 113 (April):103507. https://doi.org/10.1016/j.jtherbio.2023.103507.

Umweltbundesamt. 2020. ‘Klimaschutzbericht 2020’. Report REP-0738. Vienna. https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0738.pdf.

UN DESA. 2024. ‘Urbanisierung Österreich 2022’. Statista. 16 March 2024. https://de.statista.com/statistik/daten/studie/217716/umfrage/urbanisierung-in-oesterreich/.

USGCRP. 2018. ‘Fourth National Climate Assessment’. U.S. Global Change Research Program, Washington, DC. https://nca2018.globalchange.govhttps://nca2018.globalchange.gov/chapter/14.

Vicedo-Cabrera, Ana M. 2024. ‘Heat and Illness’. In *The Climate Book*, by Greta Thunberg, 2nd ed., 137–39. Penguin Random House UK.

Watts, Nick, Markus Amann, Sonja Ayeb-Karlsson, Kristine Belesova, Timothy Bouley, Maxwell Boykoff, Peter Byass, et al. 2018. ‘The Lancet Countdown on Health and Climate Change: From 25 Years of Inaction to a Global Transformation for Public Health’. *The Lancet* 391 (10120): 581–630. https://doi.org/10.1016/S0140-6736(17)32464-9.

World Bank. 2020. *Analysis of Heat Waves and Urban Heat Island Effects in Central European Cities and Implications for Urban Planning*. World Bank, Washington, DC. https://doi.org/10.1596/34335.

WWF Austria. 2024. 'Tatort Kaunertal #3: Wasserkraft - Die unsichtbare Gefahr'. *WWF Österreich* (blog). 2 April 2024. https://www.wwf.at/artikel/tatort-kaunertal-3-wasserkraft-die-unsichtbare-gefahr/.

Appendix

A: Interview Participant Consent Form (German)

Information für Teilnehmende und Einwilligungserklärung

Masterarbeit zum Thema Hitzeresilienzpläne Österreichischer Städte

Sehr geehrte/r Interviewteilnehmer/in!

Herzlichen Dank für Ihre Bereitschaft, an einem Interview teilzunehmen. Dieses Interview führe ich im Zuge meiner Masterarbeit durch. Dabei möchte ich erforschen, wie oft und auf welche Arten Hitzeresilienz in den Plänen von urbanen Räumen in Österreich auftaucht. Der Zweck der Forschung ist es, einen Eindruck der jetzigen Situation zu bekommen, um Schwächen und Verbesserungsmöglichkeiten zu identifizieren.

Das Interview wird aufgezeichnet, um eine spätere Analyse zuzulassen. Nur ich und mein Betreuer werden Zugriff auf die Aufnahme haben. Nach dem Abschluss der Masterarbeit wird die Aufnahme zudem permanent gelöscht. Alle auf der Aufnahme aufbauenden Transkripte werden anonymisiert und ebenfalls nach der Beendigung der Masterarbeit Ende Mai 2024 gelöscht.

In der Arbeit werden keine Namen der interviewten Personen publiziert, die Stadt-Gemeinden und Regionen werden aber identifizierbar sein.

Bis zu der Fertigstellung der Arbeit Ende Mai 2024 können Sie jegliche Informationen sowie die gesamte Partizipation widerrufen. Zudem haben Sie ein Recht auf Auskunft über Ihre personenbezogenen Daten.

Diese Rechte können Sie unter dem angegebenen Kontakt geltend machen.

Kontakt:

Agnes Widensky & Dr. Iosif Botetzagias

Mail: Agnes.widensky@mespom.eu & Iosif@aegean.gr

Tel: -

Einwilligungserklärung „Hitzeresilienzpläne“

Name der/des Teilnehmerin/Teilnehmers in Druckbuchstaben:
....

Ich habe dieses Informationsschreiben gelesen und verstanden. Alle meine Fragen wurden beantwortet und ich habe zurzeit keine weiteren Fragen mehr.

Mit meiner persönlich datierten Unterschrift gebe ich hiermit freiwillig mein Einverständnis zur Teilnahme an einem Interview.

Ich weiß, dass ich diese Einwilligung jederzeit und ohne Angabe von Gründen widerrufen kann.

....

(Datum und Unterschrift der/des Teilnehmerin/Teilnehmers)

B: Interview Participant Consent Form (English)

Information for Participants and Declaration of Consent

Master's thesis on the topic of heat resilience plans of Austrian cities

Dear interview participant!

Thank you very much for your willingness to take part in an interview. I am conducting this interview as part of my Master's thesis. I would like to investigate how often and in what ways heat resilience appears in the plans of urban areas in Austria. The purpose of the research is to get an impression of the current situation in order to identify weaknesses and opportunities for improvement.

The interview will be recorded to allow for later analysis. Only my supervisor and I will have access to the recording. Once the Master's thesis has been completed, the recording will also be permanently deleted. All transcripts based on the recording will also be anonymised and deleted after completion of the Master's thesis at the end of May 2024.

The names of the interviewees will not be published in the thesis, but the municipalities and regions will be identifiable.

Until the completion of the thesis at the end of May 2024, you can revoke any information and the entire participation. You also have the right to access your personal data.

You can assert these rights using the contact details provided.

Contact us:

Agnes Widensky & Dr. Iosif Botetzagias

Mail: Agnes.widensky@mespom.eu & Iosif@aegean.gr

Tel: -

Declaration of Consent 'Heat Resilience Plans'

Name of the participant in block capitals:

....

I have read and understood this information letter. All my questions have been answered and I have no further questions at this time.

With my personally dated signature, I hereby voluntarily give my consent to participate in an interview.

I know that I can revoke this consent at any time and without giving reasons.

....

(Date and signature of the participant)

C: Keith et al's (2022) definitions of Heat Mitigation Strategies and Subcategories

Table 4. Heat mitigation strategy categories and subcategories

Categories (bold) and subcategories	Definitions
Land use	
Urban development patterns	Urban development pattern is defined as a special pattern of human activity in a certain point and certain time. It includes two main categories of horizontal expansion or urban dispersion and the pattern of a compact city.
Roadways and parking lots	The use of manmade materials (asphalt, concrete used for parking lots and roadways) in urban areas are one of the main (if not the single largest) contributors to the urban heat island effect. Asphalt/concrete have low albedos and high heat capacities, meaning that solar radiation is mostly absorbed and reemitted as heat. There are ways to mitigate the impacts of roadways and parking lots, like using reflective surfaces, reducing, or eliminating parking lot requirements, "right-sizing" existing streets (e.g., road diets) and planning for new more narrow streets. (e.g., complete streets)
Ventilation corridors	An urban area that allows fresh air to flow through a city to mitigate the urban heat island effect, increase ventilation, or generally improve the climate. (e.g., wind corridors, urban canyon)
Land conservation	Protecting natural land and returning developed land to its natural form. This also includes the preservation of working agricultural land and natural open space outside of a city. (e.g., smart growth, infill development, urban growth boundaries)
Urban design	
Street and building orientation	Solar, wind, and drainage elements that are considered in the orientation of streets and buildings to alleviate reduce waste heat and mitigate urban heat.
Building shape and massing	Massing is the overall, basic shape of a building. The more compact a building is, the less amount of roof and wall exposure to the sun, making it easier to cool.
Shade structures	Built shade structure designed for pedestrian use and protection from direct sun, which can be either attached to a building or free-standing. (e.g., playground shade structures, ramadas, pergolas, awnings, canopies, arbors, and canvas)
Cool pavements	Reflective surface coating for streets or sidewalks that store less heat and may have a lower temperature. (e.g., cool sidewalks, reflective coating)
Urban greening	
Urban forestry	The planting, maintenance, care and protection of tree populations, such as shade trees, in urban settings. Urban forestry can be found in parks, gardens, landscaped boulevards, greenways, and street-side tree boxes.
Vegetated parks and open space	Broadly, the network of planned and unplanned green spaces within a city, spanning both the public and private realms, and managed as an integrated system to provide a range of benefits. (e.g., parks, greenways; passive, active, and/or natural recreation areas)

Green stormwater infrastructure	Approaches designed to capture, infiltrate, or evapotranspirate stormwater close to where it falls, reducing the volume entering sewer systems or water bodies, often with permeable or vegetated elements. (e.g., bioswales, rain gardens, cisterns, and basins)
Green walls and roofs	Elements of green infrastructure on buildings that utilize living vegetation to increase the cooling inside and outside and reduce stormwater runoff. (e.g., living roofs and walls)
Water features	Elements like pools, ponds, fountains, splash parks, natural water features, artificial waterfalls, and streams can help to decrease the urban heat island effects. Note: does not include green stormwater infrastructure.
Waste heat	
Building energy efficiency	A reduction in the unused energy required to operate a building that is released to the environment in the form of thermal energy. Waste heat can be recovered and used to decrease energy consumption. (e.g., LEED requirements, efficient HVAC systems, sustainable and/or green building requirements)
Cool roofs and walls	A roofing system that delivers higher reflectance and absorbs lower amounts of solar radiation, compared to conventional materials, to reduce surface temperature. Cool walls are exterior walls with high albedo, which helps to keep the inside cooler and decrease the urban heat island effect due to the exterior walls of the building. (e.g., white painted roofs and walls, reflective roofs and walls)
Transportation	Any approach that reduces waste heat from traditional fossil fuel-powered vehicles. This includes land use and infrastructure changes that support active transportation modes (e.g., walking and bicyling), transit use (e.g., bus, light rail, train, etc.), and the transition to hybrid and electric vehicles (EV) (e.g., EV charging stations, EV residential charging).

Adapted from Keith & Meerow (2022).

D: Results Table for Research Question 1

Code	Criteria	Cases number	1	2	3	4	5	6
A1	Waste Heat							
A1_A	Building Waste Heat reduction programs	3	x			x	x	
A1_B	Vehicle waste heat reduction	1			x			
A1_C	Cool roofs and walls	1				x		
A2	Urban Greening							
A2_A	Vegetated Parks and Open Spaces	3	x	x		x		
A2_B	Green Roofs and Walls	3		x	x		x	
A2_C	Urban Forestry	6	x	x	x	x	x	x
A2_D	Water Features	0						
A2_E	Green Stormwater Infrastructure	1		x				
A3	Urban Design							
A3_A	Built Shade Structures	4		x	x	x	x	
A3_B	Cool Pavements	0						
A3_C	Building Shape and Massing	1		x				
A3_D	Building Street Orientation	0						
A4	Land Use							
A4_A	Ventilation Corridors	1	x					
A4_B	Land Conservation	1		x				
A4_C	Urban Development Patterns	1	x					
A4_D	Roadways and Parking Lists	4	x	x	x		x	
B1	Energy							
B1_A	Indoor cooling	1	x					
B1_B	Grid resilience	2	x		x			
B1_C	Accessible and affordable energy	0						
B2	Personal Heat Exposure							
B2_A	Transit System Operations	0						
B2_B	Parks and Trails operations	0						
B2_C	School operations	0						
B2_D	Occupational safety operations	0						
B3	Public Health							
B3_A	Education and awareness	5	x	x	x	x	x	
B4	Emergency Preparedness							
B4_A	Early Warning Systems	0						
B4_B	Heat Response Plan	1					x	
B4_C	Cooling Centers and resilience	0						
BONUS	E5/E4 region?			x				
	Total Projects by Town		9	9	6	6	7	1
	out of 27 possible subcategories of adaptation projects							

E: Condensed Results Table for Research Question 1

This Table supplied the values for Diagram 3, in the Results chapter

Code	Criteria	Cases number	1	2	3	4	5	6
A1	Waste Heat	5	1	0	1	2	1	0
A2	Urban Greening	13	2	4	2	2	2	1
A3	Urban Design	5	0	2	1	1	1	0
A4	Land Use	7	3	2	1	0	1	0
B1	Energy	3	2	0	1	0	0	0
B2	Personal Heat Exposure	0	0	0	0	0	0	0
B3	Public Health	5	1	1	1	1	1	0
B4	Emergency Preparedness	1	0	0	0	0	1	0

F: Results Table for Research Question 2

					Cases / Interviews						
Category	Code	Subcateg	Number of Mention	Total Mentions	1	2	3	4	5	6	Number
Technical Feasibility	C1	Positive	4	8	0	0	0	1	2	1	3
Technical Feasibility	C1	Negative	4		1	0	0	2	0	1	3
* Geography	C1_G	Positive	1	3	1	0	0	0	0	0	1
* Geography	C1_G	Negative	2		0	0	0	0	0	2	1
Money	C2	Positive	9	35	3	2	2	2	0	0	4
Money	C2	Negative	26		6	2	5	3	4	6	6
Politics	C3	Positive	18	28	1	3	2	3	6	3	6
Politics	C3	Negative	10		1	0	2	3	2	2	5
Social Acceptance	C4	Positive	12	36	1	1	2	3	3	2	6
Social Acceptance	C4	Negative	24		3	2	7	7	2	3	6
Category	C5	Positive	10	31	1	1	1	4	2	1	6
Priority Conflicts	C5	Negative	21		3	6	4	4	1	3	6
				Total Categories	10	7	8	10	8	10	
			Number of mentions =	Positives	7	7	7	13	13	7	54
				Negatives	14	10	18	19	9	17	87

H: Expanded Results Table for Research Question 2

Includes additional case-specific notes for linking between locations, project types and factors impacting success. Used as reference in the Discussion chapter.

					Cases / Interviews							
Category	Code	Subca	Number Mentio	Total Menti	1	2	3	4	5	6	Number c Cases	Notes
Technical Feasibility	C1	Positive	4	8	0	0	0	1	2	1	3	Int4,5:Drone Flights, Int5: website tool, Int6: trees
Technical Feasibility	C1	Negative	4		1	0	0	2	0	1	3	Int4,6: greenery upkeep, incl salt in winter
* Geography	C1_G	Positive	1	3	1	0	0	0	0	0	1	Int1: talks are visited if topic is locally relevant
* Geography	C1_G	Negative	2		0	0	0	0	0	2	1	Int6: proximity to water removes desire for water
Money	C2	Positive	9	35	3	2	2	2	0	0	4	Int2: more money wouldn't make a difference, Int3: money from State/Land und Bodenbonus, Int4: large towns have own funding, got 90% funding for drone
Money	C2	Negative	26		6	2	5	3	4	6	6	Int1:10-15k over 3 years for a project is insufficient, time limited funding,only 2 trees per townsponge city expensive!, Int2: Vienna is richer, Int3: Entsiegelungsfunding only for large projects, renaturierungsfunding decreased bc of Covid, Int5&6: don't immediately get all the money from start, but afterwards, so towns need to have it
Politics	C3	Positive	18	28	1	3	2	3	6	3	6	Int2: sexy to have good projects to show off, Int4: Possibility of lobbying to be put into ÖEK Örtliches Entwicklungskonzept, Carynthia already has heatwave plan, Int5: always supportive towns, bauordnung limits the versiegelung per build - 10% green for industry. Int6: mayor supportive
Politics	C3	Negative	10		1	0	2	3	2	2	5	Int1: more pressing priorities, Int4: bureaucracy is slow, the larger the town the slower, very dependant on mayors' stances, Can put off pop bc seems v top-down
Social Acceptance	C4	Positive	12	36	1	1	2	3	3	2	6	Int1: no rejected projects rn, Int3&4: care workers have good understanding of heat, everyone loves trees, Int4: Unis focus on this topic now more, the more people are affected, the more they understand
Social Acceptance	C4	Negative	24		3	2	7	7	2	3	6	Int1&2&3: w private property all up to individuals and they need examples to agree (Int3: more important than politics), Int2: pop unaware of KLAR , Int3: roof/wall greening still unfamiliar, heat is 'uncool' topic, fight against PV areas bc misinformed, Int4: opinions re:trees change quickly, NIMBY!, not taken seriously, Int6: even if want trees still NIMBY, would be better if pop FELT cc effects
Category	C5	Positive	10	31	1	1	1	4	2	1	6	Int1: KLAR is flexible and can add to other progress, Int3: trees also used to slow traffic, Int4: with leader-regions and tourism regions and ÖEK, trees are also aesthetic bonuses, Int5: agriculturw w their water-saving adds support to KLAR ideas, Int6: not using russian gas to heat is also social
Priority Conflicts	C5	Negative	21		3	6	4	4	1	3	6	Int1&3: parking space loss, Int2: moors vs agrarian land expansion, green walls ugly, bureaucracy, Int3: transport>cc, water waste, Int1&4: NIMBY, bikes>ecars, water,
				Total Categ	10	7	8	10	8	10		
			Number of me	Positives	7	7	7	13	13	7	54	
				Negatives	14	10	18	19	9	17	87	
											Total mentions	