ADAPTING TO RISING TEMPERATURES

Heatwave risk governance in Rotterdam's social housing

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ABSTRACT

The frequency and intensity of heatwaves increases because of climate change, particularly in urban areas. Existing houses within the rental housing sector are vulnerable to heat, as heat-alleviating measures are often lacking. Both the comfort and health of residents are negatively affected by this trend. The current study dives into the implementation of heat management strategies in existing rental housing in Rotterdam, along with the division of responsibilities between housing associations, local governments, and residents within the implementation process.

By conducting interviews with housing associations, municipal actors, and residents, combined with analyses of various documents, a qualitative approach is followed. The development of heat management policies in the rental housing sector is still in an early stage, resulting in a fragmented response. Housing associations apply differing strategies towards making their houses more heat-resilient: some conduct pilot projects with sun-shading systems, while others integrate the heat measures into planned maintenance. Governmental support is provided via municipal subsidies but lacks regulatory enforcement. Residents face both financial and practical barriers to implement heat adaptation measures. The absence of clear responsibilities and legal obligations hinders the establishment of a structured and coordinated approach to heat management. These findings underline the need for integrated policies that engage all relevant stakeholders.

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INTRODUCTION

Global temperatures have been rising at an accelerating rate, with the pace of global warming more than doubling the past two decades (KNMI, 2023). While rising sea levels are often highlighted as an effect of global warming, the impact on people and their environments is significant. One major concern is the increasing frequency of summer heatwaves (Perkins-Kirkpatrick & Lewis, 2020). The World Meteorological Organization defines a heatwave as prolonged excessive heat, with temperatures significantly above seasonal averages, lasting multiple days and nights (WMO, 2023). The Royal Netherlands Meteorological Institute (KNMI) predicts that both overall temperatures and heatwaves will continue to rise (KNMI, 2023).

Moreover, urban areas are especially vulnerable to rising temperatures due to their unique characteristics. They tend to experience higher heat levels than rural regions, a phenomenon known as the Urban Heat Island effect (Chapman et al., 2017; Kleerekoper et al., 2011). This effect is caused by the high density of buildings and paved surfaces, which absorb and retain heat. In Rotterdam, temperature differences of up to 8°C have been reported between urbanized areas and green, low-rise neighbourhoods (Nationaal Onderzoekprogramma Kennis voor Klimaat et al., 2011).

HEATWAVES, HEALTH, AND HOUSING

Given these urban temperature changes, the effects of heatwaves on health and housing conditions become crucial to understand. Heatwaves pose significant risks to both the environment and human health. One major health issue caused by heatwaves is heat stress, which leads to increased mortality and morbidity, as well as adverse pregnancy outcomes (Ebi et al., 2021; Kovats & Hajat, 2007). Heat stress refers to the negative effects of prolonged exposure to high temperatures. Heat stress can lead to poor sleep, behavioural changes, reduced productivity, and discomfort. More severe cases can lead to kidney failure, stroke, and respiratory problems, of which extreme cases are potentially fatal (TNO, n.d.). Vulnerable groups such as the elderly, those with pre-existing conditions, and low-income populations are particularly affected by heat stress, with rising mortality rates and heat stress incidences (Takahashi et al., 2007).

Housing conditions play a crucial role in mitigating heat-related risks. Adaptations such as air-conditioning or improved ventilation can significantly reduce the impact of heat stress (Kovats & Hajat, 2007). As hospital admissions typically rise during heatwaves, application of appropriate measures helps alleviate pressure on healthcare systems (Bishop-Williams et al.,

2015). Thus, developing effective strategies to manage and mitigate heat stress is essential for improving public health and preventing further strain on health services.

In the Netherlands, housing plays a vital role in creating healthy living environments by maintaining stable indoor temperatures and preventing exposure to extreme heat. However, many homes, especially traditional "doorzonwoningen" designed to maximize natural light, are poorly equipped to manage rising heat. As Runhaar et al. (2012) emphasize, factors like shading, material reflectivity, and building density are key in both managing and reducing urban heat. Modern housing designs should prioritize adequate shading and reflective materials, rather than focusing on insulation and natural light. This is especially important for residents of rental housing, as they often lack the permission to make modifications, such as installing sun shutters (Salomons & Woutersen, 2024). Additionally, they may not have the financial means to invest in heat-mitigation measures. Low-income residents, who are more likely to live in rental housing, are especially vulnerable to climate-related health issues, such as heat stress (Van Daalen et al., 2024). Given these factors, residents of rental housing are at an elevated risk for heat stress and its associated consequences.

STRATEGIES AND GOVERNANCE

To address the elevated vulnerability of residents of rental housing to heat stress, two primary strategies are commonly used: heat mitigation and heat management (Keith et al., 2023). Heat mitigation strategies aim to reduce heat in the built environment through measures such as land use changes, neighbourhood and site-level urban design, urban greening, and reducing waste heat. Heat management, on the other hand, tackles extreme heat events through emergency preparedness, personal heat exposure reduction, and addressing chronic heat risks. While much research has focused on heat mitigation (Sheehan et al., 2022; Taleghani, 2018), heat management remains underexplored, especially in terms of responsibility for its implementation.

Effective heat management requires collaboration between the municipality, rental associations, and residents, with clear responsibilities defined for both parties (Mees et al., 2012). Housing associations must provide adequate measures and support vulnerable residents, while tenants should be empowered to act in their own homes. However, governance gaps persist. The division of responsibilities between local governments, housing associations, and residents remains vague (Mees et al., 2014), leading to fragmented or insufficient responses to heat stress (Runhaar et al., 2012). Compounding this, renters often

lack the autonomy and resources needed to undertake the necessary heat adaptation measures themselves (Salomons & Woutersen, 2024).

RESEARCH RELEVANCE

Considering these challenges, it is essential to gain a deeper understanding of how vulnerable populations, especially low-income tenants in rental housing, can be effectively protected against urban heat. This research contributes to this societal need by analysing how housing associations currently approach heat stress and how residents perceive and experience these measures. The findings aim to support the development of more equitable and effective policies that improve living conditions, protect public health, and empower tenants who often lack the means or authority to act themselves.

From a scientific perspective, the study builds upon existing literature on urban heat adaptation by focusing not on mitigation alone but on the governance of heat management in the housing sector, an area that remains underexplored. By exploring the responsibility and combining it with empirical insights from the Rotterdam context, this research offers a more nuanced understanding of how responsibilities between municipalities, housing associations, and residents are currently distributed.

RESEARCH AIM AND STRUCTURE

This study seeks to address the implementation responsibility and the governance gap regarding heat stress by investigating the following research question:

How are heat management strategies implemented to reduce indoor heat stress in existing rental housing in Rotterdam, and what role do housing associations, local governments, and residents play in the implementation?

This central question will be explored through the following sub-questions:

- *What policies and regulations currently exist at the municipal and national levels regarding heat management in rental housing, and who is responsible?*
- *How do residents in rental housing experience heat (stress) during summer?*
- *What informal or self-initiated heat management practices exist within rental housing?*
- *What measures do housing associations take to mitigate heat stress in existing social renting housing?*

- *What barriers do housing associations and local governments face in implementing heat management strategies, and what recommendations can be made for future heat management plans?*

The structure of this thesis begins with the development of a theoretical framework, introducing key concepts and models relevant for the study. This is followed by a description of the research methods used for data collection. The empirical findings, derived from interviews and policy document analysis, are then presented and analysed, leading into a discussion of the findings. Finally, the thesis concludes with a summary of key insights and a critical reflection on the results and their broader implications.

THEORETICAL FRAMEWORK

DIVISION OF RESPONSIBILITY IN HEAT MANAGEMENT

Addressing heat stress in urban environments requires clarity on the division of responsibilities regarding the implementation of effective strategies (Mees et al., 2012). This clarity could help identify barriers housing associations face regarding heat management strategies. While research has explored the issue of responsibility for heat management and protection, no clear answer was found. Currently, heat management is being viewed as a shared public and private responsibility (Mees et al., 2012), leading to confusion among stakeholders and an increased risk of vulnerable stakeholders falling through the cracks, as no single actor feels fully accountable for implementing protective measures.

To better understand the division of tasks and roles, it is important to first clarify the concept of public responsibility in the context of heat management. Public responsibility is primarily assigned to government institutions, such as the central government and municipalities. These actors have a duty of care to protect public health and are responsible for establishing policy frameworks and regulations to safeguard vulnerable groups from the effects of heat (Mees et al., 2014). Examples of this include developing heat warning systems and urban heat maps. This public responsibility is considered essential, particularly because vulnerable populations often lack the capacity or resources to implement protective measures themselves. Moreover, heat stress management involves collective risks and unequal vulnerabilities that require coordinated, large-scale interventions, something only government institutions can effectively provide (Mees et al., 2014; Uittenbroek et al., 2022). The central government is seen as the party responsible for ensuring the safety of vulnerable citizens who are unable to organise protection themselves (Uittenbroek et al., 2022). Additionally, responsibilities for preventing and managing heatwave risks have shifted from national to regional and local authorities (Vanderplanken et al., 2021), emphasizing the importance of localized interventions in reducing heat-related health risks.

While the public sector holds an official duty of care, the way this responsibility is perceived and enacted in practice can differ. Gaining deeper insight into this gap between formal and perceived responsibilities, Mees et al. (2014) explored heat management responsibilities through focus groups and case studies of cities with existing heat stress policies. They compared perceived versus actual responsibilities in heat management and found that protecting vulnerable citizens from heat stress is viewed as a public duty. This is primary because vulnerable populations often lack the necessary resources, knowledge, or capacity to protect themselves effectively against extreme heat (Few et al., 2007). Therefore,

from a societal perspective, governments hold a duty of care to safeguard public health and reduce inequalities in exposure and vulnerability to heat hazards (Ebi & Semenza, 2008).

Even though governmental institutions hold a primary public responsibility, non-governmental actors also play an essential role in heat management. According to Mees et al. (2012, 2014) and Uittenbroek et al. (2022), private responsibility refers to tasks and actions that non-governmental actors, such as residents or organisations, voluntarily undertake to reduce heat-related risks in their immediate environment.

Among these actors, housing associations occupy a particularly complex position; while often treated as private actors, their role extends beyond that definition. As Helderman (2007) argues, housing associations in the Netherlands are hybrid organisations: they operate with a private legal status but fulfil public duties, such as ensuring access to affordable and healthy housing. This dual character places them in an ambiguous position, balancing market incentives, public incentives, public expectations, and societal needs (Conforth & Spear, 2010). Helderman emphasizes that while these organisations are semi-autonomous, they are still expected to serve collective goals, without the state directly steering or financing all activities.

Other private actors include healthcare institutions and individual citizens. These actors are responsible for implementing measures such as home insulation, providing care during heatwaves, and creating living environments aimed at reducing indoor and outdoor heat. The involvement of both private and hybrid actors is crucial, as many heat-alleviating measures need to be applied at the building or household level, spaces where government influence is limited. Moreover, both private and hybrid actors are often in closer contact with vulnerable residents than public actors, making them best positioned to respond quickly and effectively to heat-related risks.

In contrast to public responsibility, private and hybrid responsibilities are typically less strictly regulated and more dependent on voluntary cooperation and personal initiative of stakeholders (Runhaar et al., 2021; Groven et al., 2012). In addition to institutional actors, individual citizens also play a role in reducing heat-related health risks. While individuals are encouraged to manage their personal heat exposure, community-based strategies such as a buddy system, where neighbours, friends, and family check on vulnerable people, has also been suggested (Lane et al., 2013). Such community-based strategies will help reaching residents who cannot be reached through formal structures (Guardaro et al., 2022).

At the individual level, private responsibility translates into concrete actions and choices that residents must make to protect themselves and their homes against heat stress. This

includes personal measures, such as installing sun shutters in social rental housing (Mees et al., 2014). Research shows that people who perceive heat as a risk are more likely to take heat management measures (Beckmann & Hiete, 2020). For these measures to be effective, residents need to acknowledge that heat could be a serious risk. Moreover, residents should be aware of the possible risks and consequences of heat stress on their health; otherwise, they might not apply sufficient coping strategies. All of this underlines the importance of effective communication and education about heatwaves and its associated risks. However, simply providing information is not always sufficient. Few et al. (2007) argue that communication is not only about raising awareness but must also involve meaningful engagement that supports residents to act. Effective communication therefore includes locally tailored messaging and communication suited for different linguistic and cultural backgrounds.

Importantly, the capacity to recognize and respond to heat risks varies significantly among residents, raising key questions about equity and the allocation of support mechanisms. Nonetheless, not all residents can manage this responsibility, highlighting the need to balance empowerment with fairness. The study of Mees et al. (2014) stresses the importance of a tailored approach to heat management that considers the varying capacities and vulnerabilities within communities, ensuring that protective measures are both inclusive and effective.

Overall, actors such as the central government and municipalities hold a public responsibility to develop policies and warning systems (Mees et al., 2012; Mees et al., 2014). They have a duty of care to protect public health and reduce inequalities among citizens (Ebi & Semenza, 2008; Uittenbroek et al., 2022). Private responsibility lies primarily with individual residents, who are expected to take protective actions during extreme heat and support vulnerable neighbours (Mees et al., 2014; Lane et al., 2013). In addition, housing associations, although sometimes considered private actors, occupy a hybrid position. They are privately governed but fulfil public duties, such as maintaining living conditions for tenants (Helderman, 2007). As such, they can be seen as hybrid actors who combine private autonomy with public responsibilities.

Housing associations are expected to inform tenants and implement heat-alleviation measures, yet they are dependent on the frameworks and incentives provided by public authorities, which can limit their capacity to limit individually (Mees et al., 2012; Vanderplanken et al., 2021). This dual positioning contributes to the ambiguity in the division of responsibilities. On the one hand, housing associations are tasked with implementing measures, while on the other hand, residents are also expected to take initiative (Mees et al., 2012; Groven et al., 2012).

This overlap and interdependence can create confusion about who is responsible for which actions (Mees et al., 2014). Therefore, clearer coordination and increased interaction among these actors are essential to ensure that responsibilities are shared effectively and no vulnerable individuals are left unprotected (Runhaar et al., 2021; Mees et al., 2014).

RISK GOVERNANCE FRAMEWORK

Since multiple stakeholders engage in heat management strategies, it is important to develop a structured approach for assessing the risks associated with heatwaves (Lass et al., 2011). Establishing such a framework fosters collaboration between housing associations and residents. Research emphasized the importance of coordination, cooperation, and learning in improving warning systems and forecasting for heatwaves (Lange et al., 2013). Moreover, evidence shows that the effectiveness of heat warning systems relies heavily on clear communication and stakeholder engagement to ensure protective actions are taken, particularly among vulnerable populations (Toolo et al., 2013). These principles are reflected in the risk governance framework, which outlines four key steps for effective risk management (Lass et al., 2011). The structured governance approach and effective communication strategies are not only essential for enhancing heat warning systems but also crucial for developing and implementing heat management measures within homes (Vanderplanken et al., 2021; Berger et al., 2022).

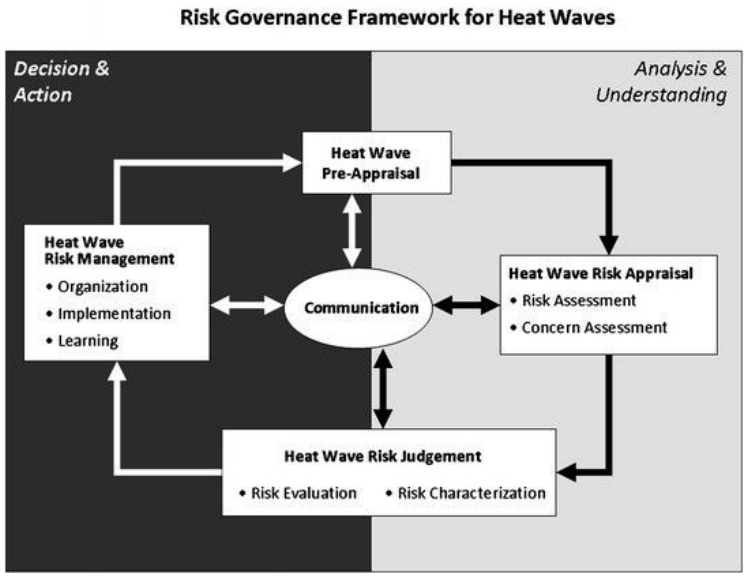

Figure 1: Risk governance framework (Lass et al., 2011)

The first step, heatwave risk pre-appraisal and appraisal, includes risk assessment and concern assessment to establish a mutual understanding of the risks and societal concerns associated with heatwaves (Lass et al., 2011). In this step, residents and housing associations must engage in open conversations about their perceptions of heat stress (Mees et al., 2014). Therefore, facilitating two-way communication between residents and housing associations is crucial for developing a shared understanding and effective risk governance.

The second step, heatwave risk judgement, bridges analysis and action by involving risk characterization and the evaluation of ethical and sector-specific consequences (Lass et al., 2011; Terpstra, 2011). For this step, housing associations need a clear understanding of the existing regulations and policies on heat management within rental properties (Vanderplanken et al., 2021). Achieving this requires collaboration between local governments and housing associations (Groven et al., 2012).

The third step, heatwave risk management, focuses on implementing measures such as early warning systems and adaptation strategies (Lass et al., 2011). This step requires collaboration among stakeholders and a clear distribution of responsibilities (Mees et al., 2014). Housing associations and residents must consider the key roles in governing heatwaves, as described by Vanderplanken et al. (2021), ensuring that interventions are both equitable and practical.

The fourth and last step, effective communication, is essential throughout the entire process to ensure stakeholder involvement and transparency in decision-making (Lass et al., 2011). In line with heatwave risk management, heat action plans must not only be evidence-based but also effectively communicated to the residents (Berger et al., 2022). The informer, as previously mentioned, is responsible for communication about the heatwave plan. These plans should be informed by real-time surveillance data to ensure that health protection strategies are tailored to current conditions (Berger et al., 2022). This aligns with the framework's approach to reducing heat-related health risks through adaptive measures and coordinated actions, addressing the societal vulnerabilities that arise from extreme weather events.

However, beyond the structural and procedural aspects of risk governance, the success of these measures hinges on how residents perceive climate change and heat stress. Understanding public perception is crucial because residents' views can directly or indirectly influence local heat management governance (Rudell et al., 2011). Research shows that awareness and knowledge regarding heat management strategies is limited but has increased in the last few years (He et al., 2022). Raising awareness through targeted education and information supply can strengthen community resilience to extreme heat events.

In sum, the risk governance framework offers a structured approach to assess heat-related risks, with communication and participation as its core (Lass et al., 2011). It helps to navigate the complexity of heat management and provides a valuable lens for analysing both existing and potential measurement within the context of rental housing.

HEAT MANAGEMENT STRATEGIES

Several heat management strategies are described in the literature. In general, most of the literature makes a division between active and passive cooling strategies. Passive cooling strategies refer to a natural method of cooling buildings without the use of mechanical systems, whereas active cooling strategies refer to the use of energy to cool buildings, such as air-conditioning (Al-Shamkhee et al., 2022; Chetan et al., 2020).

Overall, passive cooling strategies are seen as most effective. Among passive cooling strategies, shading is one of the most effective methods, reducing indoor temperatures by an average of 3°C (Chetan et al., 2020). Shading can be achieved through curtains; however, this approach has drawbacks, including limited options for ventilation and poor-quality lighting (Chetan et al., 2020). Among the passive cooling strategies, wall insulation and measures to reduce solar heat gain, such as external window shutters and painting the external walls in a light colour, were identified as particularly impactful (Al-Shamkee et al., 2022; Hu et al., 2023; Porritt et al., 2011).

Ventilation is another passive strategy that plays a crucial role in cooling buildings by promoting air circulation and heat dissipation. Cross-ventilation enhances indoor flow, while night cooling leverages cooler outdoor temperatures to remove accumulated heat (Ali et al., 2023). Although ventilation is often framed as a highly effective cooling strategy, its success depends on building design, climate conditions, and occupant behaviour (Al-Shamkee et al., 2022; Hu et al., 2023). Given these factors, ventilation and shading should not be presented as conflicting strategies but rather as complementary techniques.

While passive cooling strategies focus on reducing heat gain through design and occupant behaviour, active cooling methods rely on mechanical systems to actively remove heat and regulate indoor temperatures (Chetan et al., 2020). In general, there are four main types of active cooling strategies: fans, heat pumps (with cooling capacity), conventional air conditioning, and solar air conditioning (Joshi et al., 2024). Fans are typically considered the most cost-effective option; however, health agencies should caution against their use, particularly for individuals with impaired sweating ability, as fans can blow hot air without enabling proper body cooling (Meade et al., 2024). Heat pumps are especially beneficial in climates with distinct seasons, hot summers and cool winters, since they can both cool and heat a space. But their overall effectiveness depends on the specific characteristics of the heat pump (Husetić & Salkić, 2023). Conventional air conditioning works by transferring heat from inside the house to the outside environment. Solar air conditioning systems tend to have significantly higher upfront costs but offer greater energy efficiency compared to standard air conditioning (Joshi et al., 2024).

Importantly, when considering active cooling strategies within rental housing, affordability becomes a critical factor. Many residents of rental homes have limited financial resources, which affects their ability to adopt energy-intensive cooling methods. Studies emphasize the need for housing associations to take residents' economic constraints into account when implementing heat management measures (Vanderplanken et al., 2021; Berger et al., 2022). Ensuring that active cooling solutions are accessible and affordable is essential to avoid increasing energy poverty among vulnerable tenants (Groven et al., 2012). Therefore, housing providers must balance effective heat mitigation with cost-efficiency and equitable access to cooling interventions.

INSIGHTS INTO BARRIERS IN SUSTAINABLE HEAT MANAGEMENT STRATEGIES

Heat management strategies, such as shading, may encounter various implementation challenges. These challenges, commonly referred to as barriers, can be further divided in diverse ways. A framework was developed that mentioned barriers on the structural, organizational, mitigation measure, and stakeholder dimensions (Quitmann et al., 2023). Structural barriers refer to the external conditions, including financial, political, and economic constraints.

Stakeholder-related barriers concern both implementors and those affected. In practice, it remains unclear whether installing shading devices is a responsibility of the housing association or the residents (Mees et al., 2014). Organizational barriers entail aspects that are specific to the organization, for example, housing associations state that there is limited feasibility of measures focused on climate change adaptation and that this should change for them to be willing to take measures (Roders et al., 2013). These barriers should not be seen as failures on the part of the organization, but rather as structural or contextual constraints, such as lack of funding, unclear mandates, or competing priorities, that limit their capacity to act. Lastly, the mitigation measure-specific barriers concern factors intrinsic to the intervention itself, including perceptions about heat management strategies. Some residents might view shading devices as unnecessary and therefore limit their acceptance of such measures (He et al., 2022). Identifying and addressing those barriers will facilitate effective implementation of heat management strategies (Quitmann et al., 2023).

A complementary way to examine implementation challenges is through the three-lens framework developed by Rajagopalan et al. (2023). The strategical lens suggests that heat management strategies should be embedded into institutional planning frameworks. This

involves implementing measurable goals, for example, within five years 50% of the assets should have sun protection measures. Setting such clear goals eventually helps overcome strategic barriers commonly faced by housing corporations (Miller & Weiss, 2015).

The political lens underscores the importance of stakeholder involvement and leadership in enhancing heat resilience (Rajagopalan et al., 2023). Effective collaboration between local government, housing associations, and residents is essential, with one stakeholder taking the lead. This contributes to the clarification of responsibilities, which are frequently undefined or contested in the context of heat management (Mees et al., 2014). An enabling environment, including supportive structures, systems, and resources, is essential for the development of effective adaptation strategies. This can be achieved through good governance and appropriate institutional arrangements (Akompab et al., 2012).

Finally, the cultural lens highlights the role of organizational and community culture, including the values and norms that influence how heat management strategies are perceived and prioritized (Rajagopalan et al., 2023). For example, when implementing a warning system, it is necessary to maintain effective communication of the information and an understanding of the local context where the adaptations take place (Antwi-Agyei et al., 2014).

To further understand the complexities of sustainable heat management, Van Der Byl and Slawinski (2015) propose four approaches to manage the tensions between economic, social and environmental goals. In the context of heat stress, where competing priorities such as affordability, comfort and sustainability often collide, the paradox approach may be particularly relevant. This approach acknowledges that such tensions are always present, but rather than prioritizing one objective at the expense of another, it promotes embracing and addressing all dimensions simultaneously (Carmine & De Marchi, 2022). In practice, this could involve balancing short-term financial constraints with long-term investments in heat-resilient infrastructure.

Taken together, the literature suggests that organizing sustainability in heat management is often impeded by a range of structural, organizational, stakeholder-related, and measure-specific barriers (Quitmann et al., 2023). Additionally, the three-lens model of Rajagopalan et al. (2023) emphasizes the importance of strategic planning, political involvement, and cultural norms in the implementation of heat management strategies.

These insights underscore the need for an integrated and balanced approach that enables housing associations to embed sustainability practices while addressing both affordability and living comfort.

OVERALL THEORETICAL LENS FOR ANALYSIS

The combined theoretical perspectives offer a comprehensive framework to analyse heat stress governance in rental housing. The responsibility framework of Mees et al. (2012, 2014) helps clarify the distinction and ambiguity between public and private responsibilities for heat management in urban settings, identifying accountability gaps. Vanderplanken et al.'s (2021) stakeholder role framework complements this by illustrating how the different actors can take on roles like implementor, evaluator, and informer, which helps to assess the level and quality of collaboration. Lass et al.'s (2011) risk governance framework adds another layer, highlighting the importance of communication, risk perception, and coordinated decision-making in the development of heatwave responses. Additionally, literature on heat management strategies (Ebi & Semenza, 2008; He et al., 2022) emphasizes the need for locally tailored interventions and the critical role of risk perception and behaviour at the household level. Finally, insights from the field of organizing sustainability (Runhaar et al., 2021; Uittenbroek et al., 2022) contribute to understanding the institutional and organizational conditions that shape the willingness and capacity of stakeholders, such as housing associations, to engage in long-term adaptation strategies. Together, these theories enable a multi-level analysis of structural and behavioural influences on implementing heat management.

METHODOLOGY

RESEARCH DESIGN AND DATA COLLECTION

In this study, a qualitative research approach was employed to explore the experiences, opinions, and beliefs of housing associations, national and local institutions, and residents regarding heat management strategies. The research question focuses on the institutional and political factors that shape the development and implementation of heat management measures. These aspects are not easily captured through quantitative methods, which primarily emphasize numerical data (Mortelmans, 2018). By using a qualitative approach, the study was able to gain deeper insights into the social and institutional dynamics and personal experiences regarding heat stress in rental housing.

The core of the data collection consisted of semi-structured interviews with 13 key stakeholders. This format enabled open-ended questions and allowed for follow-up enquiries based on participants' responses, enabling in-depth exploration. Consequently, the method provided valuable insights into both policy perceptions and implementation by housing associations, as well as residents' experiences and reactions to heat management strategies. The participants included policy advisors and implementers within housing associations, municipal staff involved in climate adaptation, representatives of national and local initiatives, tenant representatives, and residents. Their roles ranged from strategic policy making to technical implementation and lived experience, offering a diverse and multi-level perspective on heat stress management. The sample size aligns with guidelines for data saturation in qualitative research, where rich data can be obtained from approximately 12 interviews (Guest, Bunce, & Johnson, 2006). An overview of the respondents is presented in Table 1 on the next page.

Recruiting resident participants proved challenging, partly due to the sensitive nature of the topic and the limited availability of individuals willing to participate. Despite these difficulties the study succeeded in including a limited but diverse sample of residents' perspectives (n=4). Among the residents interviewed, one younger respondent lived in a large housing complex consisting of studios and multi-room apartments in Delfshaven, while another lived in a terraced house with a shared apartment in Tarwewijk. A third respondent, approximately 50 years old, lived in a terraced house in the neighbourhood of Bloemhof. In addition, experiences from older tenants from Overschie were included, who lived in a complex building with multi-room apartments. Although the number of resident participants was limited, the sample included a range of housing types and age groups, which allowed the study to explore diverse perspectives on heat stress, including differences in perceived urgency and vulnerability.

Table 1: overview of stakeholders interviewed in this study

Stakeholder Group	Organisation	Interviewee Code	Function / Role	General Role in Heat Management
National/Local Initiatives	HeatLab	R1	Research coordinator	Research, awareness campaigns, pilot testing
National/Local Initiatives	WIECK	R2	Researcher	Advocacy, research, awareness-raising
National/Local Initiatives	Climate Alliance	R3	Advisor heat adaptation	Advocacy and awareness-raising
Municipal Authorities	Municipality of Rotterdam	R4	Advisor climate adaptation and climate justice	Local coordination, planning, subsidy development
Housing Associations	Woonstad Rotterdam	R5	Advisor of circularity and climate adaptation	Strategic policy development, integration in planning
Housing Associations	Woonstad Rotterdam	R6	Technical Implementer	Execution of physical measures
Housing Associations	SOR	R7	Technical implementor	Execution of physical measures
Housing Associations	Hefwonen	R8	Sustainability coordinator	Strategic policy development, integration in planning
Housing Associations	Havensteder	R9	Climate adaptation program manager	Strategic policy development, integration in planning
Caretaker	Woonstad Rotterdam (linked)	R10	Caretaker	Representing tenant interests, reporting problems
Residents	Delfshaven resident	R11	Tenant (young adult)	First-hand experience
Residents	Tarwewijk resident	R12	Tenant (shared terraced house)	First-hand experience
Residents	Bloemhof resident	R13	Middle-aged tenant in terraced housing	First-hand experience

The interviews were conducted between April and June 2025, with an average duration of 30 minutes. Due to the researcher's personal medical circumstances, all interviews were held online via Microsoft Teams. The conversations were guided by a topic list, as provided in the appendix, developed from the research sub-questions and theoretical framework, ensuring that the themes addressed were directly relevant to the core issues of the study.

The interviews covered key themes such as the division of responsibilities, barriers to implementing heat adaptation measures, current and potential strategies for heat management in the rental sector, and the perceived urgency and awareness of heat stress as a climate risk.

Within these overarching themes, various subtopics emerged during the interviews, including legal and technical limitations, stakeholder engagement, and communication with residents. The topic list was continuously refined throughout the data collection process to align with the backgrounds and roles of individual respondents. The flexible adaptation of the topic list towards the respondents' background enhanced the trustworthiness and relevance of the findings. This approach ensured that all interviews addressed core themes such as responsibility and barriers, while allowing space for the respondents' own insights, for example, technical limitations mentioned by housing associations and personal experiences of residents. This balance contributed to the reliability of the results and their broader applicability to heat governance in the rental housing context.

In addition to conducting the interviews, a document analysis was conducted to support data triangulation (Mortelmans, 2018). The focus of this study was limited to Rotterdam and the Netherlands in general, ensuring relevance to urban heat management. Priority was given to documents that are linked to actors involved in the interviews. A total of seven documents were reviewed, covering themes such as residents' experiences, internal research conducted by a housing association, a local heat plan, and a practical guidance document on heat management measures. Additionally, a national guideline from the Knowledge and Innovation Programme Water and Climate (NKWK) was included, offering direction for policy development and heat management strategies. These documents provided insights into existing policies and the roles of associations and residents in addressing heat stress. An overview of the analysed documents is visible in Table 2.

Table 2: Overview of analysed documents

Document Title	Organisation / Author	Document Type	Scope	Relevance for Heat Management
Kuijer, VENI: Effective Shading	Academic (research project)	Scientific article	National	Scientific insights into shading measures from the resident's perspective
Heat Stress Factsheet	Climate proof cities	Factsheet	National	Summarises risks and impacts of heat stress
Heat Stress Guidelines – Aedes (March 2025)	Aedes (housing association umbrella)	Practical guideline	National / sectoral	Provides sector-specific guidance for housing associations

Guideline heat stress in existing housing	NKWK	Practical guideline	National	Likely provides additional or updated guidance on heat stress
Local Heat Plan Guideline (2019–2020)	Ministry of infrastructure and water management	Implementation guide	Local / regional	Offers municipalities a framework for developing local heat plans
Climate Change and Adaptation	Municipality Rotterdam	Policy overview	Local	Provides general background on climate adaptation
Heat Stress Survey 2023	Own data / resident initiative	Survey results	Local (Rotterdam)	Reflects residents' perceptions and experiences of indoor heat

DATA ANALYSIS APPROACH

Interviews were recorded and transcribed verbatim (Mortelmans, 2018). The transcripts underwent a structured coding process that combined inductive and deductive coding approaches. Deductive codes were derived from the theoretical framework as well as from the research sub-questions on responsibilities, perceived barriers, and strategies. At the same time, inductive coding was used to identify new concepts and patterns that directly emerged from the data, such as diverse residents' perspectives. The process ensured both theoretical alignment and openness to lived experiences and stakeholder perspectives. A brief overview of the resulting code structure is presented in Figure 2.

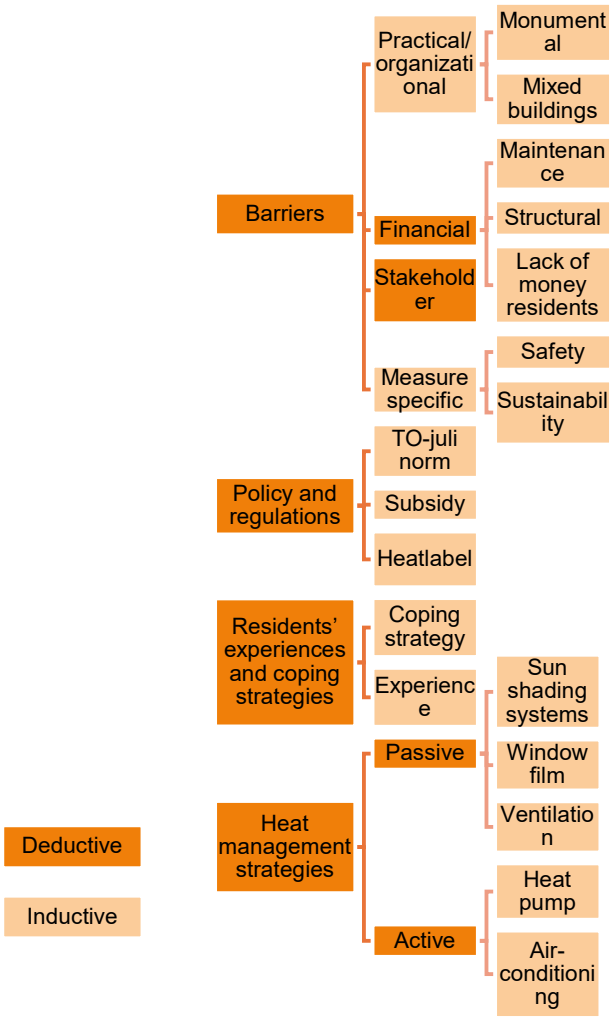

Figure 2: Coding tree

The resulting structure reflects how the data was thematically organized based on recurring patterns, stakeholder roles, and contextual factors. This systematic and transparent coding process allowed for a nuanced understanding of heat management strategies and responsibilities within the context of rental housing. It supported the analytical depth needed to interpret both policy intentions and everyday experiences related to heat stress.

The document analysis followed a directed content analysis approach, informed by the topic list and the theoretical framework. Key terms like 'high temperature', 'heatwaves', and 'heat management' guided the targeted reading and coding of the documents. This enabled comparison between policy narratives and the experiences shared by interviewees, strengthening both the depth and credibility of the findings (Mortelmans, 2018).

ETHICAL CONSIDERATIONS

Before the interviews were conducted, all participants provided informed consent for video and audio recording as well as for the use of their data. This procedure followed ethical research standards. To safeguard privacy while maintaining transparency, organizations are named, but individual respondents are referred to by their role or function. Potential researcher bias was minimized using a structured data collection approach. A predefined topic list guided the interviews to minimize the risk of leading questions. Triangulation was achieved by including multiple stakeholder perspectives, including municipal staff, housing association representatives, tenant representatives and residents. This diversity of perspectives allowed for cross-verification of the findings and strengthened the objectivity and credibility of data interpretation (Mortelmans, 2018).

The interviews were conducted online due to the personal medical circumstances of the researcher. While this facilitated access to a broader range of respondents, it also introduced certain limitations, such as reduced observation of non-verbal cues and occasional technical issues. These limitations were acknowledged during analysis and considered when interpreting the depth and nuance of responses.

In a few cases, the researcher had a prior professional relationship with participants. This familiarity may have influenced the openness or direction of the conversation. To mitigate potential bias, reflexivity was actively practiced throughout the research process by continuously and critically reflecting on one's own role, assumptions, and potential influence on the study. The structured interview guide and anonymized analysis supported a consistent and balanced interpretation of the data.

Academic integrity was prioritized to ensure trustworthy and verifiable research. This includes a commitment to principles such as honesty, accountability, rigour and respect for all participants and sources. To promote transparency, both raw data (where appropriate) and interview transcripts were included as supplementary materials. This allows future researchers or reviewers to cross-check findings. All procedures adhered to the Netherlands Code of Conduct for Research Integrity (VSNU, 2018), thereby ensuring that all procedures reflect ethical and responsible research practices.

VALIDITY AND RELIABILITY

Validity in this research encompasses both internal and external dimensions. Internal validity was strengthened by aligning the data collection with the theoretical concepts and the

sub-questions (Mortelmans, 2018). Additionally, recording and transcribing the interviews verbatim contributed to methodological transparency, allowing others to verify the findings and thus supporting the overall credibility of the research.

External validity concerned the generalizability of findings to other contexts (Mortelmans, 2018). While the study focused specifically on rental housing and heat-related challenges in Rotterdam, certain findings, such as faced barriers, stakeholder roles and governance dynamics, may be transferrable to other urban settings facing similar heat-related issues. To facilitate this, a detailed description of the research context, participant selection, and data collection has been provided. Allowing readers to assess the transferability of the findings to similar urban and institutional settings.

Reliability refers to the consistency and reproducibility of the research outcomes, regardless of who conducts the study or when it is performed (Mortelmans, 2018). In this study, reliability was strengthened by using a structured topic list, developed from the theoretical framework and the research sub-question. To support transparency and replicability, the topic list of interview questions is included in the appendix, enabling a thorough evaluation of the data collection process.

Together, the structured methodology, transparent documentation, and clear contextual framing contribute to the credibility, dependability, and transferability of the study's findings.

RESULTS

INTRODUCTION TO THE FINDINGS

For data collection, interviews were conducted with residents, representatives from housing associations, local authorities, a local initiative focussed on heat-related issues, and a national climate organization. Table 3 provides an overview of the different housing associations involved and their key characteristics.

Table 3: overview of housing associations involved in the study

Housing Corporation	Focus & Target Group	Main Areas of Operation	Housing Stock Characteristics	Approx. No. of Dwellings
Havensteder (A)	Low-income residents, elderly, people with care needs	Oude Noorden, Agniesebuurt, parts of Prins Alexander	Multi-story apartment buildings in dense urban areas	± 29,800 (social rental); > 45,000 total
Woonstad Rotterdam (B)	Broad target group: families, single households, older residents	Delfshaven, Het Oude Westen, Afrikaanderwijk, Kralingen, Lombardijen	Mix of low-rise and high-rise buildings in urban areas	± 43,000 (social rental)
HefWonen (C)	Affordable housing in socio-economically challenged areas	Feijenoord, Hillesluis, Charlois	Apartment blocks, gallery flats, terraced houses	± 30,000 (social rental)
SOR (D)	Older residents	Overschie, Kralingen, Het Lage Land, Binnenhof, Hoogvliet, Brielle, Pernis	56 multi-story apartment buildings across the city	± 7,300 units

In addition, a document analysis was conducted, examining various policy documents on heat management in existing housing as well as studies involving residents. The analysed documents include internal policy papers from the umbrella housing association, the municipal heat adaptation plan, an informational flyer on heat stress from the GGD, an omnibus survey conducted among Rotterdam residents, and a research project at Havensteder involving housing assessments. Furthermore, this study examined publicly available survey data collected from housing associations across the Netherlands.

The findings are presented thematically, based on key patterns that emerged from the interviews and were further supported by document analysis. Each theme captures a distinct aspect of heat stress governance in the rental housing context, illustrated with quotes from

participants and references to relevant policy or organizational documents. This approach enables a comprehensive understanding of the roles, responsibilities, and challenges identified across different actors.

POLICIES AND REGULATIONS IN ROTTERDAM

NATIONAL POLICY CONTEXT AND STRATEGIC FRAMEWORKS

At the national level, efforts to guide climate adaptation in the housing sector are continuously evolving. While several housing associations are actively developing or implementing heat management policies for their existing housing stock, these efforts occur within a broader national context where formal policies and binding standards are still in development. A national climate organisation provides strategic direction by developing overarching policy frameworks and supporting local initiatives. This organization has identified three key pillars for heat adaptation policy: public areas, buildings, and the user. The ‘area’ pillar refers to the surrounding environment, the ‘building’ pillar focuses on the physical characteristics of homes, and the ‘user’ pillar refers to resident behaviour and health. These pillars are also referenced by several housing associations and the municipality, offering guidance for shaping their own strategies.

EVALUATION OF CURRENT HEAT PLANS

The national climate organisation noted that most municipal heat plans are primarily focused on the KNMI’s national weather warning system, particularly ‘code yellow’ scenarios, which entails a warning for possible hot weather. With increasingly hot summers, KNMI ‘code orange’, signalling high temperatures with a greater risk for health, and even ‘code red’, indicating extreme heat and dangerous health consequences, are becoming more common and more likely. This climate trend suggests that current heat plans may need to be revised to better reflect changing climate conditions and more extreme heat events.

NATIONAL GUIDELINES AND POLICY RECOMMENDATIONS

Interviews revealed variation in the way housing currently approaches adaptation, with no consistent standards guiding their efforts. Nevertheless, a national umbrella organization representing Dutch housing associations (hereafter referred to as ‘the national umbrella organization for social housing’) published a report outlining measures to prevent heat stress (Aedes, 2025), which serves as one of the key national reference documents for the social housing sector. In this report, the TO-juli norm is highlighted as a key metric for assessing

vulnerability to heat in existing residential buildings. Properties most at risk typically have poorly insulated roofs and large windows facing east or west. To prioritize interventions, the report proposes the introduction of a 'heat label', which can help classify assets by their heat vulnerability and guide decision-making on adaptation, suggesting that housing associations should develop policies on heat by adopting the heat label and adhering to the TO-juli norm.

In addition to assessment tools, the national umbrella organization outlines several potential measures for effective heat policy. Potential measures included developing a local heat plan (Ministry of Infrastructure and Water Management, 2023), distributing informational flyers, providing clear guidelines for the application of a *Zelf Aangevraagde Voorziening* (ZAV), increasing green space, and conducting an inventory to determine which assets are most vulnerable to overheating. In addition to policy tools, the national umbrella organization focuses on the structural implementation of physical heat management measures. Those measures include maintaining a cool environment by increasing vegetation around buildings; keeping out heat through the installation of sun-shading screens, shadow cloths and window film; passive cooling by heat pump and night ventilation hatches; and active cooling through air conditioning. Each of these strategies varies in terms of cost, feasibility, and infrastructural requirements and depends on specific building characteristics.

Despite the availability of this comprehensive set of tools, interviews revealed that most housing associations currently focus on relatively low-threshold interventions, particularly the implementation of sun-shading screens and window films. This trend suggests that while the national guidance offers a comprehensive toolkit, practical limitations, such as funding, logistical complexity, and existing building structures, significantly influence which measures are implemented in practice. Moreover, the ability of housing associations to implement these measures often depends on support and coordination at the local level.

MUNICIPAL SUPPORT AND FACILITATION

Municipalities play a crucial role in the implementation of national guidelines on the local level. In Rotterdam, for instance, the municipality has taken active steps to support housing associations and other stakeholders in addressing urban heat, not only by co-developing technical standards like the adapted TO-juli norm, but also by offering financial incentives and working towards more structured governance of heat adaptation.

A key example of this support is the introduction of a tailor-made-subsidy scheme for housing associations, developed two years ago. This subsidy was developed to address financial and bureaucratic barriers that prevent housing associations from acting. Before this tailor-made subsidy scheme was implemented, housing associations had to apply for the

measures for each house individually, which was time-consuming and inefficient given the size of their housing stock. This was largely due to existing regulations that required individualized applications and assessments, making it difficult to implement measures at scale. The new subsidy schema allows housing associations to submit applications for a whole building, which significantly streamlines the process and leads to a shortened lead time.

Through this subsidy, housing associations can get a refund for sun-shading screens, awnings, heat-reflective window film, ventilation grills, shade cloths and sun-protective glass. The subsidy amount depends on the measures taken and the covered surface.

Beyond immediate financial support, the municipality invests in long-term planning. It is currently developing a standardized protocol for heat management in public outdoor spaces. This signals a clear shift toward a more coordinated and sustained approach to heat adaptation at the local level. Beyond technical solutions and financial support, the municipality works with local research initiatives to improve the evidence base for heat adaptation.

LOCAL RESEARCH AND CLIMATE INEQUALITY

In addition to financial and policy tools, the municipality closely collaborates with local knowledge partners to strengthen and embed heat policy through research and community engagement. Collaboration between the municipality and a local heat research initiative on heat adaptation (hereafter referred to as 'the Heat Initiative') was described as an important element of heat policy development. This local research and action platform on heat adaptation was described as a key partner, playing a central role by facilitating research, supporting local engagement, and co-developing measures to address urban heat challenges. According to the research coordinator of the Heat Initiative, research topics are often determined jointly by the Heat Initiative and the municipality, suggesting co-productive collaboration. In this context, co-production refers to a collaborative process in which researchers and policymakers collaborate across institutional boundaries to jointly define problems, set research agendas, and develop context-specific solutions. The research coordinator mentioned that the Heat Initiative has a coordinating role, where they collect issues and link students to them. Through research activities, the initiative has generated important insights into how heat exposure varies across different types of housing and neighbourhoods.

One of the researchers affiliated with the Heat Initiative showed that there was climate inequality, which is supported by the following quote: "*Often owner-occupied homes that are well insulated, yes, those people experience much less trouble with heat. Meanwhile, the most vulnerable homes with low-income residents in social rental housing are also more exposed to the highest temperatures in this study."* This quote illustrates how perceived heat exposure

appears to be unevenly distributed, particularly affecting residents with lower incomes. Such patterns of climate inequality are not only visible in housing quality and location but also reflected in municipal agreements with housing associations (Gemeente Rotterdam & Rotterdamse woningcorporaties, 2023). These agreements currently focus exclusively on addressing heat stress among the elderly, thereby overlooking other vulnerable groups who may also be disproportionately affected by extreme heat.

These insights start to affect the assessment and prioritisation of heat-related risks by some housing associations. In line with this focus, housing association A mentioned that, specifically for older residents, they are considering escalating heat risk classifications from code orange to code red, acknowledging the increased vulnerability of this group. The national climate organization further highlights heat-risk inequalities with the following slogan: "*The poorest neighbourhood is the hottest neighbourhood*," which underscores their concern about the disproportionate impact of heat on low-income and rental housing areas. Their concerns reflect the need to prioritize heat preparedness of residents in poor neighbourhoods over solely focusing on climate change mitigation, as current measures are not keeping pace with climate change, particularly in urban areas with large populations of vulnerable residents.

DEVELOPMENT OF HEAT MANAGEMENT POLICIES WITHIN HOUSING ASSOCIATIONS

Given the diversity of challenges and local conditions, housing associations have developed varied strategies and policies to manage heat risks in their housing stock. This part highlights these differences by giving examples from various Rotterdam housing associations.

Several respondents of various associations noted that policies regarding heat management strategies for existing housing are still under development. As a result, some housing associations are currently working on a draft policy towards improved heat management, while others have conducted inventories to identify which of their properties are most vulnerable to heat.

For example, Housing Association A has a heat policy in place, adjusting properties based on an internal label, which reflects heat vulnerability. To develop this label, the housing association conducted an inventory study of all its properties and compared the results to an existing standard for new buildings. This standard is defined in the "Bouwbesluit*"* and referred to by respondents as the "TO-juli norm". For use on existing buildings, the TO-juli norm was multiplied by a factor of four to establish a reference value, which was developed in collaboration with the municipality. Based on the comparison between this adapted TO-juli

norm and the performance of their existing properties, the housing association classified their buildings into different categories of adaptation to urban warming.

Properties in the highest category require immediate attention, while those in the lower categories may need interventions in the future but are not currently a priority. The highest risk category, which are called code red properties, consists of approximately 1,200 assets. On top of that, approximately 2,300 of the assets get a code orange and will require attention soon. According to the climate adaptation programme manager at housing association A, the plan is to adapt these assets over the next 10 to 15 years due to the limited availability of money for climate adaptation measures.

Housing Association B is still in the early stages of developing a heat management strategy. Their current policy framework does not cover heat risks within their properties; therefore, Housing Association B is currently seeking approval from their board to make changes to its existing policy framework. The advisor of circularity and climate adaptation of housing association B noted that the absence of legal obligations makes it more difficult to prioritise such measures. As the advisor explained, *"If it's not legally required, it's just quite difficult for us to actually start working on it."* This quote illustrates the hesitation and uncertainty that housing associations experience when there is no regulatory pressure to guide or mandate action on heat management.

Nevertheless, housing association B has initiated some pilot projects where they installed sun-shading screens on buildings housing older residents. The project manager planned maintenance of housing association B explained that screens were placed on the building and specifically on the sides that face the most sun during the peak moments of the day. However, this could mean that people living on the corners of the building have screens in one room but not in all rooms of their apartments. Nonetheless, the caretaker of the building mentioned that most people seem to be happy with it and that especially the residents living on the upper floors are using them frequently, suggesting that the pilot has had a positive influence on the experiences of residents. Moreover, residents indicated that they appreciated the possibility to look outside, and their reaction suggests a sense of relief and satisfaction that the housing association is actively addressing the issue of indoor heat.

Housing association C is more advanced in its heat adaptation efforts compared to B. According to their sustainability coordinator, the association has a sustainability strategy organized around several thematic pillars, including heat-related issues. The heat policy of housing association C has already been approved by the board and is currently awaiting approval from the tenant council. Like housing association A, housing association C uses the adapted TO-juli norm to prioritize interventions; in their case, approximately a quarter of their

assets does not meet the requirements of the adapted TO-juli norm. In addition, the sustainability coordinator noted that the adapted TO-juli norm was developed in collaboration with the municipality and other housing associations.

In contrast to other housing associations, housing association D does not currently have a dedicated policy for heat adaptation. According to their project manager planned maintenance and sustainability, heat is not addressed as a separate theme within their policy framework but is instead integrated into broader sustainability for maintenance projects. For example, in a recent refurbishment project, housing association D added sun protection film to a big glass wall in one of their buildings. This may imply a more reactive approach to heat adaptation, in which measures are primarily taken in response to immediate problems or complaints. As a result, long-term planning and equitable prioritisation may be overlooked.

However, each organization retains the autonomy to implement the policy according to its own approach. While housing associations A and C have conducted inventories to identify the most heat-vulnerable assets, housing association B has initiated small-scale pilot projects by installing screens in two of their buildings. Additionally, housing association D has no policy related to heat but has a pragmatic approach where they implement heat measures into ongoing renovation projects.

KEEPING ROTTERDAM'S HOMES COOL

The national umbrella organization for social housing proposes a range of strategies that housing organizations and residents can implement to keep indoor temperatures manageable. These fall into four categories: creating a cool environment (e.g., planting trees and installing green facades), keeping out heat (e.g., using external shading such as sunscreens or reflective films), passive cooling (e.g., night ventilation and heat pumps), and active cooling (e.g., air conditioning systems). Housing associations have translated these general categories into specific measures tailored to their housing stock.

These recommendations are reflected, to varying degrees, in the strategies adopted by housing associations. Both housing association A and C use a heat label to guide their selection of appropriate measures, while housing association B has piloted sun-shading systems to test their effectiveness. As the sustainability coordinator of housing association C explained: "*For now, we are assuming the most passive form, which is simply sun shutters or screens."* This comment illustrates a broader institutional preference for passive, low-maintenance solutions. That preference is supported by the availability of municipal subsidies for installing shading devices.

Alongside these interventions, housing associations inform their residents on heat-coping strategies. Considering heat management communication, housing associations report that they make efforts to inform residents about how to cope with heat. For example, Housing Association A distributes informational flyers with tips for staying cool during hot weather, which are displayed in shared spaces. Housing Association B, by contrast, primarily provides advice reactively, responding to individual complaints from residents about indoor heat. According to the advisor of circularity and climate adaptation of housing association B, they are trying to inspire the residents but acknowledge that it is up to residents themselves to act. These examples suggest that while communication efforts do exist, they are often limited in scope and tend to be either passive or complaint-driven, rather than part of a structured and proactive outreach strategy.

This increased awareness is not limited to residents alone but is echoed in a national survey conducted by the national housing organization among multiple housing associations (Samen Klimaatbestendig & Aedes, 2023). Compared to 2020, housing associations reported more frequent integration of heat measures into maintenance, post-insulation, and renovation projects, and greater efforts in communicating about heat risks. Passive shading was once again the most frequently cited measure. Housing associations observed that tenants appear more aware of and concerned about heat than in previous years. However, the interview with housing association A indicates that, in practice, heat measures are not yet integrated into maintenance activities. When improving the insulation, they do consider possible consequences for the indoor temperatures.

This institutional preference for sun shading aligns with national guidelines and is further supported by the Heat Stress Factsheet, which states: "*To keep indoor temperatures limited, it is important to block sunlight using (external) sun shutters or screens."* This quote underscores that a large portion of indoor heat gain can be prevented through adequate external shading. In addition to shading, effective ventilation is identified as a key strategy, as recognized by both the national housing organization and the housing associations. The fact that both ventilation and sun shutters are consistently highlighted by the Heat Stress Factsheet, the housing associations, and the national umbrella organization for social housing suggests that a multifaceted approach to heat management is both recognized and encouraged.

This multifaceted approach to heat management involves the municipality, which plays a crucial role not only in providing green public spaces but also in raising awareness about the importance of shading. This focus is reflected in initiatives such as the introduction of 'shadow maps', which help residents locate nearby shaded areas. However, the national housing organization notes that green interventions have limited impact on indoor temperatures. This

limitation was echoed by housing association representatives, who highlighted that much of their stock is situated above street level and that green roofs contribute minimally to the context of well-insulated buildings. In contrast, the sustainability coordinator of housing association C pointed out that interventions such as private gardens or small green spaces can be effective in reducing indoor temperatures. Based on these varying perspectives, stakeholders suggest that while outdoor greening has some benefits, it alone may not be sufficient to reduce indoor heat, indicating that building-level measures may also be necessary.

RESIDENTS' EXPERIENCES AND COPING STRATEGIES

Despite growing awareness and interventions, significant disparities remain in perception of indoor heat, particularly in vulnerable housing situations. As a caretaker in a social housing complex of housing association B stated: *"You almost die from the heat in here."* This statement underscores that for some residents the experience of indoor heat can be severe and even threatening to health. Furthermore, some residents require additional support due to language barriers and cognitive challenges, such as difficulty remembering how to operate the installed screens. These lived experiences highlight the urgency of tailored measures that go beyond general averages and address specific vulnerabilities within the housing stock.

Residents reported that their apartments often become very warm, making it difficult to get rid of the heat. One resident from Bloemhof vividly described the situation: "Yes, it gets so hot and stuffy in here, and you just can't get rid of the heat. Even if you leave everything open for hours, the heat just doesn't go away." Certain building features, such as flat roofs, exacerbate this problem, causing rooms like bedrooms to become especially hot during summer nights, which may lead to heat stress.

When it comes to measures residents take, some expressed distrust in window shutters and avoid using them when they are away from home due to concerns about their vulnerability to weather conditions like wind and rain (Kuijer, 2024). Others mentioned that shutters make their homes too dark when closed, which discourages use. While many residents try to open windows during the day to improve air circulation, nighttime ventilation is often avoided due to fears of burglary and noise pollution (Kuijer, 2024). This tension between trying to cool the home and concerns about safety and comfort highlights the complex dilemmas residents face in managing indoor heat. Addressing such social and contextual barriers is essential to ensure heat management strategies are both effective and equitable.

Despite these barriers, residents are increasingly taking initiative. A municipal survey among Rotterdam residents (Gemeente Rotterdam, 2024) found that 10% of residents planned to install sun-shading measures in 2023 (N = 713), rising to 15% in 2024. This suggests growing concern and awareness about climate-related heat. Additionally, over half of the 740 respondents in 2024 reported that their homes remain adequately cool during extreme heat. However, the survey did not specify what types of housing the respondents live in or their socioeconomic status, making it difficult to generalize the results across different housing contexts.

HURDLES IN HEAT MANAGEMENT MEASURES

Despite increasing awareness and strategic intent, housing associations face several barriers in implementing heat adaptation measures effectively.

Financial constraints remain one of the most pressing challenges. Although the municipality provides a subsidy for heat adaptation, this only covers initial installation costs and excludes long-term maintenance. Representatives from both housing associations A and B argued that this limited scope reduces the effectiveness of the subsidy in practice: *"This illustrates how the system world fails to align with real-world conditions."* This quote reflects the perceived disconnect between policy design and practical needs.

While housing association C noted that both installation and maintenance expenses can be passed on to tenants through service charges, this strategy proves problematic. But as became evident from the caretaker of housing association B, most of the people do not have the financial space to pay extra rent or pay for the installation of those measures. This was by a resident of Bloemhof: "*There are also a few people in the street who have indeed installed those electric shutters themselves. But yes, that's just not feasible for me, also financially.*" This shows that passing on maintenance expenses to tenants does not work in lower-income settings because of the limited availability of money.

Moreover, the scale of the housing stock makes universal implementation unrealistic. The national housing organization highlights that sunshades involve high maintenance costs and are vulnerable to storm damage, with indicative costs ranging from several hundred to several thousand euros per house. The Heat Initiative emphasized that the challenge is not only financial; many residents are unaware of the municipal subsidies available for heat adaptation, and the most vulnerable groups often have limited access to or understanding of the information provided by the municipality or the housing association. This indicates a language barrier among residents, as is noted by the caretaker of housing association B. The

caretaker confirmed this, as highlighted by the following statement: "*There are, for example, people who don't speak Dutch very well, so then I have to explain what the purpose is, what they are coming to do, when they are coming, and possibly give some instructions on how to operate things."*

In addition to financial and language barriers, Housing Associations A and B noted that some of their properties have protected architectural status or are designated as monumental, which restricts the implementation of external interventions. Housing Associations A and C also highlighted that certain buildings have a mixed composition, meaning that not all dwellings within the same structure are equally affected by heat. As a result, some units may require heat adaptation measures while others do not.

Finally, regulatory frameworks further complicate implementation. For instance, the municipality explained that the legal definition of the subsidy restricts its use to installation costs only, excluding maintenance expenses. This legal constraint limits the long-term feasibility of adaptation measures, even when technical and financial conditions are met.

THE RESPONSIBILITY PUZZLE

Housing associations conceptualize heat management as a shared responsibility, emphasizing the roles of both the organization and its residents in the implementation of effective physical strategies such as installing sun shading systems, applying heat-reflective window film, or improving ventilation. This perspective is illustrated by a statement of the climate adaptation manager of housing association A: "*At least that home is, technically speaking, sufficiently capable of staying cool. So, when a resident in that category still finds it too warm, then it's really mostly about behaviour, that's our assumption."* This indicates that housing associations see themselves as responsible for ensuring the home meets technical guidelines but consider their responsibility to end once these standards are met, placing further responsibility on residents' behaviour.

However, this division of responsibility presents practical challenges. As the advisor of circularity and climate adaptation from housing association B noted: *"The behaviour of residents is quite a difficult factor; it's something that should also be taken into account when designing physical intervention packages."* This indicates that while housing associations take responsibility for providing physical measures, they acknowledge that the effectiveness of these interventions depends largely on how residents use them in practice. The importance of residents' effective use of these interventions, as well as their responsibility, is emphasized by

the national housing organization as well, which advocates for providing clear information to support residents in correctly utilizing physical measures.

Building on the recognition of the residents' role, the sustainability coordinator from housing association C noted a recent shift in the organisation's approach to residents living conditions. Previously, the responsibility for maintaining a comfortable indoor environment rested largely with residents. However, there is now a growing recognition within the organisation that it is their duty to enable tenants to maintain an indoor climate that aligns with the overall quality standards of the housing association. For example, when doing a renovation project, they have an integral package where they combine insulation of the homes with venting options and replace single glass in some of their properties. In addition to the role of the housing association, the sustainability coordinator noted the role of the municipality in providing green spaces in the surrounding environment. At the same time, residents are expected to contribute by maintaining green gardens or balconies, rather than fully paved areas, to help reduce perceived temperatures.

Adding to this complexity, residents have opportunities to take independent action through tenant-initiated modifications. While housing associations and residents share responsibility for heat management, the ways in which this responsibility is enacted can sometimes lead to contradictions. For instance, housing associations can apply for subsidies to implement measures such as sunshades, thereby assuming responsibility for their implementation. Conversely, residents themselves can apply for so-called *Zelf Aangevraagde Voorzieningen (ZAVs*), tenant-initiated modifications to their homes. These ZAVs typically include sun-adaptation film, sunscreens, and shadow cloths, for which residents may receive subsidies to partly fund it. This dual system highlights a complex dynamic in how responsibility and initiative are divided.

This approach shifts the responsibility for implementing and maintaining certain heat adaptation measures to the residents, highlighting the complex and sometimes unclear division of responsibilities between housing associations and tenants. This ambiguity raises questions about who is ultimately accountable for acting and covering the associated maintenance costs. This confusion around responsibility is evident in something the advisor of circularity and climate adaptation of housing association B noted about the application of the ZAVs: "*We have all sorts of rules and regulations for that, and you can make various changes to your home, but sometimes you need permission for them and sometimes you don't"*. This illustrates unclarity about potential measures to be taken by the residents themselves and what the housing associations are accountable for. As such, the ZAV system reveals both flexibility and ambiguity in the governance of heat adaptation at the household level.

The complex and shared nature of responsibilities regarding heat management is noted by the Heat Initiative. According to the research coordinator, the municipality is accountable for maintaining and adapting outdoor spaces while considering its impact on heat management, while the housing associations are expected to explore ways to keep their properties cool during periods of extreme heat. Additionally, their research coordinator suggested involving residents in discussions about their preferences and perspectives regarding the implementation of heat management measures. In addition, the topic of heat was described as a relatively new and complex challenge in urban housing policy, which raises questions about who should be responsible.

DISCUSSION AND CONCLUSION

This chapter discusses the main findings of the research in relation to the theoretical frameworks and existing literature on heat management and housing. Particular attention is given to the implications of the results for the various stakeholders involved. The discussion is structured around the main themes of this research that emerged during the analysis. This is followed by a reflection on limitations of the research, which serve as a basis for directions of future research. The chapter concludes with a concluding section summarizing the key findings of the research.

INTERPRETING THE FINDINGS

POLICIES AND REGULATIONS

This discusses how the presence or absence of relevant policies and regulations shapes efforts to adapt to heat in Rotterdam's rental housing sector.

Heat management policy in Rotterdam's rental housing sector remains fragmented and underdeveloped. Notable variation exists between housing associations: while some, such as housing associations A and C, have taken concrete steps, like adopting the TO-juli standard and conducting inventory assessments, these measures largely focus narrowly on technical solutions, particularly the installation of sun-shading devices. Other important interventions, such as improved ventilation, behavioural support for residents, or indoor climate monitoring, remain largely unaddressed.

Meanwhile, other associations, such as B and D, are either still in early phases of policy development (B) or lack any form of formal strategy (D). Heat is addressed by association D only incidentally, through standard renovation processes. The inconsistent approaches indicate that heat risk in Rotterdam's housing sector is addressed in a limited, reactive way, with little evidence of integrated or long-term planning. This variation highlights underlying governance challenges in defining and implementing responsibilities across organisations.

The uneven uptake of heat adaptation strategies is indicative of what Lass et al. (2011) describe as early-stage risk governance: a phase marked by ambiguous roles and fragmented policy responses. This dynamic is clearly visible in Rotterdam, where association A prioritizes homes with elderly residents while association D adopts a collective and area-based approach. The application of such a range of approaches reflects a lack of consistency in applying existing knowledge frameworks.

Despite the availability of clear guidelines, housing associations interpret and implement available knowledge in variable ways. The GGD's *Heat and Health* framework identifies high-risk groups, such as the elderly and chronically diseased, and risky housing conditions, such as poor ventilation and top-floor apartments (GGD GHOR Nederland, 2021).

Rotterdam's case reflects a broader pattern observed in urban climate governance, where the absence of clear regulatory mandates makes taking appropriate action increasingly difficult. As noted in previous studies (Mees et al., 2013; Uittenbroek, 2016), the lack of institutional clarity is a key barrier to effective adaptation. What distinguished this study, however, is the specific focus on housing associations as key actors in urban heat governance.

Emerging policy tools could provide the structure that is currently missing. The proposed introduction of a national 'heat label' could serve as a crucial step towards heat resilience. If made mandatory and tied to enforcement and funding mechanisms, such a label could provide a clear baseline for action. Moreover, it would allow housing associations to tailor interventions to specific building types and resident profiles, thereby balancing standardisation with the flexibility required for locally appropriate solutions (Kelly & Reid, 2020; Terpstra, 2011). As such, the heat label has the potential to support both consistency across Rotterdam while allowing customized solutions.

While national instruments such as the heat label aim to set a unified standard, municipal actors start responding with their own localised solutions. At the municipal level, promising developments, such as the Heat Initiative and the tailor-made subsidy scheme for housing associations, illustrate a growing institutional awareness of heat as both a public health and housing issue. Yet municipalities remain constrained by the absence of standard norms for retrofitting existing buildings, even though such standards could help assess the effectiveness of adaptation measures (Stanton & Ackerman, 2011).

This study contributes to the literature by illustrating how baseline instruments such as the heat label may strike a balance between standardization and context-specific flexibility, an aspect often overlooked in climate governance research.

Beyond technical standardisation, however, concerns around fairness and distributional impacts are increasingly coming to the fore in both national and local discourse. As both the national climate organization and the Heat Initiative rightly notes, "*the poorest neighbourhood is the hottest neighbourhood,"* underlining that the issue of heat-related inequality is recognized at both national and local levels. This shared concern signals equity in heat adaptation as not merely a local challenge but as a structural issue requiring coordinated responses across governance levels (Adger et al., 2005). Avelino (2024)

emphasizes that power relations can both enable and constrain change. In the context of heat inequality, these specific power dynamics shape the relationship between residents and housing associations, often determining who holds control over adaptation measures and who remains most vulnerable.

Building on this, the findings expose a critical policy gap: equity. It underscores the urgent need for a regulatory response that explicitly prioritizes the needs of low-income renters, who are often most exposed and least empowered to take adaptive action. As Anguelovski et al. (2016) emphasize, when urban climate adaptation policies ignore socio-spatial vulnerability, they risk reproducing and even deepening existing inequalities. Addressing heat stress in cities like Rotterdam therefore requires not only technical or environmental solutions but also a deliberate focus on social justice. In doing so, this research extends equity-centred critiques (Anguelovski et al., 2016) by empirically linking fragmented housing governance to real-world consequences for heat-vulnerable populations.

HEAT MANAGEMENT STRATEGIES

The findings of this research reveal that heat management strategies in Rotterdam's rental housing mainly consist of passive and low-maintenance measures, with sun-shading systems being the most adopted intervention due to the availability of municipal subsidies. These limited interventions reflect an early stage of heatwave risk governance (Lass et al., 2011), where risk appraisal and judgement remain underdeveloped. While sun-shading is relatively widespread, more substantial interventions, such as structural renovations or active cooling measures, remain rare. This indicates that the scope of application of heat management strategies is narrow and unevenly distributed.

The uneven uptake among housing associations can be attributed to several factors: municipal subsidies prioritise easily implementable, short-term solutions; and housing associations lack clear policy guidance or regulatory incentives at the national level. These challenges expose several key barriers to effective heat adaptation, including fragmented responsibilities, uncertain funding structures, and limited institutional capacity within housing organisations (Biesbroek et al., 2011; Mees et al., 2014). Consequently, investment in more comprehensive, structural housing adaptations remains limited, and coordinated, long-term strategies are difficult to realize.

These limitations have direct implications for tenants, particularly vulnerable residents such as the elderly or those in top-floor apartments, who remain exposed to indoor overheating. The results indicate that municipal initiatives, such as shadow maps, reflect a growing awareness of heat risks and represent a step forward in local risk recognition.

However, stakeholders emphasize that such initiatives alone are insufficient to effectively address indoor heat stress. This finding aligns with Rudell et al. (2011), who highlighted the critical importance of building-level adaptations to protect vulnerable populations. In line with this, stakeholders stress the need for structural housing renovations, such as improved insulation, reflective roofing, and sustainable ventilation systems, which are essential as long-term solutions.

Effective heat management thus requires an integrated approach (Lass et al., 2011) that combines passive measures, active interventions, and behavioural adaptations to mitigate heat risks. Achieving this necessitates robust collaboration between housing associations, residents, and municipal authorities (Mees et al., 2014), not only to coordinate implementation but also to align renovation strategies with broader climate resilience goals and ensure long-term commitment.

This multifaceted approach is further supported by the risk governance framework (Lass et al., 2011), which underscores the importance of stakeholder cooperation to ensure equitable and effective policy implementation. To support such cooperation, policy instruments need to evolve: municipal subsidy schemes should be structurally aligned with the maintenance and renovation policies of housing associations, rather than functioning as isolated incentives. Moreover, local actions would benefit from being embedded within a broader national policy framework to ensure consistency, long-term effectiveness, and efficient allocation of resources. Expanding the range of supported measures, providing regulatory clarity, and stimulating knowledge-sharing between housing associations would be essential steps toward scaling up and diversifying the current strategy landscape (Uittenbroek et al., 2015).

RESIDENT'S PERSPECTIVES

Residents report varying experiences with heat mitigation measures. Those who received sunscreens are generally satisfied and report frequent use, feeling that the screens help reduce indoor temperatures. In contrast, residents without any such measures report significant heat stress and discomfort during hot periods. Many of those without any measures expressed a clear desire to have similar solutions installed, particularly because proper ventilation in their homes is often limited. These differences not only reflect disparities in material conditions but also point to underlying issues of engagement and communication (Adger et al., 2005).

This suggests that the mere provision of technical solutions is not always sufficient; attention must be paid to the socio-economic and communicative context in which these

measures are implemented. Residents' capacity to respond to heat is shaped not only by the physical characteristics of their homes, but also by their access to resources, information, and support systems (Shi et al., 2016). For instance, some residents involved in the pilot project faced linguistic barriers and required additional explanation on how to operate the sunscreens. Others, such as older residents, reported difficulties in remembering how the screens function. These examples, drawn from the conducted interviews, highlight the need for housing associations to tailor their communication strategies to the diverse characteristics and needs of their residents when introducing heat mitigation measures.

Moreover, many residents noted that they rely on housing associations to act, not only because they view them as responsible for maintaining liveable homes, but also because their own financial resources are insufficient to invest in cooling measures. This highlights the importance of institutional support for vulnerable households in the context of climate adaptation. From a climate justice perspective, this underscores the perspective of distributive justice, where there is unequal access to different measures (Adger, 2006; Meyer & Roser, 2006). In this context, residents living in rental housing, have the least access to heat management measures.

Conversely, initiatives that involve residents early on, whether through co-design processes, neighbourhood meetings, or pilot projects, tend to foster a greater sense of ownership and responsiveness (Adger et al., 2013). This is particularly relevant given that residents expressed both a willingness to act and a dependence on housing associations to initiate adaptation measures. Research shows that meaningful participation enhances not only the legitimacy of interventions but also their long-term effectiveness, as residents are more likely to support and maintain solutions they helped shape (Reed, 2008). This underlines the importance of participatory approaches that go beyond informing or consulting residents and instead seek to integrate their lived experiences and local knowledge into climate adaptation strategies (Adger et al., 2013; Mees et al., 2013). As van der Jagt et al. (2016) demonstrate in the context of urban green infrastructure, co-design and bottom-up engagement can contribute to more context-sensitive and widely accepted interventions. Thus, any effective heat management strategy must combine physical interventions with inclusive and responsive forms of resident engagement.

PRACTICAL BARRIERS

The findings from this study highlight multiple barriers that hinder effective implementation of heat management strategies in the rental housing sector, which resonate

closely with the existing theoretical framework of Quitmann et al. (2023), including structural, organisational, stakeholder-related and measure-specific barriers.

Financial constraints were shaped by rigid annual budgets, as highlighted by housing association A. Even when heat adaptation is considered necessary, its prioritisation competes with renovation needs. These financial limitations reflect deeper structural issues in the governance of housing adaptation, where short-term funding cycles and a lack of operational flexibility hinder long-term strategic planning, particularly for vulnerable populations living in subsidised housing who face disproportionate heat exposure (Gabbe & Pierce, 2020).

These findings build on earlier studies that identify fragmented and unclear responsibilities in climate adaptation governance (Mees et al., 2014; Lass et al., 2011) but offer a more detailed account of how this fragmentation manifests in the social housing sector, particularly through budgetary structures. This aligns with the concept of Home Thermal Security, which frames such limitations not just as budgetary constraints but as structural barriers to thermal comfort and equity for vulnerable households (Kear et al., 2023). This highlights a critical gap in the operational implementation of adaptation measures, one that deserves more attention in adaptation governance research. Addressing these barriers will require not only improved integration of funding mechanisms but also better alignment between strategic ambitions and operational capacity.

Practical and organisational barriers were evident. Heritage protections and mixed building compositions complicated the uniform application of shading measures. Moreover, heat management is often deprioritised due to financial implications and the lack of existing policy indicating a lack of institutional urgency, which Rajagopalan et al. (2023) describe in their cultural lens, highlighting how organisational norms, values, and risk perceptions influence the prioritisation of climate adaptation measures (Kirchoff et al., 2013; Runhaar et al., 2012). In many cases, organisations focus on immediate, tangible maintenance needs rather than on longer-term climate risks, partly because of limited awareness or the perception that heat stress is a lower priority issue compared to other housing challenges, such as energy transition (Aall et al., 2007).

Stakeholder-related barriers arise from unclear divisions of responsibility between housing associations and residents. For example, confusion arises over whether residents should implement their own measures, such as through ZAV, or whether housing associations are responsible. This uncertainty is created by limited resident awareness, which, among other things, is due to language barriers. This limited resident awareness reduces resident engagement and hinders effective collaboration. To address this issue, housing associations and municipalities should adopt targeted communication strategies, for example via

multilingual information and proactive outreach by housing associations and municipalities to ensure residents are informed, empowered, and able to participate meaningfully in heat adaptation measures (Anguelovski et al., 2016; Runhaar et al., 2012).

Additionally, several measure-specific barriers contribute to the limited uptake of more transformative adaptation options, such as green roofs, reflective roofing, or structural redesigns. These measures are rarely considered by housing associations, primarily due to concerns about affordability and technical feasibility. For instance, green roofs are often dismissed due to structural unsuitability, and their maintenance can be expensive. Some housing associations questioned the effectiveness of green roofs in reducing indoor temperatures, perceiving their impact as limited. These concerns, whether based on technical constraints or perceived inefficacy, illustrate how practical and perceived barriers influence the selection of adaptation measures (Kirchoff et al., 2013; Uittenbroek, 2015).

Finally, heat adaptation strategies in the rental housing sector are constrained by trade-offs between affordability, comfort, and sustainability. Housing associations are under pressure to maintain low operational costs while ensuring adequate thermal comfort for residents. Measures such as sun-shading and ventilation can significantly reduce indoor heat stress and associated health risks but entail considerable upfront and maintenance costs (Mees et al., 2012). These trade-offs are not unique to Rotterdam; across Europe, social housing is often excluded from urban adaptation plans because of the tension between cost-effectiveness and investment in long-term resilience (Reckien et al., 2017). These financial burdens are often difficult to justify without transferring some of the costs to tenants. The paradox approach (Van der Byl & Slawinski, 2015) provides a valuable lens for addressing these tensions, as it encourages stakeholders to embrace competing priorities rather than treat them as mutually exclusive. Instead of prioritising one objective at the expense of others, this approach supports integrated solutions that account for all dimensions. For instance, adaptive investments in sun-shading could be made more feasible through cost-sharing models between housing associations and residents (Wrigley & Crawford, 2015), thereby balancing affordability with long-term resilience and comfort.

Together these barriers underscore the complexity of heat adaptation in the rental housing context, reinforcing the argument that effective strategies not only require financial and technical resources but also tailored policy frameworks and enhanced stakeholder engagement to ensure equitable and sustainable outcomes. To overcome the identified barriers, an integrated approach is essential that simultaneously addresses financial, organisational, and communication challenges. This includes developing long-term financing models that cover maintenance costs, easing budgetary constraints within housing

associations, and implementing targeted, multilingual communication campaigns to better engage residents. Additionally, applying the paradox approach (Van der Byl & Slawinski, 2015) can help stakeholders find solutions that balance affordability, comfort, and sustainability, such as cost- and risk-sharing models between housing associations and residents.

RESPONSIBILITY

The literature highlights that responsibility for heat management is both shared and ambiguously distributed among local governments, housing associations, and residents. This reflects a broader recognition that heat management encompasses both public and private responsibilities (Mees et al., 2012; Mees et al., 2014). This study confirms that ambiguity, showing that while housing associations focus on making policy for implementing physical interventions, their impact often depends on residents' behavioural adaptations.

Meanwhile, the municipality is expected to manage heat in public spaces through interventions like greening and shading, whereas residents are expected to maintain private green areas, such as balconies or gardens. However, a lack of clarity remains regarding who is ultimately responsible for informal or resident-initiated adaptations, such as sun-shading screens or window film.

This fragmented responsibility becomes particularly visible in practice. Although residents are willing to act, such as applying for tenant-initiated modifications (ZAVs), these often require permission from housing associations, which can discourage uptake. In turn, housing associations argue that municipal subsidies only cover installation, not long-term maintenance, making it difficult to justify large-scale investments. Communication from municipalities to residents is often limited, especially due to language barriers and the need for residents to actively seek out information. This reveals a gap between what is expected of residents and what is practically feasible in their daily lives.

These observations echo prior research on fragmented climate governance and demonstrate how unclear responsibility undermines effective adaptation (Lass et al., 2011; Mees et al., 2012; Bulkely & Kern, 2006). As Vanderplanken et al. (2012) argue, clearly defined responsibilities, such as the evaluator, implementor, and informer, are crucial for operationalising shared responsibility. In this study, housing associations A and C are beginning to fulfil the role of evaluator by performing an inventory of their assets, while others lack such structures, making targeted interventions difficult. As implementers, some housing associations run pilot projects, whereas others only address heat informally during renovations. The municipality acts both as implementer and informer in public spaces, focusing

on urban greening and infrastructure, but communication to residents is often limited by language barriers.

Furthermore, the role of informer remains underdeveloped. Information about heat risks and adaptation options is often inaccessible or fragmented, especially for vulnerable populations. As a result, residents are expected to act without sufficient support, and housing associations bear responsibility without adequate institutional guidance. This lack of formalised role division and communication strategies leads to fragmented implementation and inconsistent protection of vulnerable residents (Runhaar et al., 2012).

Overall, clearly defined and constantly applied roles are currently lacking across all levels. Strengthening the urgent need for formalised role allocation and improved communication strategies to enhance the effectiveness of heat adaptation measures (Anguelovski et al., 2016; Vanderplanken et al., 2021).

RESEARCH LIMITATIONS

While this study provides valuable insights, several limitations should be acknowledged. First, interviews were conducted online through Microsoft Teams, this may have limited respondents' ability to fully elaborate on their answers. Moreover, the digital format likely resulted in a younger, more digitally literate group of participants, potentially restricting the diversity of perspectives. The qualitative approach restricts the ability to present hard data, making it difficult to quantify the scale of the problem or the effectiveness of specific measures. The study further includes a limited number of resident perspectives, which may omit important insights from this key stakeholder group. Furthermore, the findings reflect the specific policy context and circumstances at the time of data collection, which means that changes in heat management strategies or regulations since then may not be captured. The absence of longitudinal data restricts understanding of trends and developments over time. This time-bound nature of the research limits the applicability of the results to future developments and highlights the need for ongoing study in this evolving field.

SUGGESTIONS FOR FUTURE RESEARCH

Several suggestions for future research emerge from this study, highlighting important gaps and opportunities to deepen the understanding of heat management in the rental housing sector.

This study shows housing associations to be in early phases of the development and implementation of heat management strategies. However, knowledge about the translation of related policies and plans into concrete actions is rather limited. Future research should therefore critically examine the implementation process of these policies and plans within housing associations, e.g. the decision-making process, allocation of resources, and prioritization and integration of different types of measures (passive, active, and behavioural) over time. Moreover, the actual effectiveness of the applied interventions in reducing indoor heat stress and improving tenant comfort and health should be critically assessed. The identification of gaps between policy intentions and actual outcomes facilitates the clarification of barriers and enablers for successful adaptation.

Secondly, the study shows the lack of knowledge on the effect of indoor heat exposure on the health of vulnerable resident groups in Rotterdam's rental housing. A study linking heat management policies and quantitative health data could provide valuable insights into the social equity dimensions of climate adaptation. Such research could explore questions like: *To what extent do existing heat management measures protect elderly or chronically ill tenants?* Answering this research question would shine valuable light on the extent to which current policies serve the residents that are most at risk and inform more targeted interventions.

Finally, further research could expand its geographical scope beyond Rotterdam to include other regions or cities, both urban and rural. Comparative studies would enable the identification of spatial disparities in policy development and implementation and highlight context-specific challenges and best practices. For instance, Reckien et al. (2017) demonstrate that across many European cities, heat adaptation policies are required to explicitly address rental housing, underscoring a widespread policy gap across Europe. Comparisons between cities and/or countries could help understanding how governance structures and mechanisms as well as socio-economic factors affect heat management strategies and offer lessons to improve policy coherence and effectiveness.

CONCLUSION AND RECOMMENDATIONS

This research aimed to analyse the implementation of heat management strategies in existing rental housing and to examine the roles of housing associations, local governments, and residents in this process. The findings reveal that current policies and regulations on heat management in rental housing are limited at both national and regional levels. At the national level frameworks are provided, but there is no legal obligation for heat management in existing rental housing. The municipality of Rotterdam supports local research initiatives and offers subsidies but lacks binding obligations. As a result, housing associations have only partially integrated heat management into their policies.

In practice, housing associations often bear responsibility for implementing heat measures, but the division remains unclear. Residents are expected to protect themselves individually but do face practical, financial or informational barriers, and their role is not embedded within policy. This lack of clarity across all levels hampers effective and coordinated heat adaptation.

Results indicate that residents experience heat stress, through suffering from discomfort due to high temperatures. The limited ventilation options in some of the housing further exacerbated these issues. Residents' ability to implement heat management measures is often limited because of the high associated costs. However, when such measures are in place, residents stated that their comfort and living conditions were improved. Besides the formal interventions, residents can adopt informal, self-initiated measures to cope with the heat, such as using fans and ventilation through opening their windows.

To mitigate heat stress in existing social housing, associations implement several measures. Sun-shading systems are the most used option and have been tested in pilot projects. Some associations mention the use of window films and the incorporation of heat considerations in renovation projects. Other potential measures, such as green roofs and enhanced ventilation options, are rarely considered by housing associations due to feasibility challenges and high costs.

Housing associations and local governments face several barriers in implementing heat management strategies. A major challenge is the financial barrier, as subsidies only cover implementation costs and exclude maintenance expenses. Additionally, many residents have limited capacity to pay for measures through service charges, and the large scale of housing stocks makes it infeasible to address heat stress across all units. Practical barriers arise from mixed building compositions and the protected status of monumental buildings. Furthermore, legal restraints limit the long-term implementation and financing of heat adaptation measures.

The implementation of heat management measures in existing rental housing in Rotterdam is still in an early phase and faces significant obstacles. Some housing associations are currently developing policies, and the measures taken are mostly limited to passive, low-maintenance strategies like sun-shading and window films. This uneven policy development is the consequence from a lack of legal obligations stated by municipalities and national governments. However, the municipality has made some efforts by implementing a tailor-made subsidy for the housing associations but lacks top-down control. Residents are largely left to take their own measures, constrained by financial limitations and practical barriers. As a result, responsibilities remain ambiguously divided, and a coordinated and structural approach to heat adaptation in the rental sector has yet to be established.

RECOMMENDATIONS

Therefore, it is recommended that national and local governments establish clear legal obligations for heat management in existing rental housing to make it feasible for housing associations to take localised interventions. Additionally, housing associations should be supported financially and technically to broaden their scope of measures beyond sun-shading and window film. Finally, residents should be encouraged to actively participate in the design and implementation of heat management strategies to ensure solutions meet their needs and capacities, thereby decreasing the existing social inequality.

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APPENDIX

TOPICLIST RESIDENTS

Residents' Experiences with Heat (Stress)

- How long have you lived here? And how do you feel about living here?
- How would you describe your living situation during a heatwave? Is your home comfortable to live in during the summer?
- Do you have difficulty keeping your home cool in the summer? If so, at what times of the day in particular?
- What challenges do you face in trying to keep your home cool during heatwaves?
- Have you received any information from your housing association about how to deal with heat?

Measures Residents Take to Manage Heat

- What measures do you currently take during a heatwave?
- Do these measures help to make it cooler?
- Are there any additional measures you think your housing association should take?
- Are there any adjustments you would like to make but cannot? What are the reasons for that?

Measures Taken by Housing Associations

- Do you think it is important that the housing association addresses heat adaptation in your home? Why or why not?
- Has your housing association taken any steps to reduce the indoor temperature in your home or building?
- Do you feel that your housing association gives priority to heat management? Why or why not?

Barriers and Recommendations for Housing Associations

- What improvements would you like to see in your home to better cope with heatwaves?
- If you could make one recommendation to your housing association regarding heat management, what would it be?

Policy, Regulations, and Responsibilities

- In your opinion, who should be responsible for taking measures to reduce heat in your home?

TOPICLIST HOUSING ASSOCIATIONS

Introduction

- How long have you been working for the organization, and what is your role?
- What are your daily tasks, and what are you responsible for within the organization?

Measures Taken by Housing Associations

- How do you think residents experience indoor heat during hot days?
- Do residents ever contact you about this?
- What do they contact you about, and how do you respond to it?
- What is the nature of the communication with residents about this issue?
- What actions do you take to prevent extreme heat in homes?
    - Can you give examples, or explain why heat is not currently a focus?
- Do you use heat labels that indicate how warm homes get? Why or why not?
- Are there any ongoing projects related to heat, and who is involved?
- Are these projects specific to certain neighborhoods, or citywide? Can you provide examples?
- Are tenants involved in the development of these measures? Why or why not?
- Have you provided your tenants with information about heat management measures? If so, how do you communicate this information?
    - For example, the flyer from the GGD and Rotterdams Weerwoord about heatwave measure, are you familiar with it?

Barriers and Recommendations for Housing Associations

- Are there currently any barriers preventing the implementation of heat measures? Can you give some examples?
- What measures that are not currently in place do you think could help reduce heat in homes?

Policy, Regulations, and Responsibilities

- Who do you think should be responsible for taking measures to reduce heat in homes?

Closing

- Do you have anything you would like to add?
- May I contact you again at a later time if needed?
- Are there any other people you believe I should speak to?

TOPICLIST MUNICIPALITY

Policy, Regulations, and Responsibilities

- How long have you been working for the municipality? What is your exact role and what are your daily responsibilities?
- How did you become involved with the topic of climate adaptation and heat resilience?
- What is your role in developing policies related to heat and heat resilience?
- Can you give a concrete example of such a policy?
- Is this policy developed in collaboration with housing associations?
- Is the policy specifically aimed at social housing?
- Is heat included in broader plans such as climate adaptation, spatial planning, or the environmental vision?
- To what extent is there cooperation with other institutions or with higher levels of government?
- What aspects of this cooperation work well, and what challenges do you encounter? Can you provide examples?
- How are responsibilities divided between the municipality, housing associations, and other stakeholders when it comes to heat?
- In your view, who is responsible for implementing heat-related measures, and why?

Measures and Strategies

- What measures have already been taken (or are planned) in neighbourhoods with a high concentration of social housing to reduce heat stress?
- Which neighbourhoods are prioritized, and why?
- Why have you chosen specific measures?
- How does the municipality evaluate whether the measures taken are effective?

Closing

- Do you have anything to add?
- Which people and/or organizations do you think should also be consulted?

TOPICLIST OTHER ORGANISATIONS

Introduction and relevance

- Could you tell me about your background and how you came to take on the role of community manager for heat and health?
- What personally motivates you to engage with the topic of heat?
- Why do you think heat is such a relevant issue for the housing sector, and specifically for housing associations?
- In your opinion, what are the main health risks related to heat in relation to housing?

Practical challenges

- What heat-related problems do you see most often occurring in existing homes—especially rental homes?
- Are there certain building types or neighbourhoods where heat problems are particularly severe?
- Which residents are the most vulnerable, and how do you notice this in practice?

Heat adaptation measures

- What do you consider to be the most effective measures that housing associations can take to make homes more heat-resilient?
- Can you give a concrete example of a successful heat intervention carried out by or with a housing association?
- To what extent are outdoor spaces such as courtyards or green façades involved in the solutions? Why is this approach chosen or not?

Collaboration with housing associations

- How willing are housing associations to include heat as a structural risk in their maintenance and renovation plans?
- What are the biggest challenges in collaborating with housing associations?
- I read that you consider heat a shared responsibility—why do you think this?
- How do you engage housing associations in the idea that heat is also their responsibility?

Closing

- Thank you for the interview. Is there anything else you would like to add? Are there other relevant organizations, persons, or residents I should speak to?

TOPICLIST HEATLAB

Introduction

- Could you briefly explain what HeatLab is and what your mission is?
- What is your role within HeatLab and how did you become involved?

Approach

- How does HeatLab contribute to reducing heat-related problems in Rotterdam?
- Which measures have been developed and/or tested by HeatLab?
- Do you mainly focus on the physical environment, or also on residents' behaviour?
- To what extent are outdoor spaces such as courtyards or green façades involved in the solutions? Why is this approach chosen or not?

Collaboration

- How is the collaboration with housing associations in Rotterdam going?
- In what way does the municipality support or influences your work?
- Are residents involved in your projects, and if so, how?

Policy development

- Are there any barriers you encounter when implementing heat adaptation measures?
- How do you think policies around heat adaptation could be improved?
- What lessons have been learned so far from HeatLab's projects?
- What do you consider the biggest challenges for heat adaptation in a city like Rotterdam?
- What are your plans or ambitions for the coming years?

EXAMPLE OF CONSENT FORM

Naam onderzoeksproject:

Hitte stress in huurwoningen in Rotterdam

Onderzoeksleider:

Nelleke Maring

Doel van het onderzoek

U wordt uitgenodigd om deel te nemen aan een onderzoek dat zich richt op hittestress in sociale huurwoningen in Rotterdam. Deelname houdt in dat u wordt geïnterviewd over de manier waarop uw organisatie omgaat met hitteproblematiek in woningen, welke knelpunten u tegenkomt, en welke maatregelen of strategieën worden ingezet of overwogen. Uw bijdrage helpt bij het verkrijgen van inzicht in hoe woningcorporaties omgaan met hittestress en welke rol zij kunnen spelen in het verbeteren van de leefomstandigheden voor huurders tijdens periodes van extreme hitte.

Wat houdt deelname in?

U neemt deel aan een interview (ca. 30 minuten). - Vooraf vult u een korte vragenlijst in. - Het interview wordt opgenomen (audio), en letterlijk uitgeschreven. - Gegevens worden geanalyseerd aan de hand van een topic list.

Privacy & vertrouwelijkheid

Uw gegevens worden geanonimiseerd of gepseudonimiseerd. - Opnames en gegevens worden veilig opgeslagen bij de Erasmus Universiteit Rotterdam. - Alleen geautoriseerde onderzoekers hebben toegang. - Publicaties bevatten géén identificeerbare informatie.

Vrijwilligheid

Deelname is vrijwillig en u kunt op elk moment stoppen zonder opgaaf van reden. - Tot 5 werkdagen na het interview kunt u uw toestemming intrekken. - Bij stopzetting worden uw gegevens verwijderd, tenzij u na de bedenktijd opzegt; dan worden alleen bestaande gegevens gebruikt.

Toestemming

Met ondertekening bevestigt u: 1. Minimaal 18 jaar oud te zijn. 2. Goed geïnformeerd te zijn over het onderzoek. 3. Vrijwillig deel te nemen. 4. Te begrijpen dat u kunt stoppen of vragen kunt weigeren. 5. Dat uw privacy gewaarborgd is.

6. Dat het onderzoek is goedgekeurd door een ethische commissie. 7. Een kopie van dit formulier te ontvangen.