Politecnico di Torino
School of Planning and Design

Master's degree program in

Territorial, Urban, Environmental and Landscape Planning

Curriculum: Planning for the Global Urban Agenda

Master Thesis

ADDRESSING URBAN HEAT ISLAND:

THE METHODOLOGICAL APPLICATION OF THE PLAN INTEGRATION FOR RESILIENCE SCORECARD™ (PIRS™) FOR HEAT IN TURIN, ITALY.

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Academic Year 2023/2024

TABLE OF CONTEXT

ABSTRACT

This thesis, titled 'Planning for Urban Heat Island: The Methodological Application of The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat in Turin, Italy' contextualizes the Urban Heat Island (UHI) effect in Turin. The PIRS™ for Heat (2022) methodology emphasizes the urgent need to address the UHI effect in Turin. By assessing the PIRS for Heat methodology as a policy transfer tool, the study gauges its effectiveness in Turin. The research advocates an integrated approach to urban planning and policy implementation and underscores the necessity for a comprehensive strategy to mitigate the UHI impact in the city efficiently.

Research stresses Italy's urgent heat hazard and UHI challenges exacerbated by climate change, urban expansion, and limited green spaces, which is demonstrated by a 2022 research that cited Italy as having the worst rate of summertime heat-related mortality in all of Europe. The trend continues in 2023 with record heat and a decade-high frequency of nearly eleven daily extreme weather events. Turin's vulnerability during the August 2023 African heatwave underscores the pressing need for resilience measures. Addressing the UHI effect in Turin requires a coordinated effort through spatial plans and policies. This study comprehensively analyzes the current planning framework for mitigating and adapting to the UHI effect in Turin, evaluating how various plans and policies are integrated into an overarching strategy to enhance resilience and address primary issues within the planning system.

The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat methodology was utilized as a testing approach in the Turin case study. The various plans addressing Heat Hazards within Turin were initially identified, and a 'Three Point Test' was applied to assess all associated actions and policies. Subsequently, the selected actions and policies were scored and categorized based on their impact on the UHI effect -whether they mitigated, exacerbated, or had a neutral or unknown impact. The scored policies were then overlaid onto Turin's urban plan to identify focal points and compare them with the city's most vulnerable areas, assessed through both physical and social vulnerability analysis, such as the UHI effect map and the map based on socio-economic data of the city of Turin. The results were then analyzed to underline areas that either address the city's vulnerability or require more attention from planners and decision-makers.

The application of the PIRS for Heat methodology revealed the impracticality of policy transfer within Turin's system of plans, which is attributed to the absence of effective coordination and seamless integration of planning practices into a unified framework. A distinct analysis indicates that only a limited number of plans within Turin's framework align with the scorecard criteria, demonstrating a coherent correlation between their actions and specific locations within the city. This highlights the need for a place-based approach and improved coordination among mitigation and adaptation strategies.

Moreover, it underscores the necessity for updates to pivotal planning instruments, such as the General Municipal Master Plan of Turin, and the comprehensive integration of non-binding yet pertinent strategic plans. This strategic approach is essential for a holistic and effective response to urban heat resilience challenges in future planning endeavors.

KEYWORDS: Urban Heat Island (UHI), Heat Hazard, The PIRS™ For Heat, Urban Resilience, Mitigation and Adaptation Strategies.

ABSTRACT IN ITALIAN

Questa tesi, intitolata "Pianificazione per l'Isola di Calore Urbana: L'Applicazione Metodologica del Plan Integration for Resilience Scorecard™ (PIRS™) per il Calore a Torino, Italia", contestualizza l'effetto dell'Isola di Calore Urbana (UHI) a Torino. La metodologia PIRS™ per il Calore (2022) sottolinea l'urgente necessità di affrontare l'effetto UHI a Torino. Valutando la metodologia PIRS per il Calore come uno strumento di trasferimento delle politiche, lo studio ne valuta l'efficacia a Torino. La ricerca sostiene un approccio integrato alla pianificazione urbana e all'attuazione delle politiche e sottolinea la necessità di una strategia globale per mitigare l'impatto dell'UHI in città in modo efficiente.

La ricerca evidenzia l'urgente pericolo del caldo e le sfide UHI in Italia aggravate dai cambiamenti climatici, dall'espansione urbana e dalla limitata presenza di spazi verdi, dimostrato da una ricerca del 2022 che ha citato l'Italia come il paese con il peggior tasso di mortalità estiva correlata al caldo in tutta Europa. La tendenza è proseguita nel 2023 con temperature record e una frequenza decennale di quasi undici eventi meteorologici estremi giornalieri. La vulnerabilità di Torino durante l'ondata di calore africana dell'agosto 2023 sottolinea l'urgente necessità di misure di resilienza. Affrontare l'effetto UHI a Torino richiede uno sforzo coordinato attraverso piani spaziali e politiche. Questo studio analizza in modo approfondito l'attuale quadro di pianificazione per mitigare e adattarsi all'effetto UHI a Torino, valutando come vari piani e politiche siano integrati in una strategia generale per migliorare la resilienza e affrontare le principali problematiche all'interno del sistema di pianificazione.

La metodologia del Plan Integration for Resilience Scorecard™ (PIRS™) per il Calore è stata utilizzata come approccio di prova nel caso di studio di Torino. I vari piani che affrontano i pericoli del calore a Torino sono stati inizialmente identificati e è stato applicato un 'Three Point Test' per valutare tutte le azioni e le politiche associate. Successivamente, le azioni e le politiche selezionate sono state valutate e classificate in base al loro impatto sull'effetto UHI - se mitigavano, aggravavano o avevano un impatto neutro o sconosciuto. Le politiche valutate sono state poi sovrapposte al piano urbano di Torino per identificare i punti focali e confrontarli con le aree più vulnerabili della città, valutate attraverso l'analisi della vulnerabilità sia fisica che sociale, come la mappa dell'effetto UHI e la mappa basata sui dati socio-economici della città di Torino. I risultati sono stati poi analizzati per evidenziare le aree che affrontano la vulnerabilità della città o che richiedono maggiore attenzione da parte dei pianificatori e dei decisori.

L'applicazione della metodologia PIRS per il Calore ha rivelato l'impraticabilità del trasferimento delle politiche all'interno del sistema di piani di Torino, attribuibile all'assenza di un coordinamento efficace e di un'integrazione fluida delle pratiche di pianificazione in un quadro unificato. Un'analisi distinta indica che solo un numero limitato di piani all'interno del quadro di Torino si allinea ai criteri della scorecard, dimostrando una correlazione coerente tra le loro azioni e specifiche località all'interno

della città. Questo mette in evidenza la necessità di un approccio basato sul luogo e un miglior coordinamento tra le strategie di mitigazione e adattamento. Inoltre, sottolinea la necessità di aggiornamenti agli strumenti di pianificazione fondamentali, come il Piano Regolatore Generale del Comune di Torino, e l'integrazione completa di piani strategici non vincolanti ma pertinenti. Questo approccio strategico è essenziale per una risposta olistica ed efficace alle sfide della resilienza al calore urbano nelle future attività di pianificazione.

BACKGROUND OF THE THESIS

This research thesis emerged from the intellectual groundwork laid during the workshop titled “Comparing US and EU Approaches to Planning for Urban Resilience,” organized by the Department of Environment, Land, and Infrastructure Engineering (DIST) of the Politecnico di Torino, held in Turin, Italy, between May and June 2022. The workshop was led by Professor Ombretta Caldarice from Politecnico di Torino and Professor Sara Meerow from Arizona State University. Professor Meerow, a notable co-author of the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat methodology, which serves as a core analytical tool in this research, provided critical insights that informed the foundational aspects of this thesis.

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LIST OF ABBREVIATIONS

ARPA: Agenzia Regionale per la Protezione Ambientale (Regional Agency for Environmental Protection)

ATSDR: Agency for Toxic Substances and Disease Registry

BT: Brightness Temperature

CDC: Centers for Disease Control and Prevention

DIST: Department of Environment, Land, and Infrastructure Engineering

EE: Earth Engine (related to Google Earth Engine)

EPA: Environmental Protection Agency

ESRI: Environmental Systems Research Institute (Geospatial software company)

EU: European Union

GIS: Geographic Information Systems

GREENPRINT: Il Piano Strategico dell'Infrastruttura Verde (The Strategic Plan For Green Infrastructure)

LED: Light Emitting Diode

LSE: Land Surface Emissivity

LST: Land Surface Temperature

NAP: National Adaptation Plan

NAS: National Adaptation Strategy

NDVI: Normalized Difference Vegetation Index

NIR: Near Infrared

OLI: Operational Land Imager (used in satellite remote sensing)

PAESC: Piano d'Azione per l'Energia Sostenibile e il Clima (Sustainable Energy and Climate Action Plan)

PAI: Piano di Assetto Idrogeologico (Hydrogeological Management Plan)

PGRA: Piano di Gestione del Rischio Alluvioni (Flood Risk Management Plan)

PIRS™: Plan Integration for Resilience Scorecard™

PRG: Piano Regolatore Generale (Urban General Plan)

PTPP: Piano Territoriale di Coordinamento Provinciale (Provincial Territorial Coordination Plan)

PUMS: Piano Urbano della Mobilità Sostenibile (Urban Sustainable Mobility Plan)

QGIS: Quantum Geographic Information System (Open-source GIS software)

SVI: Social Vulnerability Index

TAPE: Thermal Anomaly Profile Extraction

The U.S. (or The U.S.A.): The United States of America

TIRS: Thermal Infrared Sensor (used in satellite remote sensing)

TOA: Top of Atmosphere (Satellite data parameter)

TPL: Trasporto Pubblico Locale (Local Public Transport)

UGP: Urban General Plan (Italian: Piano Regolatore Generale)

UHI: Urban Heat Island

USGS: United States Geological Survey

CHAPTER I

INTRODUCTION

LITERATURE REVIEW

METHODOLOGY

RESULTS

DISCUSSION

CONCLUSION

ANNEXES

This chapter introduces the research titled: "Planning for the Urban Heat Island: The Methodological Application of The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat in the City of Turin." This chapter starts with the background and context of the study. It clearly defines the research problem and outlines the research aim, objectives, and questions. The chapter also explains why the study is important, describes the chosen method, and discusses its limitations. Finally, it provides an overview of the research structure.

1. CHAPTER I: INTRODUCTION

As the global community works to combat climate change, factors like rising urbanization and temperatures, along with outdated city models, have intensified the "deadliest and most silent" hazard(Keith & Meerow, 2022) - urban heat.. This phenomenon has become an important concern for cities across the globe. Consequently, urban heat resilience has emerged as a focal field of study worldwide.

This research addresses the urgent need for effective strategies to mitigate the UHI effect in the city of Turin, Italy. The primary objective of this study is to evaluate the efficacy of the "Plan Integration for Resilience Scorecard™ (PIRS™) for Heat" methodology in assessing and enhancing heat resilience planning within the Italian city of Turin.

This chapter frames the study by first exploring the background and context of urban heat challenges worldwide and in Italy. It then identifies the research problem and the study's aims and objectives, describes the study's limitations, and outlines an overview of the thesis structure.

1.1. STUDY BACKGROUND AND CONTEXT

1.1.1. URBAN HEAT ISLAND (UHI) AND GLOBAL IMPLICATIONS

Extreme heat is considered the deadliest climate-related risk in the world (Keith Ladd et al., 2022), causing thousands of preventable deaths annually. Climate change, driven by greenhouse gas emissions, has already increased global temperatures, leading to more frequent and severe heatwaves. The UHI effect exacerbates this by making urban areas significantly warmer than their rural surroundings due to factors like impervious surfaces, loss of vegetation, and waste heat emissions. This leads to more heat-related illnesses and deaths, especially impacting vulnerable populations, and increases energy demands for air conditioning, which also raises air pollution levels. Vulnerable populations, including the elderly, low-income groups, and those with chronic health conditions, are at a heightened risk due to their reduced capacity to adapt or afford cooling solutions(UN-HABITAT, 2024).

As urbanization continues and more people move to cities, the number of those exposed to dangerous heat rises. The severity of the UHI effect depends heavily on how urban environments are planned, designed, and managed. The use of heat-absorbing materials, loss of natural space, and emissions from vehicles and buildings all contribute to the problem.

More and more planners and governors worldwide are dealing with a multitude of complicated challenges that cities and their residents are currently dealing with. In the last two years, the well-known problem of excessive heat has come into a bigger focus, with a shocking amount of catastrophic heat-related events being documented and registered all over the globe.

The impact of these events is not just felt in the immediate aftermath but also has long-term consequences for public health and infrastructure. They can lead to heat-related illnesses, strained healthcare systems, and even fatalities and can also exacerbate existing social inequalities, while manifested throughout multiple layers of issues, such as climate change, excessive urbanization rates, Urban Heat Island (UHI) phenomenon with social vulnerability which exponentially increase the heat mortality risks within the urbanized areas.

The Rise of Temperature Over the Globe. The temperature rise limits set by the 1994 Paris Agreement have already been exceeded: the 1.5°C threshold above pre-industrial levels has been reached for a while now.

In July 2024, the global average surface air temperature reached 16.91°C, making it the second-warmest July on record, according to ERA5 data from the European Union's Earth observation programme – the Copernicus Climate Change Service (C3S).This temperature was 0.68°C higher than the 1991-2020 average and just 0.04°C below the record set in July 2023. Notably, July 2024 also marked the conclusion of a 13-month period during which each month set a new record for warmth in the ERA5 dataset, reflecting a pattern similar to the 2015/2016 El Niño event.

The 2024 has been particularly alarming, with Earth's average daily temperature spiking to an unprecedented 17.16°C on July 22, outstripping previous record. This escalation in temperatures highlights the disturbing acceleration in global warming. Over the past 12 months (July 2023 – June 2024), the global average temperature was 0.76°C above the 1991-2020 average and 1.64°C above the pre-industrial average, with July 2024 alone being 1.48°C above the estimated pre-industrial July average (Figure 1).

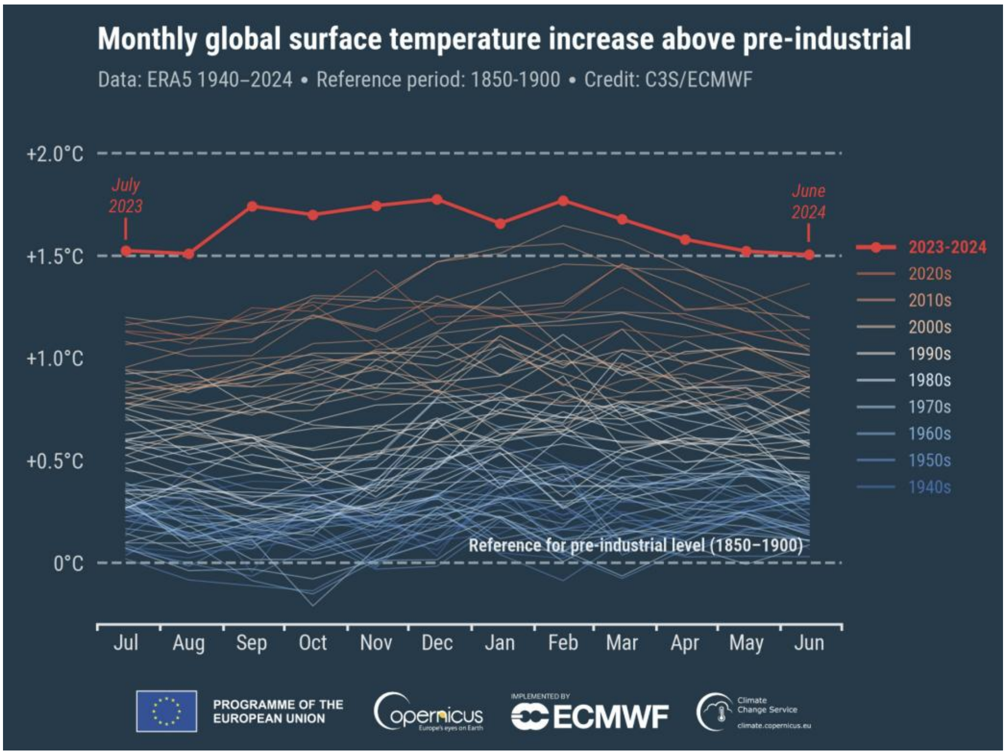
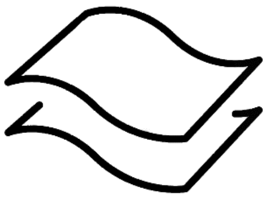


Figure 1. Monthly global surface temperature increases above the pre-industrial period. Source: C3S, 2024.

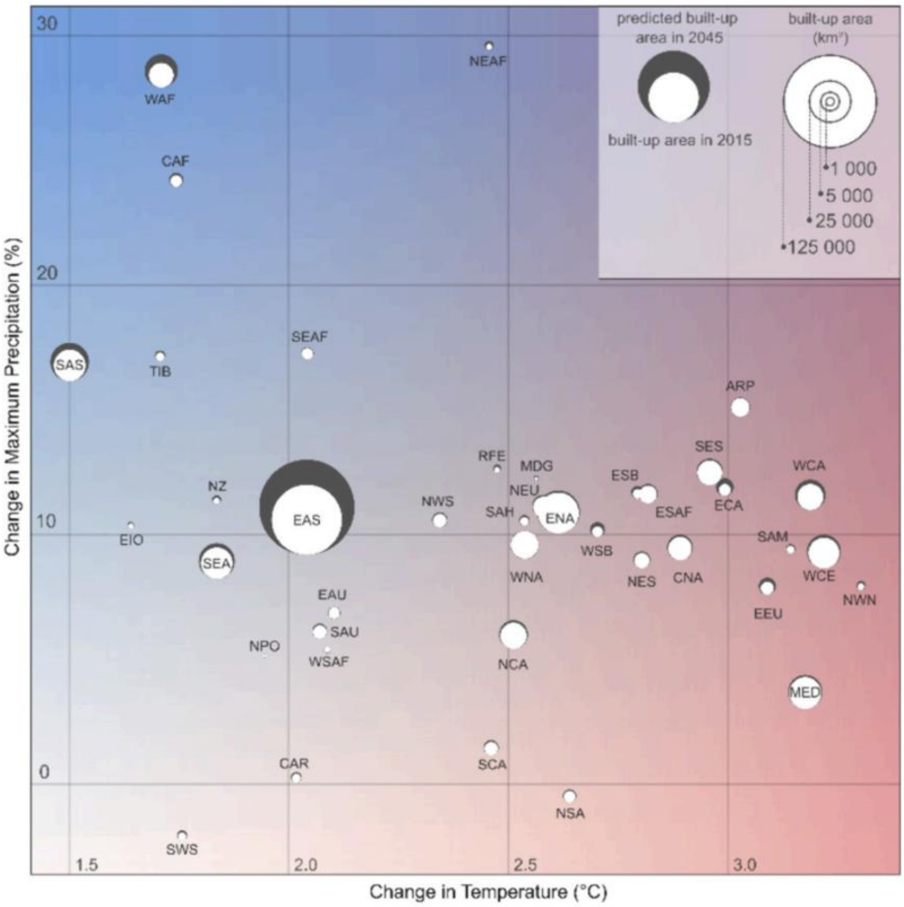
Looking ahead, if current emission trajectories persist, global temperatures could rise dramatically—potentially reaching 2.1°C by 2050, 3.0°C by 2080, and 3.6°C by the century's end. Some models even suggest worst-case scenarios where temperature anomalies could soar up to 14°C by 2100 (Noll, 2023). As we face these projections, the exact ranking of 2024 as the hottest year remains uncertain, contingent on the upcoming phases of the El Niño Southern Oscillation. However, the data unmistakably places us in "uncharted territory," as described by C3S Director Carlo Buontempo.

Current data suggests that urban residents are increasingly exposed to climate-induced extreme temperatures. For example, by the 2050s, 1.6 billion urban residents could face occasional extreme temperatures of at least 35°C (UN-HABITAT, 2024).

Urbanization growth. Layering over global warming, the cities face the urbanization issue, where growing urbanization rates play a significant role in increasing exposure to extreme climatic hazards such as heat.



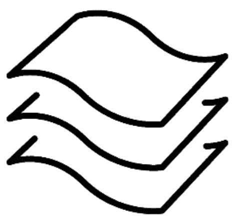
Urban areas have seen a significant increase in emissions, from 62% to 67-72% of the global share between 2015 and 2020. Urbanization can increase exposure to extreme climatic hazards, particularly in low-lying and coastal zones. Between 1985 and 2015, settlement areas of 1567 cities doubled, adding over 144,000 km² of urban area. However, there are significant differences in growth dynamics, with some cities expanding by over 1000% and others remaining constant. Asia saw the highest growth rates, with cities nearly tripling in area, with East and South Asia experiencing the highest expansion rates (Calvin et al., 2023).



	population [M]		built-up area [km²]		RMSE [km²]
	2015	2035	2015	G EX 2045	1985 2015
EAS	617	839	71788	56983	264
WAF	75	154	8843	5936	26
SAS	276	446	14621	5521	39
SEA	120	175	14554	2856	40
WCA	95	144	9830	2480	24
ECA	15	23	2057	1799	10
WCE	101	108	13830	1567	29
EEU	15	16	2443	1136	10
WSB	12	14	1691	1005	5
ENA	125	148	24298	901	42
NCA	70	90	10038	855	27
MED	158	206	14878	770	32
CNA	31	40	7996	636	20
ESB	15	19	1328	557	5
CAF	34	74	1922	406	3
NEU	47	54	6191	362	10
NEAF	7	16	528	309	4
SES	90	107	8937	301	19
NZ	2	3	567	243	2
NES	37	5	3333	223	8
NWN	3	4	635	221	3
SWS	10	12	974	189	7
RFE	4	5	473	189	2
TIB	10	17	1067	159	3
SCA	24	33	2612	159	7
SAH	13	23	1079	137	5
ESAF	33	55	4619	127	13
CAR	12	15	1192	120	5
NWS	44	57	2632	105	8
NSA	17	21	2016	93	4
WNA	42	51	11474	71	20
SAU	8	11	2623	66	4
ARP	36	57	5026	38	14
SEAF	23	56	1923	15	8
EIO	1	1	417	13	7
SAM	6	9	947	11	3
EAU	8	11	2056	13	4
MDG	3	7	192	7	2
NPO	1	1	178	0	1
WSAF	6	9	601	0	1

Figure 2. The relationship between Temperature and Precipitation and Urban Growth within the main world regions. Source: Taubenböck et al. (2024).

In Figure 2 the study by Taubenböck et al. (2024) visualized the consequences of the combination of urban territorial growth with climate change in different regions of the world and see that Central Europe (WCE on the graph), therefore Italy, could be in a higher danger of temperature rise above 3°C by 2045 in comparison to the current temperatures if the growth trends will not change.



Urban Heat Island: In addition to global warming and growing urbanization rates, there is an unequal impact of heat-related risks faced by the cities and manifested by the phenomenon called Urban Heat Island (UHI), which is characterized as the temperature rises in built-up urban areas relative to the surrounding rural countryside. This phenomenon occurs largely because man-made materials absorb and store a greater proportion of incident solar energy. The temperature difference is usually more pronounced during the night and is caused by factors such as the modification of land surfaces, waste heat generated by energy use, and the density of infrastructure. Above that, there is also a rise in temperature within the cities, in areas with low green or blu coverage and with higher surface heat absorption, which implies additional danger within the city. The UHI affects directly and indirectly many areas of life, as well as adds additional effect over already preoccupying climate change. This tendency is supported by multiple studies including those from

NASA Earth Observatory and UNEP, which show how heat accumulates in different urban fabrics, exacerbating the effects of global warming. Direct Impacts: Significant increases in both daytime and nighttime temperatures; Increased air conditioning loads; Deteriorated air and water quality; Reduced pavement lifetimes; Exacerbated heat waves. Indirect Impacts: Higher energy consumption.; Elevated emissions of air pollutants and greenhouse gases.; Compromised human health and comfort. (Arnfield, 2003; Grimmond & Oke, 1999; Keith& Meerow, 2022; Oke, 1982; Phelan et al., 2015).

Figure 3. Complex layering composing the Urban Heat Hazard risk in cities. Source: Personal elaboration.

Heat Mortality and he Invisible Danger. The UHI effect can significantly impact mortality rates during summer. Higher temperatures in urban areas can lead to heat stress, heat exhaustion, and heatstroke, particularly among vulnerable populations such as the elderly, children, and those with pre-existing health conditions. Prolonged exposure to elevated temperatures can exacerbate cardiovascular and respiratory diseases, increasing the risk of heat-related illnesses and deaths.

In fact, in the study "Heat-related mortality in Europe during the summer of 2022" by Ballester et al. (2023) published in Nature Medicine journal analyzed the Eurostat mortality database and revealed that an Estimated 61,672 heat-related deaths were registered in Europe during the summer of 2022, with Italy, Spain, and Germany having the highest mortality numbers, with Italy leading with the highest mortality rates as well.

Interestingly, **the gender inequality** was registered with women having 56% more heat-related deaths than men. Furthermore, the higher mortality rates in men were recorded for the groups aged 0-64 and 65-79, and women aged 80+ years, proving the importance of attention needed towards the vulnerable social groups during extreme heat events. The most significant mortality peaks among all groups of people occurred specifically during major heat waves, particularly in mid-July to mid-August, with Week 29 of 2022 alone causing 11,637 deaths, emphasizing the need for urgent adaptation and mitigation measures during the forecasted heat events.

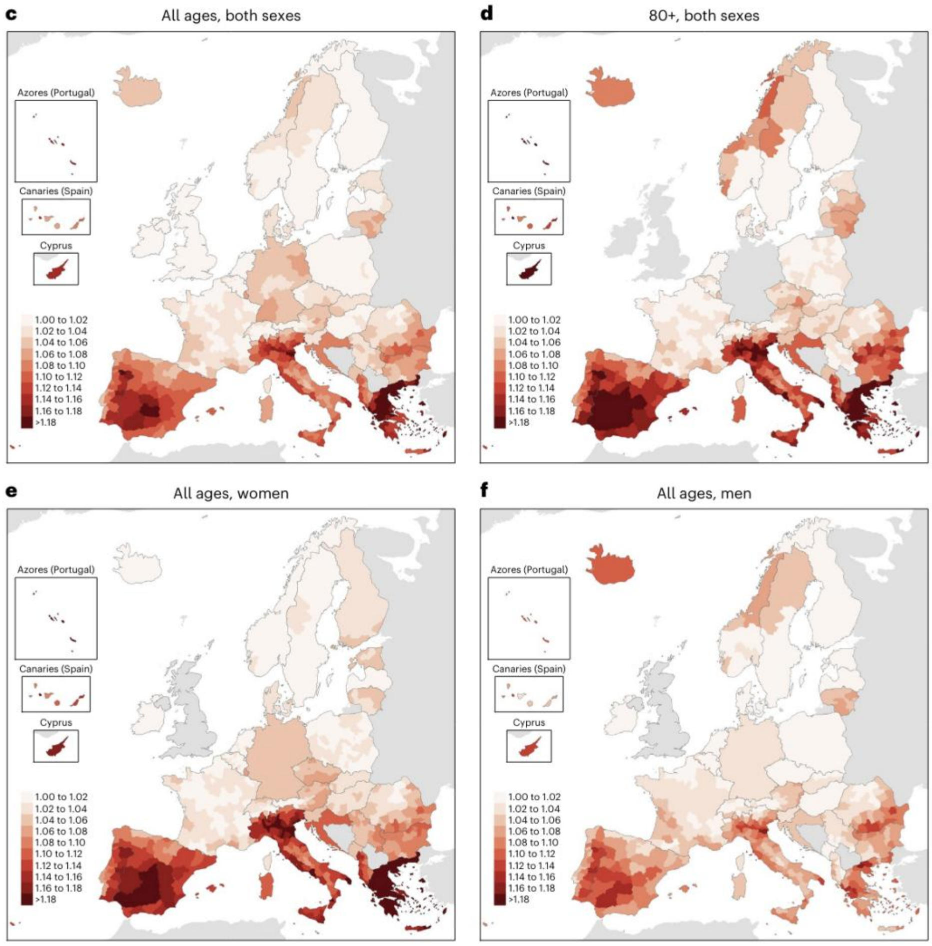


Figure 4.Heat-related risk of death during 2015–2019 period in different population groups when exposed to very high temperatures (specifically, the temperature at the 95th percentile) for the overall population (c), people aged 80+ years (d), women (e) and men (f). Source: Ballester et al., p.3 (2023).

Figure 4 shows that for all age and gender groups, the geography of the highest mortality rate is located within the Mediterranean basin, with Central and Southern Europe particularly affected during the intense heat waves of summer 2022 and Italy among the most affected for all age groups.

According to a recent study published in Nature Medicine (Gallo et al., 2024), Europe experienced approximately 47,690 excess heat-related **deaths in 2023**. This represents the second-highest heat-related mortality burden since 2015, surpassed only by 2022. Despite this substantial and largely preventable loss of life, the study estimates that the heat-related mortality burden would have been 80% higher in the absence of current adaptation measures, particularly for elderly populations.

Data on **heat mortality for 202**4 is not yet available as the year is still in progress, however, given the observed trends of increasing global temperatures and the frequency of extreme heat events, it is anticipated that heat-related deaths will remain a significant concern (Jenkins et al., 2022). There is an important link between climate change and the increasing frequency and intensity of extreme heat events, emphasizing the growing risk to vulnerable populations and climate change has an important role in the heat mortality level as well (Diniz et al., 2020) .

Furthermore, particular groups of the community—young people, the elderly, those with lower incomes, and the homeless—are more vulnerable to heat-related illnesses and deaths. In fact, forecasts show that during the previous 20 years, there has been a 53,7% increase in heat-related mortality among those over the age of 65. Due to limited access to energy-efficient housing and cooling services, vulnerable populations—many of whom reside in socioeconomically poor neighborhoods—face increased risk factors. (Hondula et al., 2015; Watts et al., 2021; Keith & Meerow, 2022; Menga, 2023).

1.1.2. ITALY IN THE FRONT ROW OF EXTREME HEAT

Italy's urban population grew at a rate of 0.27 from 72,5% per 2023 statistics and is planned to reach 81.1% by 2050, while the temperature during the summer months has broken all records over the past two years. According to Copernicus (2023) **Summer 2023** was globally the hottest on record, with the June-July-August season marking an average temperature of 16.77°C, surpassing the average by 0.66°C. The heatwaves extended to Europe, where temperatures reached 19.63°C, making it the fifth warmest summer, exceeding the average by 0.83°C, and August 2023 emerged as the warmest globally, with a temperature of 16.82°C, surpassing the 1991-2020 average by 0.71°C and setting a new record compared to the previous warmest August in 2016 by 0.31°C. The record heat was accompanied by an average of almost eleven extreme events per day along the country, including hailstorms, tornadoes, water bombs, heat waves, and wind that caused victims and damage, according to the European Severe Weather Database (2023). The alarming increase in heat-related mortality and the occurrence of extreme weather events in Italy and in the city of Turin, which itself experienced the strongest African heat wave between 18 and 24 of August 2023 (ARPA Piemonte, 2023b) Highlight the urgent need for effective heat resilience planning in urban areas.

The summer of 2024 did not break the record as the hottest summer yet was named the hottest year overall in the world according to The World Meteorological Organization (2024).

In summary, the global temperature rise, together with urban population growth and the urban heat island effect, made a perfect mix for the heat hazard risk within the city, which, if not addressed immediately, can lead to disastrous consequences, specifically for the most vulnerable groups of the society.

If **addressed properly UHI** issue through urban heat resilience practices can help not only the city population but could **help address climate change as well**. By lowering energy use, storing carbon, and boosting urban resilience, these tactics connect regional urban planning initiatives with global climate objectives. Addressing the UHI effect through vegetation and soil unsealing not only reduces urban heat but also makes a significant contribution to climate change mitigation efforts. (Keith & Meerow, 2022; Lauwaet et al., 2024).

1.2. RESEARCH PROBLEM AND AIM DEFINITION

1.2.1. RESEARCH PROBLEM

From the review of existing literature and planning instruments, it was clear that the urban heat issue is rising more and more frequently and even addressed in a few planning instruments of the city. Thus, the efforts designed by the city seem to be very dispersed and not specific in terms of localization, proper organization, and integration of heat planning within the planning framework.

Therefore, the issue of holistic planning for Urban Heat Island was identified with the main aim of understanding the effectiveness of the adopted methodology from the US that is specifically designed for addressing the Urban Heat across the network of plans within the communities and urbanized areas – "The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat: Spatially evaluating networks of plans to mitigate heat" by prof. Meerow Sara and Prof. Keith Ladd from Arizona State University, The U.S.

What is already established in the field? To this date few major facts were established within the field of Urban Heat Planning. **First, adaptation and mitigation strategies** are underlined to be the most effective in addressing the UHI issue. Mitigation efforts aim to reduce the built environment's contribution to extreme heat, thereby cooling cities, neighborhoods, and heat-vulnerable locations. Multiple actions such as, land-use planning, urban design, urban greening, and waste heat reduction, can mitigate the UHI effect and create more heat-resilient environments, protecting people, ecosystems, and livelihoods, and making a substantial impact to a sustainable future (Keith & Meerow, 2022; Calvin et al., 2023; United Nations Climate Change, 2015). **And second**, the understanding of the issue of UHI and its consequences and that the key to find **a solution through urban/spatial resilience practices is laying withing the holistic approach to the problem.**

Multiple scholars underline that addressing heat-related risks in urban areas necessitates a multifaceted approach that includes structural changes, community engagement, and targeted interventions to protect vulnerable populations and foster equitable, resilient cities. Urban communities worldwide are increasingly advancing in heat resilience planning each year, despite its nascent stage as a planning strategy. The integration of climate planning practices provides a promising foundation for future heat resilience initiatives (Menga, 2023; Keith Ladd et al., 2022). However, it is noted that defining and operationalizing spatial heat resilience remains a significant challenge due to its broad and ambiguous use; therefore, addressing structural, technical, and policy gaps is essential for practical implementation. Comprehensive measurement tools that consider multiple dimensions and spatial interactions are necessary for effective spatial resilience. Urban resilience, in general, requires a cohesive framework, bridging theoretical concepts and practical applications, integrating diverse stakeholder perspectives, and addressing contextual specificities such as temporal and spatial scales (Meerow et al., 2016; Brunetta & Caldarice, 2020). Enhancing urban/spatial heat resilience in urban areas also demands an integrated dialogue among science, policy, and practice, and robust vertical and horizontal integration. Abandoning silo thinking and fostering mutual understanding across sectors and governance levels will enable more ambitious and coordinated climate actions. The need for better integration and continuous learning underscores the importance of a circular dialogue to ensure effective resilience strategies (Caldarice et al., 2021). This comprehensive understanding and implementation of mitigation strategies in urban planning and development are vital for creating resilient and sustainable urban environments.

What is missing? Nevertheless, **the studies** focus on the need for strategies but **do not explore the way of introduction of the mitigation strategies into the planning systems of Turin.** This research addresses the urgent need for effective strategies to mitigate the UHI effect in the city of Turin, Italy. By effective strategies, this paper means the integration of UHI mitigation actions into the planning system.

As part of the LIFE-DERRIS project, the city of Turin developed a Climate Resilience Plan in 2018 to address the urban heat island effect and flood risk management. The city's experience in implementing flood mitigation measures through binding plans such as the Hydrological Management Plan and the Flood Risk Management Plan provides a realistic perspective on its potential and flexibility to introduce heat mitigation measures into its mandatory planning efforts.

The Piano di Assetto Idrologico (PAI) (Regione Piemonte, 2021c) is a critical regulatory framework that aims to mitigate hydrogeological risks within the Po River Basin. It is legally binding and has been incorporated into urban planning, ensuring that land-use decisions adhere to its standards to safeguard the region against hydrogeological hazards. Similarly, the Piano di Gestione del Rischio Alluvioni (PGRA) (Regione Piemonte, 2021b) is a comprehensive framework designed to manage and mitigate flood risks within the Po River Basin. The PAI and PGRA together ensure a coordinated and integrated approach to managing water-related risks, enhancing the resilience of the region's infrastructure and communities. However, despite these rigorous and legally binding measures for hydrogeological risk management, **no such binding action has been taken to mitigate urban heat** in the city of Turin. Only a few non-binding strategic plans have been developed, highlighting a significant gap in addressing urban heat issues and raising the question of why similar comprehensive and binding measures are not implemented for urban heat mitigation.

Why this is a problem? As a result, the existing planning system does **not have the flexibility** to fit the Urban Heat mitigation and adaptation strategies into its system, resulting in a lack of coherent and holistic addressing of the issue together with inefficient plan production, where the researchers and the practitioners develop the plans which cannot have an adequate weight in the planning system to actually fulfil their purpose.

1.2.2. RESEARCH AIM

Despite the growing acknowledgment of urban heat issues, integrating climate mitigation and adaptation actions locally need to be improved in particular in the city planning tools. **The aim of this thesis is to assess Turin's UHI issue and its heat vulnerability and provide actionable recommendations for enhancing urban heat**

resilience planning, through evaluation of the effectiveness of the "Plan Integration for Resilience Scorecard™ (PIRS™) for Heat" methodology, developed by Keith Ladd and Meerow Sara (2022), in addressing urban heat across a network of plans within urban areas of Turin.

1.2.3. RESEARCH OBJECTIVES

1. **To assess** the planning framework for heat mitigation in Turin, using PIRS™ for Heat methodology.
2. **To evaluate** and map Turin's heat vulnerability.
3. **To identify** unique challenges in urban heat planning and **provide** actionable recommendations for enhancing urban heat resilience planning within the planning network of the city of Turin.

1.2.4. RESEARCH QUESTIONS

1) **How effective** is the current planning framework in Turin for mitigating and adapting the Urban Heat Island (UHI) effect, as assessed using **the PIRS™ for Heat** methodology?
2) **What are the specific areas** of Turin that **are most affected and vulnerable** to extreme heat?
3) **What unique challenges does Turin face** in urban heat planning, and what actionable recommendations can be made to enhance heat resilience within the city's planning network?

1.2.5. RESEARCH SIGNIFICANCE

Setting specific urban heat objectives and defining specific strategies to achieve them is only one part of urban heat planning; the other part includes developing the functioning holistic planning structure to facilitate the work of planners in addressing heat issues in the city.

This study provides **the view of the Italian planning system from a different perspective**, that of a heat vulnerability utilizing the method, already broadly used in the US, the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat. The findings from **the study could work as a platform for future heat planning** and **an instrument to reflect** on flows and gaps in existing planning instruments within the city of Turin and in the Italian context in general.

1.3. METHODOLOGICAL APPROACH

The study's methodology is **based on the PIRS™ for Heat methodology**, developed for the US context, and implies a certain level of modification to suit the context of a study area, the city of Turin.

1.4. STUDY LIMITATIONS

This study is subject to several limitations, primarily due to the constraints of **available data.** The analysis relies on publicly accessible data for the city of Turin, which is limited and somewhat outdated, with the most recent information being from 2021. Such temporal gaps may affect the accuracy and relevance of the findings.

Furthermore, the PIRS™ for Heat methodology typically **requires a minimum of two reviewers** to ensure thorough evaluation and scoring of plans and actions. However, as this study is conducted as part of a personal master's degree project, the assessments and reviews were performed solely by author, which may introduce potential biases and limit the comprehensiveness of the evaluations.

The vulnerability analysis was carried out by analyzing the available data to align with the PIRS™ for Heat methodology framework. However, this process faced challenges due to **the absence of thorough open data**, including detailed information on heat-related fatalities, household conditions, and economic statistics. The absence of this information may have affected the depth and precision of the vulnerability assessment, potentially overlooking key factors influencing heat vulnerability in Turin.

1.5. THESIS OUTLINE

In **Chapter One**, the context of the study has been introduced. The main aim, together with the objectives and questions of the research, has been identifying the value of such arguments. The main limitations of the study have also been discussed.

In **Chapter Two,** the existing literature will be reviewed to understand the global UHI phenomenon and its implications, as well as approaches to Heat resilience planning within different planning frameworks and to lay the knowledge base for further research.

In **Chapter Three**, the main methodological framework will be presented. The use of both quantitative and qualitative research approaches will be justified, and the adjustments to the case study application will be presented.

In **Chapter Four**, the results of the application of the methodological framework to the case study will be shown and interpreted to subsequentially answer one of the second research questions.

In **Chapter Five,** the research results will be discussed, and the possible future application of the study will be shown. The conclusions will be made, answering the remaining research questions and underlining the main aim of the study.

CHAPTER II

INTRODUCTION

LITERATURE REVIEW

METHODOLOGY

RESULTS

DISCUSSION

CONCLUSION

ANNEXES

This chapter offers a comprehensive overview of the Urban Heat Island phenomenon through theory and practice, from the understanding of the causes and consequences to the heat resilience practices to combat UHI in Italy and the U.S.. Finally, the chapter overview the methodological tool The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat" for giving a solid knowledge base to the research.

2. CHAPTER II: UNDERSTANDING THE URBAN HEAT ISLAND EFFECT AND HEAT RESILIENCE PLANNING

This chapter **aims** to provide a foundational understanding of the urban heat island effect. It explores the causes, impacts, and strategies to address this phenomenon. The chapter then analyzes existing planning frameworks for heat mitigation in Italy and the U.S., offering a comparative perspective. It also introduces the Plan Integration for Resilience Scorecard for Heat methodology a main methodological tool for this study.

In conclusion, the chapter identifies key **research gaps**, formulates central **research questions**, and **outlines the methodological approach** for applying the PIRS™ framework in Turin, Italy. This aims to enhance urban heat resilience planning within the Italian planning system, specifically in the city of Turin, as a case study location.

This chapter is structured in two parts: **Part I** delves into the urban heat island phenomenon, exploring its definition, historical context, characteristics across various city types, underlying causes, and significant consequences. **Part II** analyzes existing planning frameworks for heat mitigation in Italy and the U.S., providing a comparative perspective and introducing the PIRS™ for Heat methodology. The chapter **concludes** by identifying research gaps, formulating key research questions, and outlining the methodological approach for applying the PIRS™ framework in Turin, Italy.

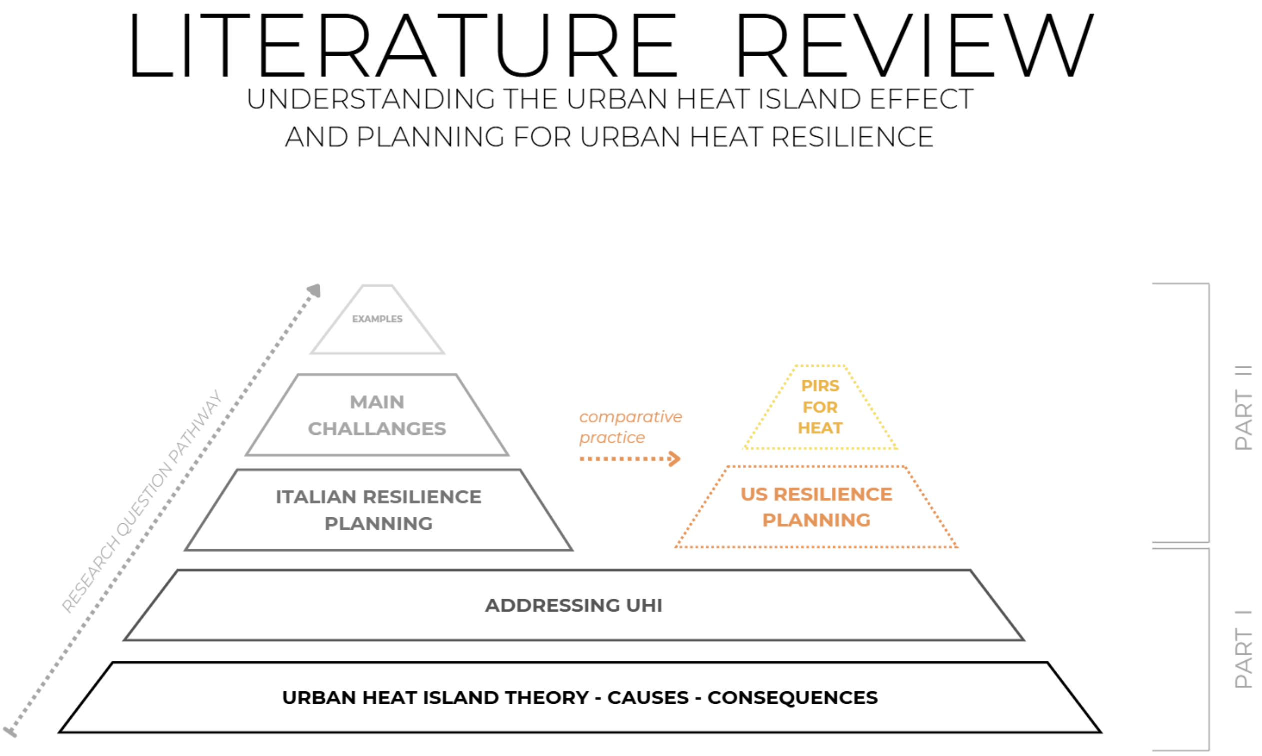


Figure 5. The logical flow of the literature review. Source: Personal elaboration.

2.1. UNDERSTANDING THE URBAN HEAT ISLAND (UHI) PHENOMENON

Extreme heat, driven by both the urban heat island effect and climate change, poses a growing threat to communities worldwide (Keith & Meerow, 2022). Therefore, prior to delving into the specifics of heat planning, it is necessary to establish a comprehensive understanding of the fundamentals of the urban heat island phenomenon.

2.1.1. DEFINITION AND HISTORICAL CONTEXT

The concept of the urban heat island effect was first noticed in the early 19th century, when Luke Howard, a British meteorologist, observed that the City of London experienced higher temperatures compared to the surrounding rural areas. The term "Urban Heat Island" was formally introduced in a paper published in 1810, where Howard documented the warmer temperatures observed within the city compared to the adjacent rural environments (Hamblyn, 2022). This observation marked the beginning of scientific research into the phenomenon of urban heat islands. In 1929, Albert Peppler introduced the term "städtische Wärmeinsel" (urban heat island) in a German publication, marking one of the earliest formal recognitions of this phenomenon (Stewart, 2019). By the late 20th century, UHI research had expanded greatly, with studies published increasing from about 30 annually in the 1990s to over 300 by 2015 (Masson et al., 2020).

DEFINITIONS - URBAN HEAT ISLAND

"The Urban Heat Island (UHI) effect can be described as a distinct urban climate, characterized by higher temperatures in densely built-up areas compared to the surrounding areas"- Oke (1982b). This phenomenon is caused by the anthropogenic alteration of the natural environment, such as the development of buildings and impervious surfaces. These changes determine a higher heat capacity which traps more energy and radiation with a consequent increase in temperature" (Marando et al., 2022).

Some definitions emphasize the importance of the rural-urban temperature differential, while others highlight the specific drivers and impacts of the UHI.

According to the Intergovernmental Panel on Climate Change (IPCC) (2023), the Urban Heat Island is defined as ***"the relative warmth of an urban area compared to its surrounding rural environs."***

This temperature differential is driven by various urban characteristics, such as land use patterns, building design and materials, reduced greenery and ventilation, and anthropogenic heat generation from human activities and infrastructure.

The U.S. Environmental Protection Agency (2024) defines the UHI as ***"a metropolitan area that is significantly warmer than its surrounding rural areas due to human activities."***

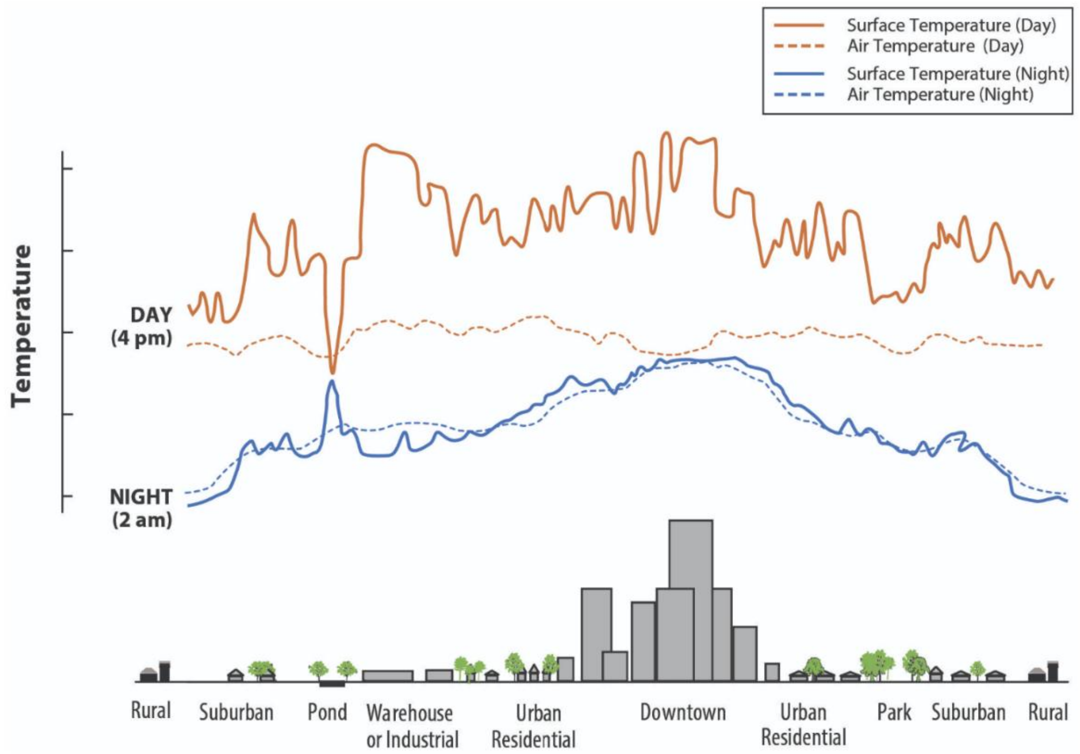


Figure 6: Heat Island Effect Diagram. Source: US Environmental Protection Agency.

While definitions provide an overall understanding of the urban heat island phenomenon, the next subsection will examine more closely the distinct characteristics and types of urban heat islands observed across different urban environments. Since each city and its surrounding environment are unique, it is crucial to understand how the urban heat island effect manifests within each specific context.

2.1.2. MAIN CHARACTERISTICS

The characteristics of Urban Heat Islands (UHI) vary within different urban fabrics of a city, influenced by factors such as density, land cover, and socioeconomic conditions. Due to the complexity of urban areas, each city possesses unique characteristics that affect the UHI phenomenon. These factors may include humidity levels, elevation above sea level, and seasonal variations, which can exacerbate heat in certain seasons more than others. Understanding these aspects adds depth to the issue, prompting urban planners and policymakers to conduct more comprehensive analyses of UHI challenges.

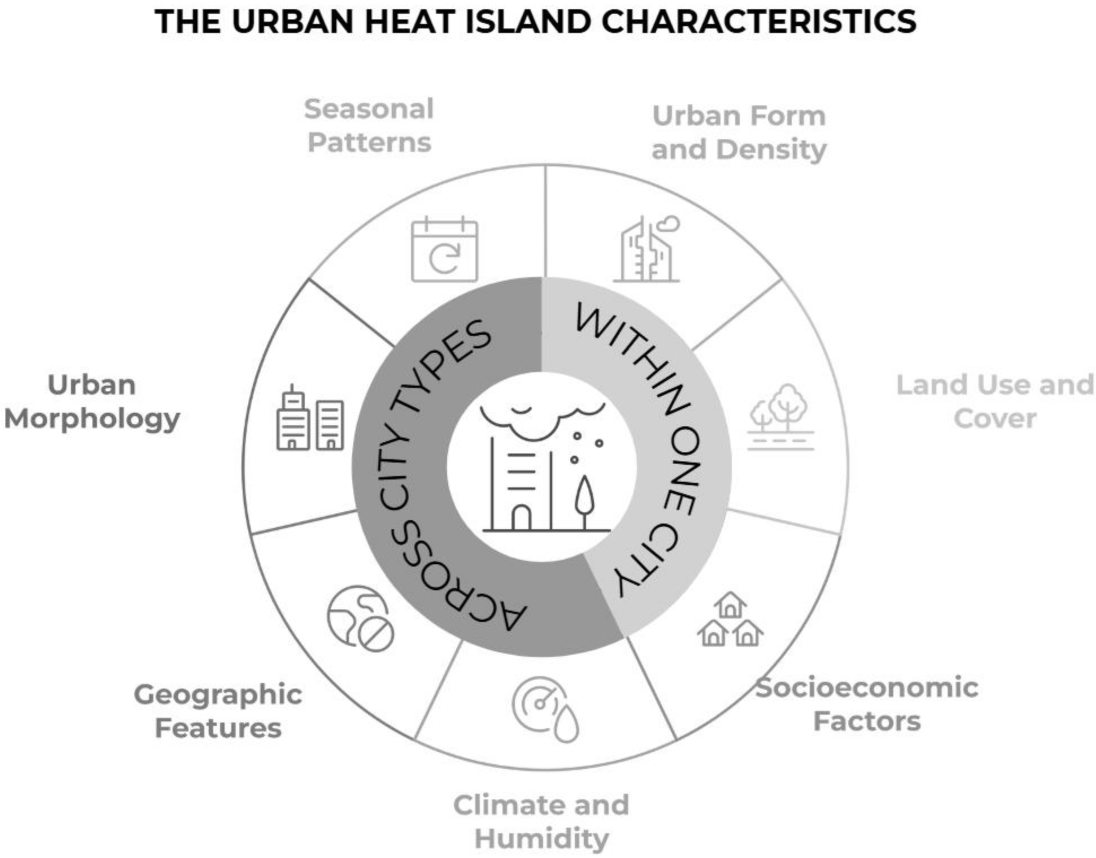


Figure 7. Graph visualizing UHI characteristics is divided into two types: characteristics within the city fabrics and across different types of cities. Source: Personal elaboration.

A. CHARACTERISTICS OF UHI WITHIN THE CITY

1. Urban Form And Density. The relationship between urban form and UHI is complex. While compact urban layouts can align with sustainability goals, they may also amplify UHI effects due to factors such as increased air conditioner usage and reduced ventilation (Kang et al., 2022; Lemonsu et al., 2015). However, compact, connected urban development might mitigate UHI by limiting sprawl. In contrast, sprawling cities often face more extreme heat risks due to broader geographic exposure (Schwarz & Manceur, 2015).

2. Land Use And Cover.

Impervious Surfaces and Vegetation. Land cover, particularly impervious surfaces with minimal vegetation, is central to UHI formation (Joshi et al., 2024; Schwarz & Manceur, 2015). Areas dominated by materials like asphalt absorb more heat due to low reflectivity and high heat retention (Bhargava A. et al., 2017; Marando et al., 2022).

Green and Blu Infrastructure: Trees, parks, and green roofs mitigate UHI through evapotranspiration and (Bhargava A. et al., 2017; Diem et al., 2024; Joshi et al., 2024; Schwarz & Manceur, 2015). Water bodies, however, show variable cooling effects depending on factors such as size and movement. Dynamic water features, like fountains, tend to cool more effectively than static ones.

3. **Socioeconomic Factors And Equity.** In past years more and more scholars linked the UHI phenomenon to socioeconomic aspects of urban areas. Which is slowly shifting in the literature from a merely physical phenomenon towards a more complex interaction between the built environment, policies, and socioeconomic dynamics (Diem et al., 2024; QIU et al., 2013; Weng & Yang, 2004). Sociodemographic characteristics, such as age, race, and socioeconomic status, have been linked to heightened vulnerability to heat-related stressors. Individuals from low-income and minority communities often have limited access to resources that could help mitigate heat risks. Populations deemed vulnerable, including the elderly, low-income households, and those without access to air conditioning, tend to be disproportionately impacted by UHI effects. These groups frequently reside in areas with diminished green spaces and high concentrations of heat-absorbing surfaces (Diem et al., 2024; Hansen et al., 2013; Shorris, 2017; Voelkel et al., 2018).

B. CHARACTERISTICS OF UHI ACROSS CITY TYPES

UHI characteristics can vary significantly based on factors such as urban morphology, climate region, and socioeconomic conditions. Due to the complex nature of this phenomenon, the severity and specific traits of UHI can fluctuate widely, depending on factors such as the city's size, layout, climate, and infrastructure. Each urban area may experience UHI effects in unique ways, with some facing more intense challenges than others, therefore, it is important to understand and identify the various UHI profiles that can manifest across different types of cities.

1. **Climate And Humidity Levels.** Cities with humid climates often experience more intense daytime UHI effects compared to those in arid climates. This stems from humidity impeding the dissipation of heat from urban surfaces into the atmosphere, intensifying surface temperatures (Zhang et al., 2009). In contrast, arid climates tend to result in more pronounced nighttime UHI, as the dry air facilitates faster cooling of rural areas, while urban areas retain more heat (Ibrahim et al., 2018). For example, previous studies have found that Delhi, India - located in a humid subtropical climate - experiences a more intense daytime UHI compared to Phoenix, Arizona - in an arid desert climate - which exhibits a stronger nighttime UHI (QIU et al., 2013; Zhang et al., 2009).

2. **Geographic Features (Coastal, Desert, Mountainous Regions).**

Coastal Cities. Large bodies of water near coastal cities can moderate UHI patterns, with proximity to the coast potentially affecting UHI intensity (Schwarz & Manceur, 2015).

Desert Cities. In desert environments, a "desert oasis effect" can occur during the day, resulting in cooler temperatures within the city than in the surrounding rural areas. This effect arises from increased evapotranspiration from irrigated landscapes and agricultural zones. However, the typical UHI pattern, with warmer urban nighttime temperatures, reemerges after sunset (Chow et al., 2012).

Topography. Urban areas with mountainous or uneven terrain may see additional UHI modifications (Oke, 1982a). This is because the surrounding terrain can influence the distribution and flow of temperatures within the city.

3. Urban Morphology.

City Size. Previous studies have found a correlation between larger city sizes and more intense urban heat island effects, with larger urban areas typically experiencing more pronounced heat island phenomena (Diem et al., 2024; Kang et al., 2022; Schwarz & Manceur, 2015). Recently, research has shifted to examining factors like population density, materials, and anthropogenic heat emissions that contribute to UHI beyond mere city size.

4. Seasonal And Diurnal Patterns

Temperate Climates: Within temperate climate zones, UHI effects tend to peak in warmer seasons, such as summer and autumn, influenced by variables like cloud cover, wind patterns, and solar angle.

Tropical Climates: In tropical climates, the UHI effect can manifest differently throughout the year, with less pronounced seasonal variations compared to temperate regions.

High-Latitude Cities: Cities in high-latitude regions, such as northern Europe and North America, may experience more complex UHI patterns, with potential heat island formation in both summer and winter due to the interactions between urban infrastructure, snow cover, and atmospheric conditions (Alexander & Mills, 2014). In high-latitude cities, anthropogenic heating—such as space heating during winter—significantly impacts the UHI, especially when solar radiation is minimal. Conversely, prolonged summer daylight may lead to reduced diurnal UHI variation.

In the end, UHI characteristics and intensity are shaped by a complex interplay of climatic, geographic, urban, and socioeconomic factors that are unique to each city. Given this complexity, further research is essential to develop effective, context-specific UHI mitigation strategies.

2.1.3. CAUSES OF UHI

The Urban Heat Island (UHI) effect arises from a complex interplay of urbanization factors, which collectively alter the natural energy balance, leading to elevated temperatures in cities compared to rural areas. This phenomenon is underpinned by a range of causes, including alterations in surface materials, reduced natural landscapes, urban morphology, anthropogenic heat, and geographical conditions.

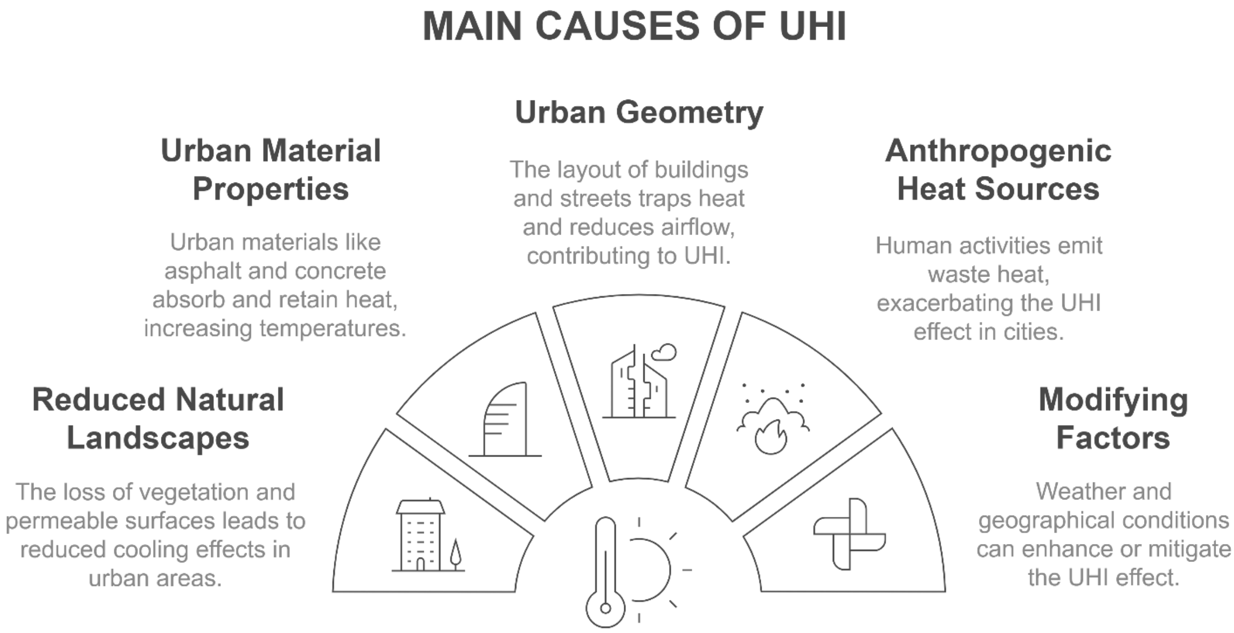


Figure 8. Main causes of Urban Heat Island. Source: Personal Elaboration.

This section discusses the main causes of UHI, such as:

1. **Reduced natural landscapes and impervious surfaces.** Urban development often replaces natural vegetation with impervious surfaces like asphalt, concrete, and buildings, reducing the cooling effects of shade, evapotranspiration, and moisture. Trees and other vegetation cool the environment through shade provision and the release of water vapor, which mitigates high temperatures (Gunawardena et al., 2017). The green spaces create microclimates that can reduce urban temperatures by several degrees (Phelan, Kaloush, Miner, Golden, Phelan, Silva, et al., 2015). When cities replace green areas with built structures, the loss of vegetation leads to reduced evapotranspiration, a critical process that disperses heat. The presence of impervious surfaces prevents water absorption, thereby intensifying surface heat. This reduction in cooling effects creates localized warming, a foundational component of the UHI phenomenon.
2. **Urban material properties and energy balance.** Conventional or "gray" urban materials, such as asphalt and concrete, absorb and retain heat more effectively than natural landscapes, leading to heat accumulation that persists, especially at night (US Environmental Protection Agency, 2024). Studies highlight that materials used in urban infrastructure, including pavements and rooftops, have lower albedo and higher thermal conductivity, which causes them to absorb solar radiation during the day and release it gradually at night (Jusuf et al., 2019). Urban materials, due to their dense and reflective properties, absorb significant amounts of solar radiation, which increases daytime surface temperatures. These materials slowly release stored heat at night, causing warmer nighttime temperatures in cities. This delayed release

contributes to the persistent warmth of urban areas, especially in regions with dense infrastructure and limited green cover.

3. **Urban geometry: "urban canyons" and heat-trapping.** The vertical structure of cities, including the layout of buildings and streets, the phenomenon known as "urban canyons", and the spatial arrangement and height of structures, all influence wind flow and heat retention, further contributing to the UHI effect. Research shows that so-called "urban canyons" trap heat by reducing natural airflow and sunlight escape (Hathway & Sharples, 2012). This effect is particularly pronounced in cities with compact structures and minimal ventilation pathways (Jusuf et al., 2019). In dense urban settings, the clustering of tall buildings blocks wind, reduces shading, and creates physical barriers that trap heat. This effect, known as the urban canyon effect, obstructs cooling winds and limits the dispersion of stored heat, resulting in higher surface and air temperatures within the city.
4. **Anthropogenic heat sources and emissions.** In addition to the urban morphology and material properties, anthropogenic heat sources also can significantly contribute to the UHI. Human activities, including industrial processes, transportation, and the use of air conditioning, emit waste heat that exacerbates the UHI effect (US Environmental Protection Agency, 2024). Studies indicate that emissions from vehicles, factories, and Heating, Ventilation, and Air Conditioning (HVAC) systems increase the thermal load in cities, especially during peak hours of human activity (Phelan, Kaloush, Miner, Golden, Phelan, Silva, et al., 2015). Anthropogenic heat sources add to the urban thermal environment, elevating temperatures by releasing heat directly into the atmosphere. As cities expand, the volume of waste heat grows, exacerbating UHI effects. In densely populated areas, waste heat becomes particularly significant, contributing to temperature increases that are often difficult to mitigate due to the density of human activity.
5. **Modifying factors: Wind, Smog and Cloudiness.** While the aforementioned factors are the primary causes of UHI, other geographic and climatic conditions can also influence the magnitude and spatial distribution of the UHI. Weather patterns and geographical features can enhance or mitigate the UHI effect. Calm, clear weather intensifies UHIs, while high winds and cloud cover reduce them. Studies show that local climate, such as wind patterns influenced by nearby mountains, can either facilitate or impede the cooling effects of wind on urban areas (Diem et al., 2024). Calm, clear nights allow for maximum heat retention by urban surfaces, while high winds can dissipate heat, diminishing the UHI effect. Therefore, understanding local weather and geography is essential for accurately assessing and mitigating UHI intensity in different urban settings.

In summary, the UHI effect is a multi-faceted phenomenon influenced by the interaction of reduced vegetation, urban material properties, anthropogenic heat, urban geometry, and weather and geography. Each factor contributes uniquely to the overall heating of urban areas, with their interactions amplifying the intensity and spread of UHI across various urban landscapes. Addressing UHI requires a comprehensive understanding of these causes to design effective mitigation strategies tailored to the specific characteristics of each urban environment

The following section discusses the main consequences of UHI and its importance, especially in the context of climate change.

2.1.4. CONSEQUENCES OF UHI

The Urban Heat Island (UHI) effect, a consequence of complex urban dynamics, leads to far-reaching repercussions that extend to human health and welfare, environmental integrity, energy demand, and socioeconomic stability. Understanding these impacts is fundamental to developing resilient and sustainable urban environments that safeguard public well-being and mitigate the environmental consequences of urbanization. Moreover, comprehending the price society bears, or has already paid, for not adequately confronting the UHI challenge is crucial. This section describes the main consequences of UHI, highlighting the need for a comprehensive approach to address the issue.

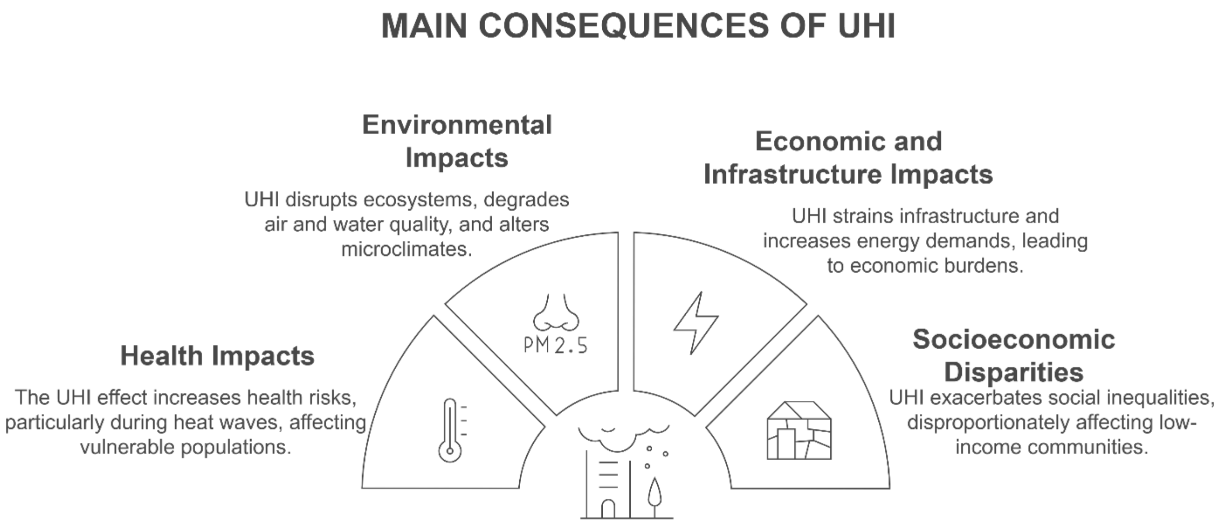


Figure 9. Main consequences of Urban Heat Island. Source: Personal Elaboration.

1. **Health Impacts.** The increased temperatures characteristic of urban heat islands pose severe health risks, especially during heat waves, which are exacerbated by the UHI effect:
    - **Heat-related morbidity and mortality.** The escalation of urban temperatures has been shown to increase the risk of heat-related morbidities, including heatstroke, heat exhaustion, and other adverse health outcomes associated with extreme heat exposure. Studies by Chow et al. (2012) and Diem et al. (2024) reveal a marked rise in heat-related illnesses in urban areas, especially during extreme heat events. Vulnerable populations, such as the elderly, young children, and those with pre-existing health conditions, are particularly susceptible. Research by Keith & Meerow (2022) and Joshi et al. (2024) has

demonstrated a robust association between elevated urban nighttime temperatures and heightened mortality rates, underscoring the critical importance of implementing measures to promote nighttime cooling in cities. UHI further complicates pre-existing conditions, particularly respiratory and cardiovascular diseases. According to Diem et al. (2024), pollutants trapped by the UHI effect worsen respiratory conditions, causing respiratory distress and other severe complications. This highlights the compounded vulnerability of urban dwellers facing both heat stress and poor air quality.

- **Reduced thermal comfort and mental health impacts.** Elevated temperatures and prolonged exposure to heat cause significant discomfort, impair productivity and harm mental health. As Marando et al. (2022) and Yang et al. (2016) observe high temperatures contribute to elevated stress levels, anxiety, and irritability. Furthermore, warmer nighttime temperatures can disrupt sleep, impairing cognitive function and mood, and disrupting daily activities and overall quality of life.

  Furthermore, the adverse human health impacts associated with the UHI can serve as a strong motivation for society, key stakeholders, and decision-makers to recognize the urgent need to mitigate the UHI and prioritize sustainable urban development initiatives.

2. **Environmental Impacts.** The environmental impacts of UHIs extend beyond temperature increases, affecting air and water quality and altering urban ecosystems:
   - **Air and water quality degradation.** UHIs exacerbate air pollution by trapping contaminants and fostering the formation of smog. Studies by Keith & Meerow (2022) and Diem et al. (2024) indicate that elevated temperatures accelerate chemical reactions between primary pollutants, resulting in increased levels of ozone and particulate matter. Furthermore, UHIs influence local wind patterns, which restrict pollutant dispersion, worsening air quality and increasing respiratory health risks. Warmer urban temperatures negatively impact urban water bodies by encouraging algal growth and lowering dissolved oxygen levels, which harm aquatic ecosystems. Heated runoff from impervious surfaces also contributes to pollution, carrying heavy metals and other contaminants into urban water bodies. Subsequentially, aquatic life is threatened, and water quality for human consumption and recreation is compromised.
   - **Microclimatic alterations and biodiversity loss.** The UHI effect disrupts local microclimates, affecting plant and animal life and potentially leading to shifts in species distribution. According to the studies, these changes can diminish biodiversity, as the altered climate may render urban areas inhospitable to certain species, thereby destabilizing local ecosystems (Diem et al., 2024). Tall structures, dark surfaces, and waste heat from human activities modify wind patterns, solar radiation, and humidity levels, creating microclimates that can be unsuitable for many species. Therefore, addressing the urban heat island

effect is important for preserving urban biodiversity and maintaining healthy ecosystems.

3. **Economic and Infrastructure Impacts.** UHIs place significant stress on urban infrastructure and increase energy demands, creating a feedback loop that exacerbates the heat island effect:
   - **Increased energy demands.** The higher temperatures associated with UHIs result in greater energy demands, particularly for cooling. As temperatures rise, demand for air conditioning in urban areas increases, leading to higher energy consumption and operating costs. Research by Bhargava A. et al. (2017) shows that peak energy demands can strain power grids, potentially resulting in blackouts. Therefore, addressing UHI is crucial for improving the overall energy efficiency of cities.
   - **Infrastructure damage and socio-economic disparities.** Extreme heat affects urban infrastructure, damaging roads, bridges, and buildings. Studies by Joshi et al. (2024) and Keith & Meerow (2022) indicate that high temperatures can cause asphalt to soften, leading to road buckling and traffic disruptions. Furthermore, power lines and other infrastructure experience heightened strain under extreme heat, increasing the risk of outages and threatening essential services.

     Furthermore, the costs associated with infrastructure repair and upgrades disproportionately impact lower-income communities, perpetuating socio-economic disparities.
4. **Socioeconomic Disparities** TheUHI effect exacerbates social inequalities, disproportionately affecting low-income communities and increasing economic costs:
   - **Disproportionate Impact on Low-Income Communities.** Studies have shown that the negative impacts of UHIs often disproportionately affect lower-income and marginalized communities due to factors such as limited access to cooling resources, less tree cover, and higher exposure to heat-absorbing surfaces (Edmondson et al., 2016). These communities may lack the financial resources to invest in mitigative measures, such as energy-efficient buildings or private air conditioning, further increasing their vulnerability to heat-related health and economic consequences.
   - **Economic Costs** UHIs impose significant economic burdens, not only for mitigating and apatating expenses but as well for potentially increased energy costs, repair and maintainance of cooling systems and healthcare expenses, that may come with UHI exacerbation. The associated economic costs extend to decreased worker productivity and additional public health expenditures, emphasizing the urgent need for mitigation efforts (Bhargava A. et al., 2017; Comune di Torino, 2020b).

In summary, the urban heat island effect poses a multifaceted challenge with far-reaching consequences for human health, the environment, urban infrastructure, and socio-economic equity. Addressing this issue requires a comprehensive, multidisciplinary approach to develop and implement effective strategies for urban heat island mitigation and adaptation.

The following section offers a comprehensive overview of global strategies for addressing the Urban Heat Island phenomenon.

2.2. ADDRESSING THE UHI: FROM STRATEGIES TO PLANNING

The significant and widespread impacts of the Urban Heat Island effect have prompted various strategies and policies to mitigate and adapt to this environmental challenge. Addressing the urban heat island effect requires a multi-faceted approach focusing on reducing heat absorption and increasing heat dissipation. Key strategies include:

- **Increasing albedo:** Implementing cool roofs and pavements that reflect more sunlight and absorb less heat. The study already in 2010 by Fabrizi et al. mentions the use of light-colour materials to improve reflective properties.
- **Expanding green infrastructure:** Planting trees and vegetation to provide shade and evapotranspiration, which cools the air (Lemonsu et al., 2015).
- **Reducing waste heat:** Improving building energy efficiency and promoting alternative transportation methods to minimize heat emissions from vehicles and buildings (ESMAP, 2020).
- **Modifying urban design:** Implementing urban design strategies that promote natural ventilation and reduce heat trapping, such as building orientation and spacing (Keith & Meerow, 2022).
- **Community engagement and education:** Raising public awareness about UHI and its impacts, and promoting individual actions to reduce heat exposure (Lenzholzer et al., 2020).

These approaches reflect a wide array of actions and policies that could be implemented to address the UHI issue and create more sustainable, livable cities. The more diverse and combined the mitigation and adaptation strategies, the more effective and comprehensive the response to this challenge will be.

2.2.1. STRATEGIES TO COMBAT URBAN HEAT ISLANDS

While the strategies mentioned in the previous section aim to address the UHI effect, it is important to understand the conceptual distinctions between mitigation, adaptation, and management approaches.

MITIGATION STRATEGIES

DEFINITIONS - MITIGATION

"Mitigation (of climate change) - A human intervention to reduce the sources or enhance the sinks of greenhouse gases. Mitigation (of disaster risk and disaster) is the lessening of the potential adverse impacts of physical hazards (including those that are human-

induced) through actions that reduce hazard, exposure, and vulnerability." - The IPCC, 2023: Climate Change 2023: Synthesis Report - Glossary (2023). As stated in the definition, mitigation strategies focus on reducing the causes or sources of the UHI effect, such as through the implementation of green infrastructure, reflective surfaces, and urban design measures. Mitigation strategies include:

1. Land-Use Planning:
   - Conserving natural areas and open spaces to reduce heat absorption and promote natural cooling.
   - Minimizing surface parking lots, which contribute to heat absorption due to the low albedo of asphalt (Keith & Meerow, 2022).
2. Urban Design:
   - Optimizing building orientation to maximize shade and enhance natural ventilation(Jusuf et al., 2019).
   - Utilizing cool roofing materials to reflect solar radiation and reduce heat absorption (Mutani & Todeschi, 2020).
   - Designing buildings to cast shade on sidewalks and public spaces (Keith & Meerow, 2022).
3. Urban Greening:
   - Increasing tree canopy cover to provide shade and promote evapotranspiration, which has a cooling effect (Calvin et al., 2023; Shorris, 2017).
   - Implementing green stormwater infrastructure, such as bioswales and rain gardens, which absorb and filter stormwater runoff while also providing cooling benefits (Keith & Meerow, 2022).
   - Installing green roofs, which reduce heat absorption by buildings and provides insulation (Marando et al., 2022).
4. Waste Heat Reduction:
   - Improving energy efficiency in buildings to reduce the amount of heat generated by air conditioning systems and other appliances (ESMAP, 2020; Keith & Meerow, 2022).
   - Transitioning to renewable energy sources, such as solar and wind power, which do not produce waste heat (ESMAP, 2020).

ADAPTATION STRATEGIES

DEFINITIONS - ADAPTATION

"Adaptation is the process of adjustment to the actual climate and its effects; human intervention may facilitate adjustment to the expected climate and its effects" - The IPCC, 2023: Climate Change 2023: Synthesis Report - Glossary (2023). In the context of UHI, adaptation strategies focus on reducing the adverse impacts of the heat island effect, rather than addressing the root causes. Adaptation strategies include:

1. **Modifying building codes** to require cool roofs or reflective surfaces to reduce heat absorption (Keith & Meerow, 2022; Schwarz & Manceur, 2015).
2. **Developing early warning systems** to alert residents of extreme heat events, allowing them to take precautions (Shorris, 2017; Tong et al., 2021).
3. **Establishing cooling centers** to provide relief from extreme heat (Keith & Meerow, 2022; Shorris, 2017).
4. **Providing public education and outreach** on heat safety measures, such as staying hydrated and recognizing the signs of heat stroke (Rony & Alamgir, 2023; Shorris, 2017).

What is the difference between adaptation and mitigation? According to the European Environmental Agency, **adaptation** involves anticipating the harmful effects of climate change and taking action to prevent or minimize the damage, or to take advantage of any opportunities that may arise. Examples of adaptation include building defenses against sea-level rise, and individuals reducing their exposure to high temperatures and checking on vulnerable neighbors during heatwaves. Adaptation is the process of adjusting to the current and future effects of climate change.

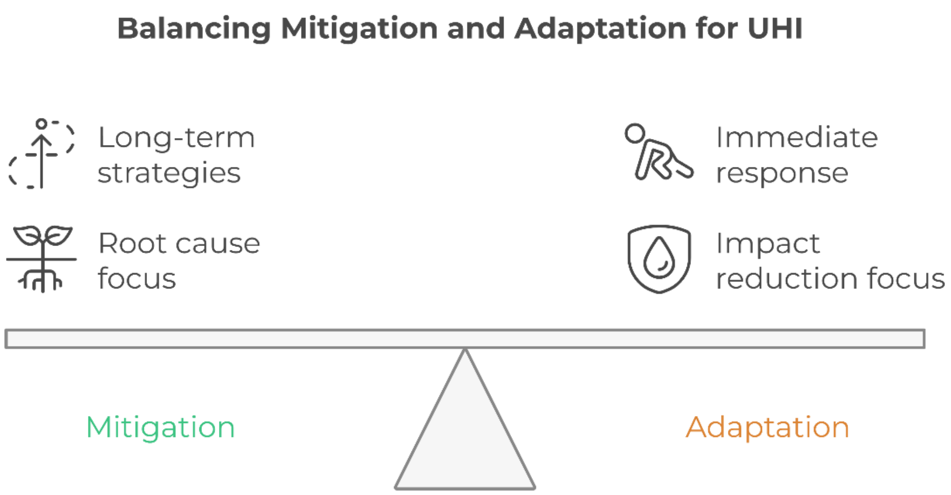


Figure 10. The importance of balance between Mitigation and Adaptation strategies. Source: Personal elaboration.

Mitigation means preventing or reducing greenhouse gas emissions to make climate change less severe. This is done by reducing the sources of these gases, like increasing renewable energy or cleaner transportation, or by increasing the storage of these gases, like growing forests. Mitigation is a human intervention that reduces greenhouse gas emissions and/or increases their absorption.

Adaptation is about making changes to handle the current and future effects of climate change, while **mitigation** means limiting or reducing greenhouse gas emissions to make the impacts of climate change less severe.

So in summary, **mitigation** focuses on the root causes while **adaptation** focuses on reducing the impacts - both are needed to address complex challenges like the urban heat island effect.

Why adaptation is essential in today's urban planning? Adaptation strategies are essential for several reasons, particularly in an urban resilience context. The impacts of climate change, such as more frequent and intense heat waves, are already occurring and will continue to worsen even with ambitious mitigation efforts. (Jain et al., 2022) Therefore, an immediate response to the already existing UHI is essential for safeguarding public health and comfort, city infrastructure and energy demands. Furthermore, adaptation strategies are essential not only to address the immediate impacts of climate change but also to build long-term resilience by strengthening governance, capacity building, and knowledge sharing within the urban planning system. This will help cities better anticipate, prepare, and respond to future climate-related challenges. Most importantly, adaptation strategies must be integrated with mitigation efforts to maximize synergies and co-benefits, while also minimizing potential trade-offs (Caldarice et al., 2021).

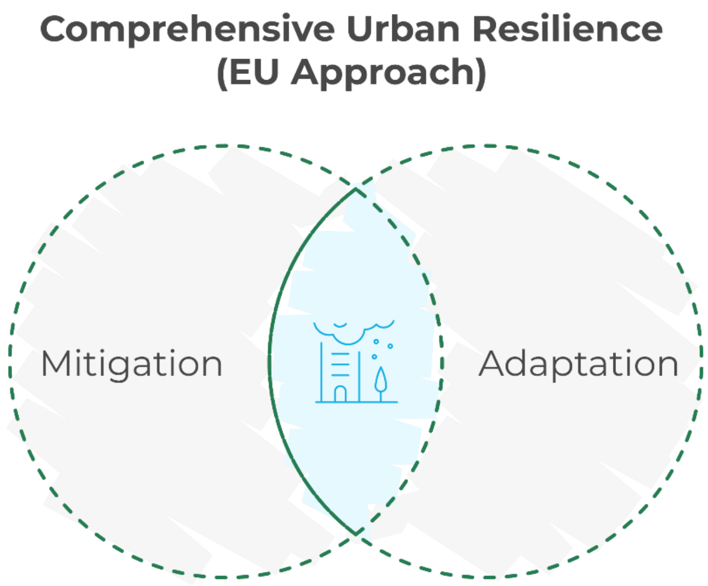


Figure 11. The visualization of the EU Integrated approach between Mitigation and Adaptation strategies. Source: Personal elaboration.

MANAGEMENT STRATEGIES

Management Strategies (U.S. Context). Heat or Climate 'Management' is a terminology that pop ups in a literature in the US, and from first site could be understood as a alternative terminology for 'Adaptation' as terminology used in Europe and within an international organizations. Yet, understanding deeper is needed, prior to substituting adaptation as it is. As indicated in the literature, Climate management includes both aspects of mitigation and adaptation.

DEFINITIONS - MANAGEMENT

The term "Management" (refers to Heat Management) refers to the strategies employed to prepare for and respond to both chronic and acute heat risks. These strategies often fall under the domains of emergency management or public health (Keith Ladd & Meerow Sara, (2022). The goal of heat management is to protect people during periods of extreme heat, minimize heat-related health risks, and build community resilience to withstand and recover from heat events (Shorris, 2017). Management strategies include:

1. **Energy.** Ensuring reliable energy supplies and access to affordable indoor cooling, especially for vulnerable populations(ESMAP, 2020).
2. **Personal Exposure.** Reducing personal heat exposure through measures like shading bus stops, implementing worker safety regulations for outdoor work, and modifying public infrastructure to provide shade and cooling options(Gallo et al., 2024; Nazish et al., 2024).
3. **Public Health.** Increasing surveillance for heat-related illnesses, implementing public communication campaigns on heat safety, expanding social services to support vulnerable individuals during heat events, and providing energy assistance(Voelkel et al., 2018).
4. **Emergency Preparedness**. Developing and implementing heat action plans, which outline specific steps to be taken during extreme heat events, such as opening cooling centers, providing transportation to those centers, and conducting outreach to vulnerable individuals (Keith & Meerow, 2022).

Is Management an alternative term for Adaptation? The literature reviewed by Keith et al. (2019) published in U.S. suggests that the main strategies to address Urban Heat are divided into two groups: Heat Mitigation strategies and Heat Management Strategies. This could be interpreted as an alternative to the European approach of categorizing strategies for Heat or Climate issues as either Mitigation or Adaptation. The term "Management" in the U.S. context may therefore serve as an alternative terminology for what is referred to as Adaptation strategies elsewhere. However, it remains unclear whether Management strategies are truly equivalent to Adaptation strategies, or if they represent a distinct third approach. The study by Perez-Lancellotti & Ziede (2021) underscores that Adaptation strategies provide important co-benefits beyond just Heat Management, such as improved air quality, reduced energy consumption, and enhanced urban livability - all of which contribute to overall urban sustainability. Therefore, this suggests that Adaptation may still be considered a separate concept from Heat Management strategies.

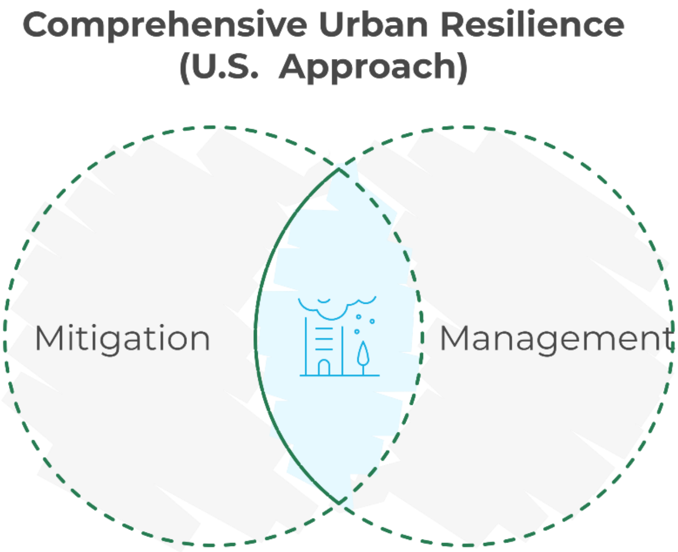


Figure 12. The visualization of The U.S. Integrated approach between Mitigation and Management strategies. Source: Personal elaboration.

In any case, the literature highlights the importance of an **integrated approach** considering both mitigation and adaptation/management measures to tackle the UHI challenge (Figure 7 and Figure 8).

URBAN RESILIENCE

Urban heat Island and Heat Hazard mitigation and adaptation strategies are closely tied to developing urban resilience. Within an Urban resilience framework, addressing heat-related risks requires a holistic approach that considers social, ecological, and technical interventions from planners and decision-makers.

DEFINITIONS - URBAN RESILIENCE

Urban resilience is the capacity of an urban system to withstand and recover from various shocks and stresses while maintaining its essential functions and even transforming to improve in the face of future challenges (Datola, 2023; United Nations, 2017). It's not just about bouncing back to a previous state, but also about adapting, evolving, and transforming to thrive amidst continuous change (Brunetta & Caldarice, 2020; Datola, 2023; Keith & Meerow, 2022). This concept recognizes the interconnectedness of social, economic, environmental, and governance aspects of a city (Brunetta & Caldarice, 2020; Datola, 2023; United Nations, 2017). There are several **factors that influence urban resilience** and, therefore, the ability of a city to address UHI and heat hazards:

1. **Shocks and Stresses.** These can range from acute events like natural disasters, pandemics, and economic crises to chronic stresses like climate change, social inequality, and resource depletion (Brunetta & Caldarice, 2020; Moraci et al., 2018; United Nations, 2017).
2. **Multifaceted and Multidimensional.** Urban resilience encompasses a complex interplay of factors that affect a city's physical, natural, economic, institutional, and social dimensions. This includes considering the resilience of communities, individuals, organizations, and businesses (Datola, 2023; United Nations, 2017).
3. **Dynamic and Adaptive.** Resilient cities are not static; they must be able to adjust, learn, and transform in response to changing conditions168. This dynamic nature recognizes that cities are complex systems that continually evolve in spatial and temporal scales (Brunetta & Caldarice, 2020; Datola, 2023; United Nations, 2017).

Why Urban Resilience for UHI? The urban heat island effect, poses a significant challenge to urban resilience. The UHI intensifies heat waves, exacerbating their impact on human health, infrastructure, and the environment, which underscores the critical connection between urban resilience and the need to mitigate UHI effects (Meerow & Newell, 2019).

Effective urban heat resilience planning is considered to primarily integrate strategies to reduce UHI intensity and its associated risks, contributing to a more sustainable and resilient urban environment (Datola, 2023). This integrated approach necessitates considering both the physical characteristics of the urban environment, such as the prevalence of impervious surfaces (Meerow & Newell, 2019) and the social and economic factors that influence vulnerability to extreme heat (Lemonsu et al., 2015).

Developing a nuanced understanding of how UHI mitigation and adaptation strategies align within the broader framework of urban resilience planning is crucial for crafting context-specific and practical approaches. Proactively mitigating and managing the UHI effect is paramount for fostering robust urban resilience. This entails implementing a range of strategies, such as increasing vegetation cover, utilizing reflective materials, and improving urban design to reduce heat absorption and enhance ventilation (Keith & Meerow, 2022). These measures not only help alleviate the UHI effect but also contribute to a more sustainable and livable urban environment, better equipped to withstand and recover from the impacts of extreme heat events. Integrating these physical interventions with social, economic, and governance considerations is key to building comprehensive urban heat resilience that can adapt and evolve in the face of ongoing challenges.

How City Officials and Practitioners Understand Urban Resilience? City officials' conceptualizations of urban resilience reflect a range of perspectives and an evolving understanding of the concept (Meerow & Stults, 2016; Reu Junqueira et al., 2021). While academic discourse often focuses on "bouncing forward" and transformative change, practitioners tend to favor "bouncing back" or engineering-based definitions (Meerow & Stults, 2016). For example, some officials prioritize a city's ability to quickly recover from heavy rains and flooding, while others emphasize the need to maintain essential functions and services during and after shocks (Reu Junqueira et al., 2021).

This diversity in conceptualizations highlights the multifaceted nature of urban resilience and the need to address the unique vulnerabilities and priorities of each city (Datola, 2023). Practitioners have varying views, with some emphasizing the ability to bounce back to a previous state, and others considering economic, quality of life, social, and sector-specific factors (Meerow & Stults, 2016).

The literature also reveals several tensions between academic and practitioner perspectives on urban resilience (Chelleri & Baravikova, 2021). The discrepancies between academic and practitioner perspectives on urban resilience include the emphasis on transformative change versus preserving the existing state, the tension between comprehensive systems-level thinking and concrete, actionable initiatives, as well as the differences in prioritizing multi-scale governance versus a more localized focus. These discrepancies underscore the need for better communication and collaboration between researchers and practitioners to ensure that resilience initiatives are both effective and transformative (Caldarice et al., 2021).

Challenges and limitations faced in implementing urban resilience strategies in a European context.

One of the main challenges in implementing urban resilience is conceptual ambiguity and a focus on short-term goals rather than long-term, transformative change. The interchangeable use of resilience and sustainability in policy, despite their distinct characteristics, exemplifies this confusion (Chelleri & Baravikova, 2021). This, coupled with a desire to maintain existing systems due to political pressures and a need for quick results (Fastiggi et al., 2021), hinders the transformative actions necessary for true resilience. The lack of clear ways to measure resilience further complicates evaluating and justifying resilience initiatives (Brunetta & Caldarice, 2020; Chelleri & Baravikova, 2021).

Furthermore, putting resilience into practice is hindered by insufficient integration of resilience principles into planning tools and regulations (Moraci et al., 2018). Financial and political constraints often prioritize short-term projects over potentially more impactful long-term initiatives (Brunetta & Caldarice, 2020; Fastiggi et al., 2021). Balancing diverse stakeholder interests and values (Chelleri & Baravikova, 2021), along with limited local authority and scale dependency, further complicates effective implementation (Brunetta & Caldarice, 2020; Chelleri & Baravikova, 2021). Finally, effectively communicating the complex and interconnected nature of urban resilience to various audiences remains a crucial challenge (ARUP, 2024) for fostering collaboration and motivating action.

In conclusion, the UHI effect poses a significant challenge to urban resilience. Effectively addressing this challenge requires a multidimensional approach that integrates urban planning, design, policy, and community engagement. By understanding the complex interplay of factors contributing to the UHI effect and its consequences, cities can develop comprehensive strategies to enhance their resilience to this growing urban challenge. In conclusion, mitigating and adapting to the UHI effect is critical for fostering robust urban resilience, as it necessitates a holistic approach that considers the physical, social, and economic dimensions of the city.

The next section of the literature review examines the application of resilience theory within the context of urban planning practices in Italy and as a comparative analysis - U.S.A. It then analyzes the primary challenges and limitations of the Italian planning framework, with the goal of understanding how to effectively address the Urban Heat Island effect and frame the research questions.

2.3. PLANNING FOR UHI: COMPARATIVE PERSPECTIVES BETWEEN ITALY AND THE U.S.

This comparative analysis between Italian and U.S. planning frameworks is crucial for understanding how different governance structures and planning approaches address UHI, and as a result understanding the practical implementation of a tolls and practices that can be transferred from one context to another, providing a new perspective and contributing to a more nuanced understanding of urban heat resilience planning in different contexts.

2.3.1. PLANNING FOR UHI: ITALIAN APPROACH

UNDERSTANDING THE ITALIAN URBAN PLANNING FRAMEWORK

Prior to diving into the Heat resilience planning, this section provides an overview of the Italian urban planning system to better understand the Heat resilience planning implementation within the existing framework.

Structure and Characteristics. The Italian planning framework is characterized by a **hierarchical, four-leveled system** (Bragaglia et al., 2023; Caldarice et al., 2021; Pietrapertosa et al., 2021), established during the Fascist regime and based on the 1942 National Planning Law (Bragaglia et al., 2023). The **four levels** of the system are:

1. **National Level:** At the national level, the Italian government sets the overarching strategy and provides tools like the National Adaptation Strategy (NAS) and the National Adaptation Plan (NAP)These national frameworks aim to guide planning activities at lower levels. The National government also submitted the National Energy and Climate Plan (NECP) to the European Commission to comply with the Paris Agreement. The NECP aims to reduce greenhouse gas emissions and was developed in collaboration with the regions (Caldarice et al., 2021; Colavitti et al., 2013).
2. **Regional Level:** Regional governments in Italy have significant legislative power and are responsible for developing regional planning laws and a regional landscape plan. However, the development of regional strategies or action plans specifically for urban resilience is not mandatory. Regions are also responsible for energy and environmental issues, including enacting laws related to energy

planning and greenhouse gas emissions. (Caldarice et al., 2021; Pietrapertosa et al., 2021).

3. **Provincial or Metropolitan Level:** Provinces, serving as an intermediary level between regions and municipalities, are responsible for developing territorially coordinated plans. The role of provinces is diminishing as many transition into metropolitan areas. This transitional phase contributes to a lack of climate plans at the provincial level (Pietrapertosa et al., 2021).
4. **Municipal Level:** At the municipal level, the focus is on implementing a municipal land-use plan, detailed through specific implementation plans. Municipal plans have legal binding authority. However, no national law requires Italian municipalities to develop plans or strategies for reducing greenhouse gases or adapting to climate change (Caldarice et al., 2021; Pietrapertosa et al., 2019).

KEY FEATURES OF THIS HIERARCHICAL STRUCTURE:

- **Top-down approach:** The national government sets the overall strategy and framework, which then cascades down to the regional, provincial and municipal levels.

- **Binding regulations:** Planning decisions at higher levels, particularly zoning regulations defined in municipal plans, are legally binding on lower levels, creating a system of compliance.

- **Limited flexibility:** The pre-allocation of land use rights through binding zoning can make the system inflexible and slow to adapt to changing circumstances or local needs.

A Conformative model. Italy's planning framework, rooted in the 1942 National Planning Law, is known as the **"conformative"** model (Janin Rivolin, 2008). The hierarchical planning structure in Italy is characterized by the pre-allocation of land use rights through binding zoning regulations in municipal plans, particularly in **the Urban General Plans**. This rigid approach can constrain community involvement and collaborative planning(co-production) processes (Bragaglia et al., 2023; Caldarice et al., 2021). While European influences have introduced more programmatic approaches (Cotella & Stead, 2011), their impact remains constrained due to weak political backing and isolation from broader European dialogues. Although sustainability policies and public participation have gained traction, their practical effectiveness varies. Moreover, the growing financialization of urban development, through public-private partnerships and real estate funds, is especially prominent in major Italian cities (Cotella Giancarlo & Stead Dominic, 2011). The system's distinctive features, including strong regional autonomy and a complex legal framework, have resisted convergence with European planning, preserving Italy's unique yet fragmented planning traditions (Bragaglia et al., 2023).

URBAN GENERAL PLANS IN ITALY.

The Urban General Plan or Piano Regolatore Generale (PRG) is the primary planning tool at the municipal level in Italy. The Plan does hold the entire framework, and therefore, understanding the strengths, weaknesses, and opportunities of these plans is crucial when examining the implementation of heat resilience in urban planning.

STRENGTHS

- **Legally Binding:** The urban general plan(UGP) (Piano Regolatore Generale - PRG) is a legally binding instrument in Italy. This means that it carries significant weight in shaping and directing urban transformations (Colavitti et al., 2013).
- **Comprehensive Framework:** Urban general plans provide a comprehensive framework for addressing various aspects of urban development, including land use, infrastructure, and social services (Colavitti et al., 2013).
- **Long-Term Vision:** The UGPs establish a long-term vision for a community's future development, promoting a cohesive and sustainable approach to urban growth (Colavitti et al., 2013).

WEAKNESSES

- **Complex Governance:** The Italian system of territorial governance is characterized by multiple levels of planning authority, often leading to overlapping jurisdictions and conflicting interests. This can create **challenges in practical implemention** of urban general plans (Caldarice et al., 2021; Colavitti et al., 2013; Pietrapertosa et al., 2021).
- **Lack of Integration:** The Italian planning system presents a historical lack of integration between environmental concerns and planning regulations, often leading to a focus on **reactive rather than proactive approaches** to climate change adaptation (Caldarice et al., 2021; Pietrapertosa et al., 2021).
- **Adaptation Challenges:** While the Covenant of Mayors has promoted some mitigation plans, **adaptation plans are not legally binding** in Italy. This results in a fragmented approach to climate change adaptation, with cities often relying on sectoral approaches rather than comprehensive strategies (Caldarice et al., 2021; Pietrapertosa et al., 2021).
- **Limited Public Participation:** The conformative approach of the Italian planning system **limits public participation**. Citizen involvement tends to operate outside the formal planning system, often through regulations and agreements with limited influence on the allocation of land rights (Bragaglia et al., 2023)
- **Implementation Challenges:**
  Outdated regulations: The national town pla
  nning Law (Law n. 1150/1942) is outdated and needs revisions to adapt to contemporary urban challenges (Colavitti et al., 2013). **Lack of Capacity:** Many municipalities lack the professional expertise and resources to effectively develop, update, and implement their urban general plans (Colavitti et al., 2013; Pietrapertosa et al., 2021). **Slow Administrative Processes:** The administrative process for formulating, adopting, and approving urban general plans can be slow and bureaucratic, leading to a disconnect between planning

theory and (Colavitti et al., 2013). **Financial Constraints:** The sources mention that financial constraints can hinder the implementation of plans and measures outlined in urban general plans (Grafakos et al., 2020).

OPPORTUNITIES

- **EU Funding:** European Union (EU) Structural Funds offer opportunities for Italian cities to finance urban regeneration projects and address strategic objectives related to economic growth, environmental protection, and social inclusion (Colavitti et al., 2013).
- **Transnational Networks:** International networks like the Covenant of Mayors one can play a crucial role in driving climate action planning, providing support, guidance, and resources for Italian cities (Pietrapertosa et al., 2019, 2021).
- **Promoting Sustainability:** Urban general plans can be a powerful tool for promoting sustainable urban development, addressing challenges related to climate change, resource management, and social equity (Brunetta & Caldarice, 2020; Caldarice et al., 2021; Colavitti et al., 2013).
- **Strengthening Governance:** Reforms that promote integration between planning and environmental concerns, streamline administrative processes, and enhance public participation can strengthen the effectiveness of urban general plans (Caldarice et al., 2021; Colavitti et al., 2013; Pietrapertosa et al., 2019, 2021).

Despite their weaknesses, **urban general plans** remain a vital instrument for shaping urban development in Italy (Colavitti et al., 2013). By addressing the identified challenges and leveraging opportunities for reform and innovation, urban general plans can effectively guide Italian cities toward a more sustainable and resilient future.

ITALIAN RESILIENCE PLANNING

Urban resilience has become a central focus in Italian planning, driven by the need for climate change adaptation and disaster risk reduction (Datola, 2023; Marta Bottero Giulia Datola, 2020). While progress has been made in climate change mitigation through initiatives like the Covenant of Mayors, the urban resilience planning framework in Italy faces significant challenges in adaptation planning. This is due to a fragmented governance structure, characterized by hierarchical levels and a disconnect between planning and environmental regulations (Caldarice et al., 2021). This fragmentation impedes the implementation of integrated urban resilience strategies, despite the supportive role of transnational networks (Caldarice et al., 2021). Although a national resilience planning framework is lacking, some regions and cities, such as Milano, Bologna, and Ancona, have demonstrated proactive adaptation planning. Methodologies like indicator-based risk assessments and multi-criteria evaluation offer valuable tools (Anelli & Tajani, 2022) , but data limitations and the complexity of urban systems pose challenges (Bottero & Datola, 2020). A key limitation is the scarcity of professional expertise and resources needed for effective resilience strategy development and implementation, particularly in adaptation. **Nature-based solutions** are emerging as a promising approach as well, but successful integration requires community engagement, consideration of historical water management practices, and robust funding mechanisms (Raymond & Frantzeskaki, 2017; Bernello & Mondino, 2022).

Overall, even with the first steps and therefore the progress has been made, the **broader implementation** of resilience planning **within Urban General Plans** remains a complex issue in Italy, requiring further research and policy reform to strengthen science-policy-practice linkages, empower local administrations, and promote more holistic and integrated resilience strategies.

EXAMPLES OF RESILIENCE PLANNING INITIATIVES IN ITALY:

The implementation of resilience planning strategies within Urban General Plans in Italian context is still a complicated matter. Nevertheless, some Italian cities have taken steps to incorporate resilience principles, others already integrated them into their planning framework:

- **Rome's Resilient Strategy:** Developed in 2018, this strategy focuses on four pillars: an efficient city, a dynamic and unique city, an open and inclusive city, and a city that protects its natural resources. Rome's participation in international initiatives like 100 Resilient Cities (Galderisi et al., 2020) and the C40 network has also influenced its approach to urban resilience.
- **Milan's Chief Resilience Office and Milan's Climate Plan:** Milan established a Chief Resilience Office in 2017 with support from the Rockefeller Foundation (2023). Milan's 2020 Climate Plan (Comune di Milano, 2020) sets ambitious goals to reduce greenhouse gas emissions and increase the city's resilience to climate change. The plan includes measures to reduce energy consumption, promote clean energy, and enhance green infrastructure.
- **Bologna and Ancona's Adaptation Plans:** These cities are recognized for developing comprehensive stand-alone adaptation plans, demonstrating proactive efforts to address climate vulnerabilities. Bologna's plan focuses on addressing risks related to extreme rain events, heat waves, and water scarcity (Boeri et al., 2018), while Ancona's plan emphasizes soft measures to raise citizen awareness and engagement (Caldarice et al., 2021).
- **Bari's Participation in EU Projects:** The city of Bari has participated in several EU-funded projects related to urban resilience, such as Nature4Cities and ROCK (Ramusino et al., 2017), which have allowed it to experiment with nature-based solutions and integrate resilience principles into its urban planning.
- **Turin's Climate Resilience Plan:** As part of the LIFE-DERRIS project, the city of Turin developed a Climate Resilience Plan (Comune di Torino, 2020b), focusing on the urban heat island effect and flood risk management.
- **Turin's The Hydrological Management Plan and Flood Risk Management Plan:**

  The Piano di Assetto Idrologico (PAI) of Turin (Regione Piemonte, 2021c), officially known as the "Piano stralcio per l'Assetto Idrogeologico del bacino idrografico del fiume Po," or **The Hydrological Management Plan**, is a critical regulatory framework aimed at mitigating hydrogeological risks within the Po River Basin. Initially approved by a decree of the Prime Minister on May 24, 2001, the PAI integrates and unifies previous basin plans, establishing comprehensive guidelines for structural and non-structural interventions to manage watercourses and slopes. The plan's primary objective is to ensure the safety of people and reduce property damage by delineating risk areas and prescribing land-use restrictions. Regular updates, the latest being the normative variant adopted on December 20, 2021, ensure the plan remains responsive to new environmental data, changing conditions, and advancements in risk assessment. The incorporation of the PAI into urban planning is mandatory, as it holds binding legal force over local development projects. The Piemonte Region, in collaboration with the interregional agency for the Po River (A.I.Po), oversees the application and periodic updating of the PAI to align with current hydrogeological conditions and legislative requirements. This ensures that urban planning and land-use decisions within the basin adhere to the PAI's standards, safeguarding the region against hydrogeological hazards. Similarly, **the Piano di Gestione del Rischio Alluvioni (PGRA)** (Regione Piemonte, 2021b), **or Flood Risk Management Plan**, is a comprehensive framework designed to manage and mitigate flood risks within the Po River Basin. Adopted by the Institutional Committee of the Po River Basin Authority on December 20, 2021, the PGRA aims to reduce the adverse consequences of flooding on human health, the environment, cultural heritage, and economic activities. The plan encompasses a range of structural and non-structural measures, including the implementation of flood defenses, improvement of forecasting and warning systems, and the promotion of sustainable land use practices. The PGRA is part of a broader strategy mandated by the European Union's Floods Directive (2007/60/EC), which requires member states to assess and manage flood risks. The PGRA and PAI together ensure a coordinated and integrated approach to managing water-related risks, enhancing the resilience of the region's infrastructure and communities to both flooding and other hydrogeological threats (Regione Piemonte, 2021a). Nevertheless, despite these rigorous and legally binding measures for hydrogeological risk management, **no such binding action has been taken to mitigate urban heat** in the city of Turin. Only a few non-binding strategic plans, such as the Climate Resilience Plan and the Strategic Plan for Green Infrastructure, have been developed without specific legal regulation. This stark contrast highlights a significant gap in addressing urban heat issues and raises the question of why similar comprehensive and binding measures are not implemented for urban heat mitigation.

MAIN CHALLENGES OF URBAN RESILIENCE PLANNING IN ITALY.

Urban resilience planning in Italy faces significant hurdles stemming from structural, institutional, and methodological shortcomings. These challenges are deeply rooted in the country's planning framework, which is characterized by fragmentation, insufficient integration across sectors, and restricted ability to tackle the complex nature of climate risks. Below is an analysis of the **main barriers** identified in the literature:

- **Structural Fragmentation and Lack of Integration.** The Italian planning system suffers from a historical separation of environmental concerns and spatial planning, creating a reactive rather than proactive approach to climate adaptation. This division, reinforced by the 2001 constitutional reform, leaves environmental protection under state control while spatial planning responsibilities are shared between the state and regions, exacerbating conflicts (Caldarice et al., 2021). Consequently, national strategies like the *National Adaptation Strategy (NAS)* emphasize environmental aspects but neglect critical social dimensions, impeding holistic urban resilience strategies (Pietrapertosa et al., 2019). Furthermore, a hierarchical system of governance—spanning national, regional, provincial, and municipal levels—creates silos that hinder coordination and knowledge sharing. This leads to misaligned priorities and fragmented implementation of resilience measures, as municipal land-use plans lack vertical integration with overarching national and regional strategies (Caldarice et al., 2021).
- **Weak Legal Framework for Adaptation.** Unlike mitigation efforts, which have gained traction through initiatives such as the *Covenant of Mayors*, adaptation remains voluntary. The absence of a binding legal requirement for local adaptation plans results in uneven progress across cities (Caldarice et al., 2021; Pietrapertosa et al., 2019). Many municipalities lack the incentive or resources to independently initiate climate action, relying heavily on external funding or international collaborations. This inconsistency exacerbates disparities in urban resilience preparedness, with smaller or economically weaker cities lagging behind (Caldarice et al., 2021).
- **Sectoral and Isolated Approach to Resilience.** Italy's unique reliance on a sectoral approach further hampers the development of comprehensive strategies. Adaptation planning often remains confined to environmental departments, neglecting the interconnected economic and social dimensions essential for addressing urban resilience comprehensively (Caldarice et al., 2021). For instance, while cities like Milan integrate adaptation into existing frameworks, others such as Turin rely on isolated sectoral plans, reinforcing fragmented approaches (Caldarice et al., 2021). This isolation risks maladaptation, where interventions in one sector inadvertently exacerbate vulnerabilities in another. A broader, integrative framework is required to reflect the systemic nature of urban resilience, accounting for cascading risks across urban systems (Pietrapertosa et al., 2019).
- **Capacity and Knowledge Gaps.** Many Italian municipalities lack the technical expertise and financial resources necessary to design and implement effective resilience strategies (Caldarice et al., 2021). This shortfall is particularly pronounced in adaptation planning, which demands specialized knowledge and interdisciplinary collaboration. The absence of robust dialogue between scientists,

policymakers, and practitioners further compounds this issue, limiting the application of cutting-edge research to practical policymaking (Caldarice et al., 2021).. Moreover, existing resilience measurement tools fail to capture the multidimensional nature of resilience. Current metrics often focus narrowly on specific challenges rather than assessing systemic capacity to adapt and thrive (Brunetta & Caldarice, 2020).

- **Implementation and Governance Challenges.** The operationalization of resilience strategies faces resistance due to bureaucratic inertia and vested interests in traditional planning approaches. The pursuit of transformative change—moving beyond reactive measures to proactive and adaptive strategies—requires fostering innovation, collaborative governance, and addressing trade-offs (Chelleri & Baravikova, 2021).. Addressing the intertwined challenges of fragmented governance, sectoral isolation, and limited capacity is vital for operationalizing urban resilience in Italy. Reforming the legal framework to mandate local adaptation plans, fostering integration across environmental and planning domains, and promoting holistic resilience strategies are critical steps (Caldarice et al., 2021). Strengthening science-policy-practice linkages and equipping local administrations with financial and technical resources will empower municipalities to design and implement robust resilience initiatives tailored to their unique contexts. Only through systemic reform can Italy transition toward resilient, sustainable, and equitable urban environments (Caldarice et al., 2021).

In summary, addressing the interconnected issues of fragmented governance, separated and disconnected approaches, and insufficient resources is crucial for implementing urban resilience strategies effectively in Italy.

Reforming the legal framework to mandate local adaptation plans, fostering integration across environmental and planning domains, and promoting holistic resilience strategies are critical steps. Strengthening science-policy-practice linkages and equipping local administrations with financial and technical resources will empower municipalities to design and implement robust resilience initiatives tailored to their unique contexts. **Only through systemic reform can Italy transition toward resilient, sustainable, and equitable urban environments.**

Therefore, a **comparative approach** with structurally diverse planning systems is undertaken in the following sections to address the fundamental challenges of urban resilience in Italy.

2.3.2. PLANNING FOR UHI: U.S. APPROACH

Having examined the complexities and emerging practices within Italian resilience planning, including its hierarchical structure and specific city initiatives, this section shifts to the U.S. urban resilience planning framework.

This comparative approach is crucial for understanding how different governance structures, planning instruments, and cultural contexts influence urban heat resilience.

By exploring the the nature of U.S. resilience planning, alongside innovative practices, such as **The PIRS™ for Heat** methodological tool, will illuminate potential strengths and weaknesses of each system in managing UHI, therefore informing recommendations for improving planning integration and governance in this study case - City of Turin, Italy.

This section provides an overview of the general city planning framework in the U.S. to better understand how resilience planning is implemented within the existing structure.

THE U.S. URBAN PLANNING FRAMEWORK

The U.S. city planning emerged in the late 19th century as a response to urban challenges, evolving into a profession aimed at creating more livable cities (Scott M., 1972). However, its effectiveness has been debated, with some arguing that planners primarily served capitalist interests rather than public needs (Simon & Boyer, 1985).

The history of town planning in America dates back to early colonial times, with deliberate planning for large towns being seen in settlements where the initiative and control were controlled by property owners. This included systematic provisions for streets, public recreation grounds, and market places (Olmsted, 1914). However, the town planning movement as a distinct and self-conscious activity with its own literature is relatively recent in America, with significant output since the late 19th century and a growing number of publications since 1900 (Olmsted, 1914).

The U.S. planning framework operates on a decentralized, bottom-up approach, with local governments holding primary responsibility for land use and urban development decisions (Bush & Doyon, 2019) . This localized system fosters flexibility and responsiveness to community-specific needs (Keith et al., 2019), but can also lead to fragmented planning efforts and inconsistencies across jurisdictions. Comprehensive plans (also known as a General Plan or Master Plan) (Bush & Doyon, 2019) , adopted by local governments, serve as guiding documents for long-term development, addressing various aspects such as land use, transportation, housing, and environmental protection. However, the extent to which these plans incorporate urban heat resilience varies considerably across municipalities (Keith et al., 2019). While federal agencies like the Environmental Protection Agency provide resources and guidance on heat mitigation and adaptation, they lack direct regulatory authority over local planning decisions (Keith et al., 2019). This decentralized structure contrasts sharply with the more top-down, hierarchical planning systems found in many European countries (Heidrich et al., 2016). The emphasis on local control in the U.S. system allows for greater community engagement and customization of planning strategies, but also presents challenges in coordinating regional responses to urban heat and ensuring equitable distribution of resources (Keith et al., 2019). Furthermore, the reliance on voluntary programs and incentives can limit the effectiveness of heat resilience initiatives, particularly in resource-constrained communities (Keith et al., 2019).

KEY FEATURES OF THE U.S. PLANNING FRAMEWORK:

- **Decentralization**: Urban planning is primarily conducted at the local level, with 70% of planners expressing concern about extreme heat risks in their communities (Keith & Meerow, 2022).
- **Public Participation**: The report emphasizes the importance of inclusive public participation, particularly for historically marginalized communities, to ensure that heat resilience strategies are appropriate and effective (Keith & Meerow, 2022).
- **Interdisciplinary Approach**: Urban heat resilience planning requires coordination across various sectors, including public health, emergency management, and urban (Keith & Meerow, 2022).
- **Regulatory Framework**: Only 9% of surveyed planners reported addressing heat in zoning codes and regulations, indicating a significant opportunity for improvement in integrating heat considerations into regulatory frameworks (Keith & Meerow, 2022).

STRENGTHS AND WEAKNESSES ANALYSIS

STRENGTHS	• **Local Relevance**: The ability to tailor planning to local conditions is crucial, as urban areas can differ in temperature by as much as 20°F (Keith & Meerow, 2022). • **Flexibility**: Local governments can adapt their strategies based on changing conditions, with 87% of planners reporting the implementation of at least one heat mitigation or management strategy in their community (Keith & Meerow, 2022). • **Community Engagement**: Engaging communities in the planning process can build trust and awareness, as demonstrated by the Nature's Cooling Systems project in Phoenix, which involved local residents in developing heat strategies (Keith & Meerow, 2022).
WEAKNESSES	• **Inequities**: Formerly redlined neighborhoods are, on average, 5°F hotter in the summer, highlighting systemic inequities in heat exposure • **Fragmentation**: The lack of a cohesive national framework can lead to inconsistent planning efforts, with only 10% of planners addressing heat in building codes (Keith Ladd & Meerow Sara, 2022). • **Resource Limitations**: Many local governments face budget constraints, which can limit their capacity to implement comprehensive heat resilience strategies (Keith & Meerow, 2022).

THE U.S. RESILIENCE PLANNING

Resilience, has become a central theme in US urban planning. The integration of resilience into U.S. urban planning is driven by factors like increasing extreme weather, climate change concerns, and the need for robust infrastructure (Prasad et al., 2023). Resilience strategies are incorporated across different governance scales, often involving public-private collaborations. For example, New York City's "OneNYC" plan included investments in infrastructure, protective measures, and climate adaptation (Prasad et al., 2023). This illustrates a multifaceted approach to building urban resilience through policy frameworks, technological innovations, and community initiatives. However, challenges include funding constraints, governance issues, and social inequalities.

The decentralized U.S. planning system allows flexibility and community responsiveness but can also lead to fragmentation and inconsistencies across jurisdictions (Keith et al., 2019). While comprehensive plans guide long-term development, their integration of urban heat resilience varies. Federal agencies offer resources, but lack direct regulatory authority, unlike more centralized systems (Prasad et al., 2023). This emphasis on local control promotes community engagement but can hinder regional coordination and equitable resource allocation, potentially limiting the effectiveness of resilience initiatives (Prasad et al., 2023).

Overall, the U.S. urban planning framework presents both opportunities and challenges for integrating heat resilience strategies, leading to the launch of various campaigns and programs to promote urban resilience.

The American Planning Association's report, **"Planning for Urban Heat Resilience"** (2022), offers a comprehensive framework for building urban heat resilience in the USA. This framework emphasizes proactive mitigation and management of urban heat across various systems and sectors (Keith & Meerow, 2022). A key component is the equitable distribution of resources and strategies, recognizing that marginalized communities disproportionately bear the brunt of heat-related risks (Keith & Meerow, 2022). The framework outlines seven practical considerations for holistic heat resilience planning (Keith & Meerow, 2022): setting clear goals and metrics; building a comprehensive data base on heat risks; developing diverse mitigation and management strategies; managing uncertainty; ensuring inter-departmental coordination; fostering inclusive participation; and implementing effective monitoring and evaluation. The report further details specific mitigation strategies (e.g., land-use planning, urban design, urban greening, waste heat reduction) (Keith & Meerow, 2022) and management strategies (e.g., energy efficiency, public health initiatives, emergency preparedness) (Keith & Meerow, 2022), integrating these into existing planning processes and regulatory tools (Keith & Meerow, 2022). **The Plan Integration for Resilience Scorecard for Heat (PIRSH)** is introduced as a tool for assessing a community's current planning efforts and their impact on urban heat resilience (Keith & Meerow, 2022). Case studies from Boston, Houston, Seattle and more, illustrate successful cross-departmental collaborations and implementation of heat resilience initiatives . The report concludes with a call to action, emphasizing the urgency of addressing this growing and inequitable threat (Keith & Meerow, 2022).

2.4. THE PLAN INTEGRATION FOR RESILIENCE SCORECARD™ (PIRS™) FOR HEAT: SPATIALLY EVALUATING NETWORKS OF PLANS TO MITIGATE HEAT.

2.4.1. BACKGROUND AND CONTEXT

The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat methodology is an important tool for the assessment of the UHI effect in the cities within the USA and worldwide. It provides a systematic process for evaluating heat mitigation strategies and their effectiveness in enhancing urban heat resilience with a special emphasis on social vulnerability, as a critical evaluation criteria (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022).

History Behind The PIRS™ for Heat. The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat is a methodology that derives from the original Plan Integration for Resilience Scorecard™ (PIRS™), which was developed in the United States by Berke et al. (2015) (further translation to planning practice was done by (Malecha et al., 2019) and adopted as a national standard and resource for building resilience across the planning sector by the American Planning Association (APA). It is designed to assess the effectiveness of a community's network of plans in addressing different hazards' risks. It assesses the capability of the community's plans and strategies to minimize its vulnerability to hazards and determines whether different policies and actions prioritize more vulnerable areas in the city. Applied in different cities across the U.S. and The Netherlands, PIRS™ provides useful information on the prioritization of mitigation strategies for urban resilience, helps communities understand the full extent of policies, reconcile conflicts, and make changes to specific policies and planning processes based on identified gaps (Keith Ladd et al., 2022, pp. 7, 10–11).

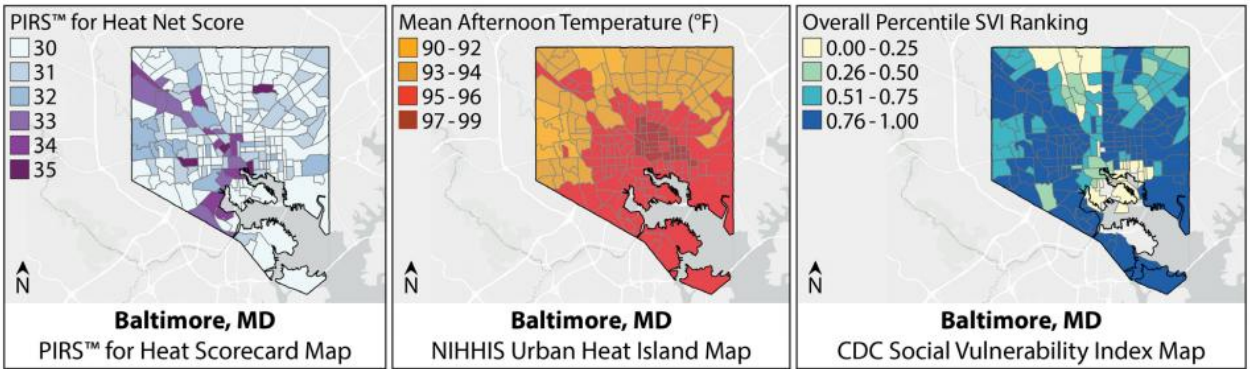
The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat, developed in 2022 by a collaborative team of authors including Ladd Keith, Sara Meerow, Philip Berke, and others, takes its forerunner's methodology and focuses on heat hazard. They adopted the same approach as PIRS™ to assess and advance heat resilience, which includes the creation of a scorecard, analysis of its results, and research of the paths to resilience through planning. (Keith & Meerow, 2022, p. 43).

Compatibility with diverse frameworks. The PIRS™ for Heat is designed as a flexible and scalable tool applicable to both centralized and decentralized planning frameworks across jurisdictions. It allows for thorough assessment of cross-sectoral and cross-jurisdictional planning efforts, while respecting local context and nuances (Malecha et al., 2021). This flexibility is crucial given the decentralized nature of the US urban planning system. When researchers evaluated the outcomes of applying the PIRSH methodology, they found that it facilitated a deeper understanding of the full extent of policies across different departments, helped reconcile conflicts, and led to changes in specific policies and planning processes based on identified gaps (Malecha et al., 2021). This collaborative approach is crucial for enhancing urban heat resilience, as it encourages integration across various planning efforts and promotes a more comprehensive understanding of heat risks and mitigation strategies.

Case Studies of the PIRS™ for Heat and Their Results. Supported by NOAA and in partnership with the American Planning Association, the PIRS™ for Heat has been then piloted in a number of US cities, including larger metropolitan areas like Boston, Houston, and Seattle, as well as smaller and medium-sized communities like Kent, Washington (Keith et al., 2023). The project team scored policies based on their potential to mitigate or worsen urban heat, mapping these scores to census tracts to assess their spatial impact. The scorecard was then compared with data on physical and social vulnerabilities to evaluate how well policies align with heat risks.

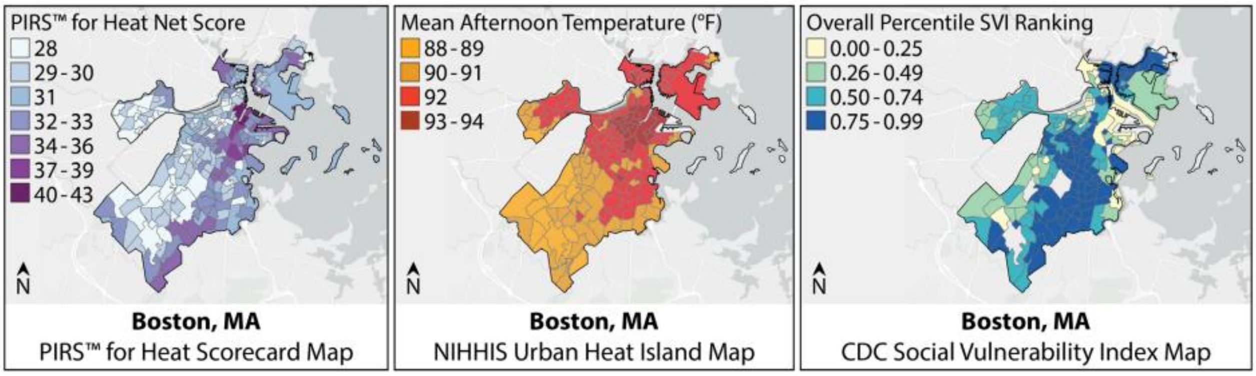
Initial Pilot Cities

Baltimore, MD (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022):



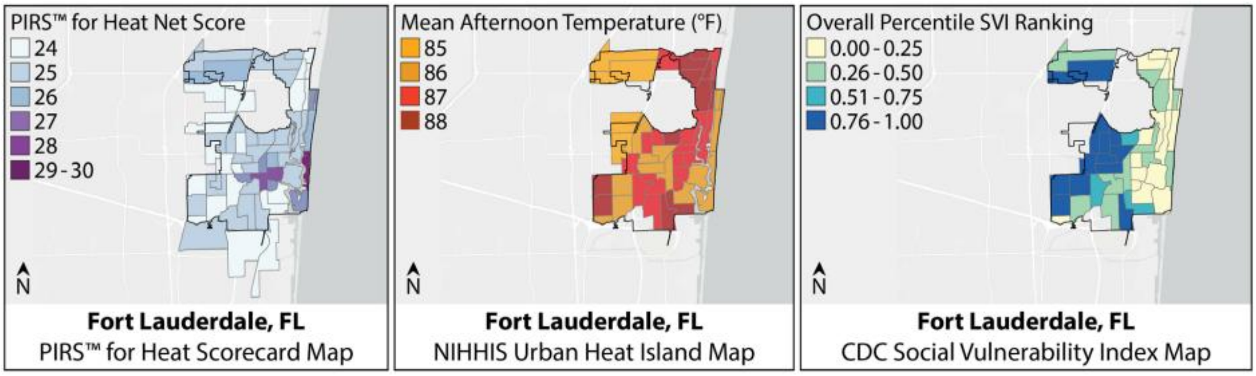
The analysis of four plans revealed 77 heat-related policies. The study highlighted the need to prioritize heat mitigation in the most vulnerable areas.

Boston, MA (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022):



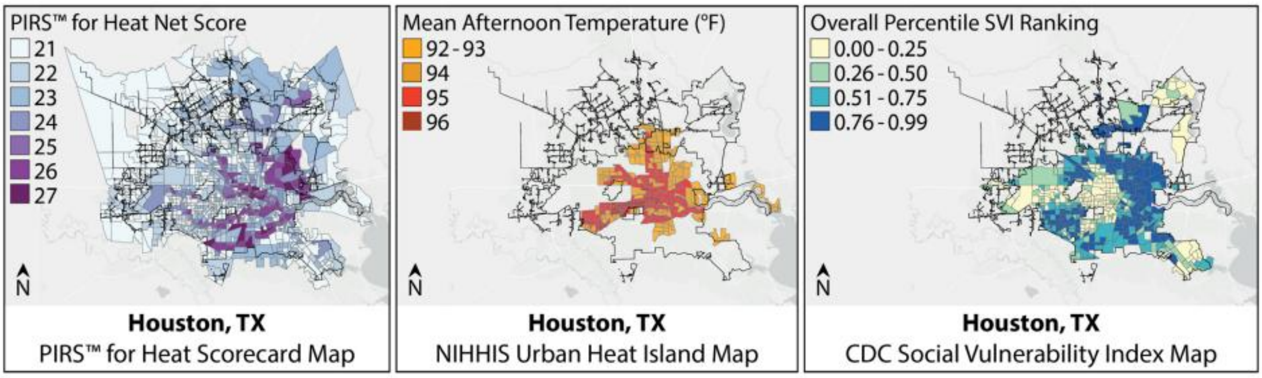
The analysis identified 106 policies that were likely to impact the urban heat island effect, with only one policy expected to increase heat risks. However, the study found that the census tracts receiving the most attention for heat mitigation policies were not always the hottest or most socially vulnerable areas. Furthermore, 37 policies had an unclear impact on urban heat due to vague descriptions in the plans.

Fort Lauderdale, FL (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022):



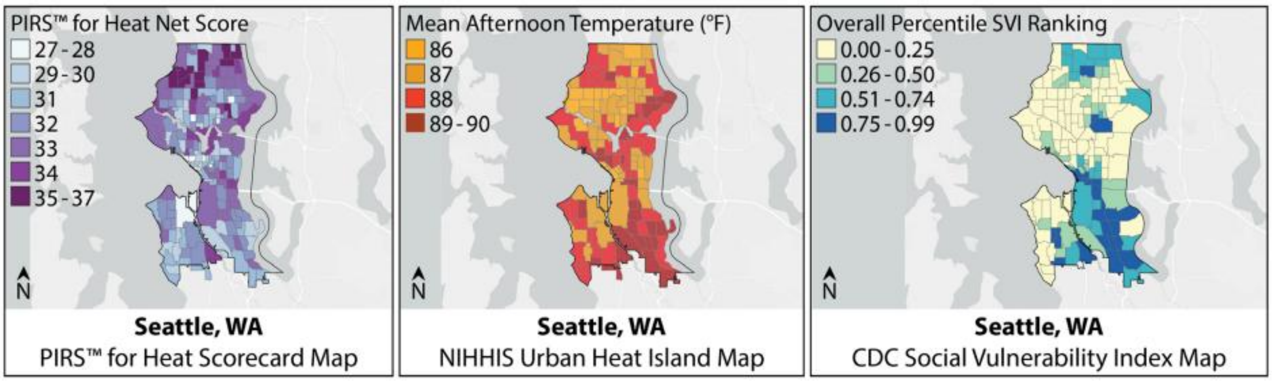
Assessment of three plans resulted in 185 heat-relevant policies, with the majority found in the comprehensive plan. While many policies addressed heat mitigation, 146 had unknown impacts.

Houston, TX (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022):



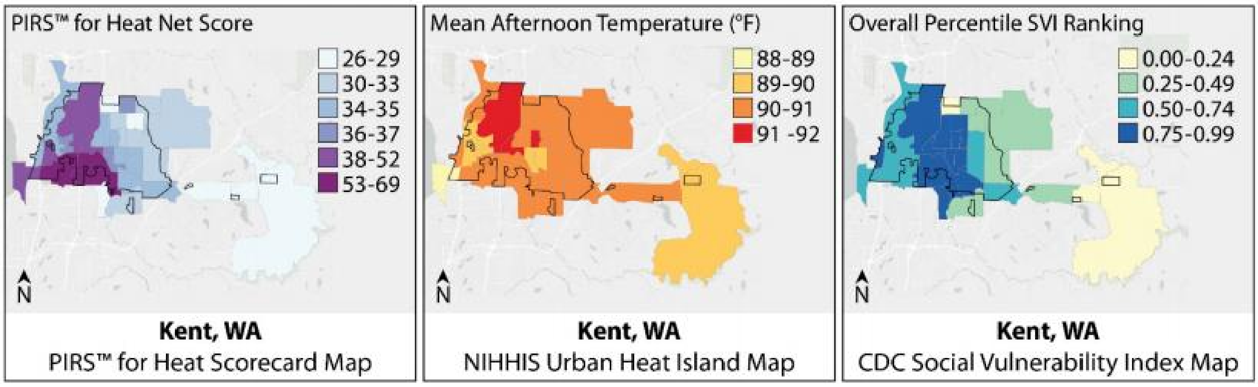
The analysis of four plans in Houston, TX, identified 60 heat-relevant policies. Similar to the findings in other cities, many of these policies had an unclear or unknown impact on mitigating urban heat.

Seattle, WA (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022):



The evaluation of four plans in Seattle, WA, revealed 150 heat-relevant policies, with the majority found in the comprehensive plan. The study highlighted the importance of prioritizing heat mitigation policies in the city's most vulnerable areas.

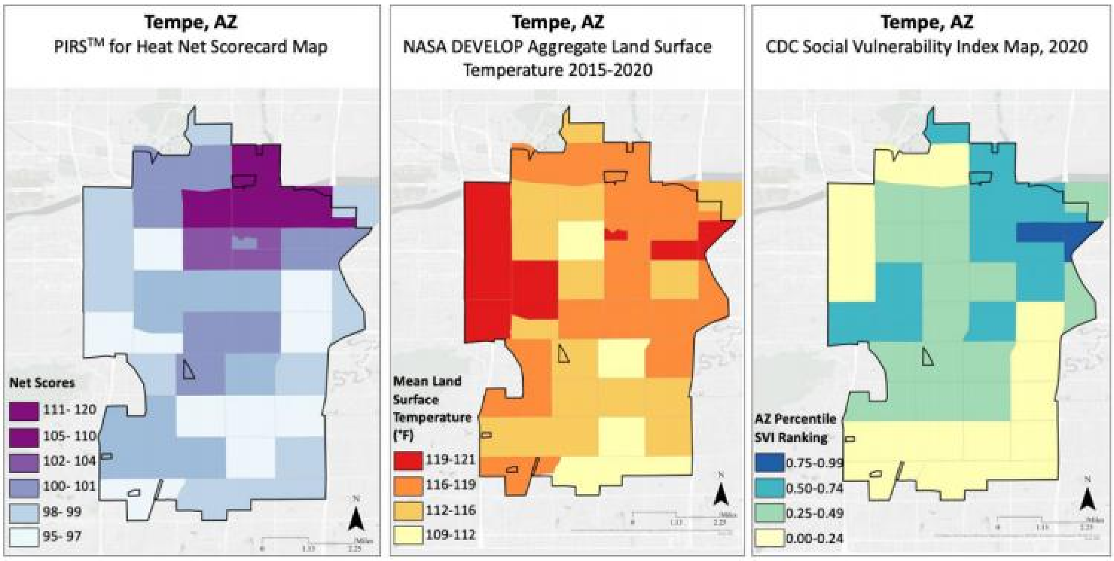
Collaborative Application in Kent, WA (Keith, Meerow, Berke, DeAngelis, Schmidt, et al., 2022; Trego et al., 2023):



This case study involved a collaborative application of the PIRS for Heat in a smaller city. The analysis of four plans identified 143 policies with the potential to mitigate heat and no policies that would exacerbate urban heat.

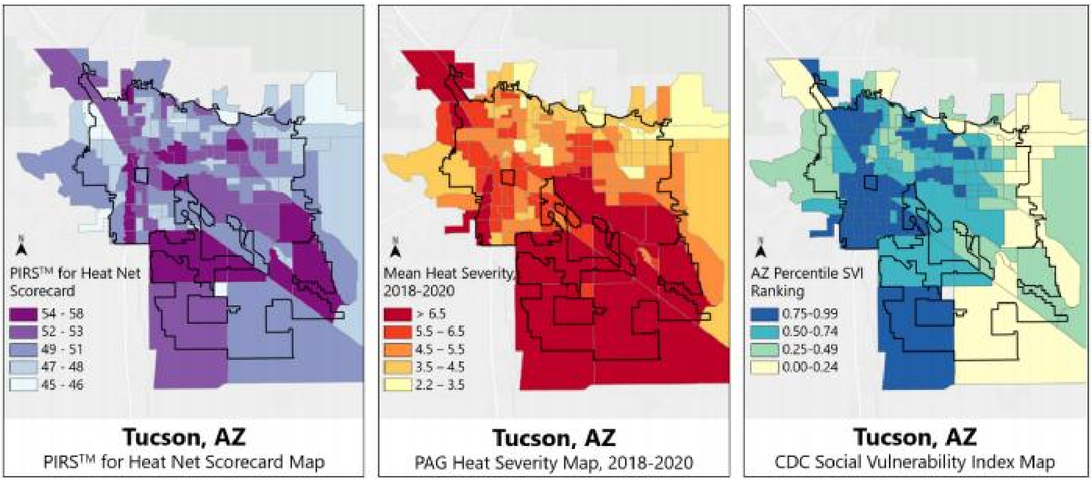
Additional Applications

Tempe, AZ (Keith, Meerow, Trego, et al., 2022):



The analysis of five plans in Tempe, AZ, revealed 229 policies with the potential to impact urban heat. However, the study found no significant correlation between the heat mitigation policy scores and land surface temperatures, suggesting that the policies were not systematically targeting the areas with the highest heat levels.

Tucson, AZ (Keith et al., 2023):



The analysis of three plans in Tucson, AZ, identified 100 policies with the potential to impact urban heat. However, the study revealed a lack of significant correlation between the implemented heat mitigation policies and the city's social vulnerability, suggesting a need to better align policies with the needs of the most vulnerable populations.

KEY FINDINGS FROM PIRS™ FOR HEAT APPLICATIONS IN U.S. CITIES

The most common heat mitigation strategies found in the analyzed plans involved enhancing urban greenery and reducing waste heat. Cities tended to rely heavily on a limited set of policy tools, particularly capital improvement projects, for implementing heat mitigation measures. Heat mitigation policies were often not systematically aligned with the areas facing the highest temperatures or greatest social vulnerabilities. Many plans included policies with unclear impacts on urban heat due to vague language and a lack of specific details.

Importance of PIRS™ for Heat. The case studies demonstrate that the PIRS™ for Heat offers a comprehensive assessment of heat mitigation policies across multiple planning documents, enabling a thorough understanding of **current heat planning efforts**. It also **identifies gaps and inconsistencies**, highlighting areas where heat mitigation policies are lacking or potentially contradictory. Furthermore, the tool helps communities **evaluate the spatial alignment** of heat mitigation policies with high-risk and socially vulnerable areas. Importantly, it **promotes collaboration** by bringing together diverse stakeholders and departments involved in planning to facilitate better coordination and integration of heat mitigation strategies.

2.4.2. LIMITATIONS AND FUTURE DIRECTION OF PIRS™ FOR HEAT

There are several opportunities to further develop the PIRS™ for Heat tool:

Assessing Policy Impact. The current scoring is binary, and future versions could explore ways to incorporate the relative effectiveness of different heat mitigation strategies.

Expanding the Framework. While the PIRS for Heat focuses on mitigation, expanding it to include heat management approaches, such as cooling centers and early warning systems, would provide a more comprehensive view of heat resilience planning.

Integrating Implementation and Monitoring. Linking the PIRS for Heat with implementation guidelines, success metrics, and monitoring would enhance its ability to track progress and ensure accountability.

Collaborative Applications. Continued involvement of practitioners in applying the PIRS for Heat can foster the co-production of knowledge and ensure the tool meets the needs of heat-affected communities.

2.5. ITALY AND THE U.S. TOWARDS HEAT RESILIENCE PLANNING

2.5.1. COMPARATIVE ANALYSIS

The comparative analysis highlights the need to strike a balance between top-down and bottom-up approaches, leveraging the strengths of each system while addressing their limitations. The utilization of a tool like the PIRS™ for Heat in the Italian context may require adjustments to accommodate the specific characteristics and constraints of the Italian planning system, as well as to ensure meaningful outcomes.

Comparing the US and Italian urban planning systems reveals both similarities and significant differences in their approaches to resilience planning. Both countries face similar challenges, including the impacts of climate change, the need for robust infrastructure, and the importance of community engagement. (D'Ascanio & Di Ludovico, 2016). However, the organizational structures and planning processes differ considerably. The US system is more decentralized, with greater autonomy for local governments and public and private initiatives. (van der Leeuw, 2010), while the Italian system has a stronger emphasis on national and regional level planning - a 'top-down' approach with a rigid conformative planning system (D'Ascanio & Di Ludovico, 2016; Janin, 2008).

The integration of resilience considerations into planning processes is evident in both countries, but the specific strategies and implementation approaches differ (Anelli & Tajani, 2022). The US has seen a greater emphasis on the use of quantitative methodologies and technological tools for resilience assessment (Sara Mehryar Idan Sasson, 2021; Xin Fu Matthew E. Hopton, 2020), while Italy has shown a growing interest in NBS and community-based approaches.

The incorporation of community engagement in planning processes is crucial in both systems (Cassidy Johnson, 2014; Diana Contreras Thomas Blaschke, 2017), but the methods and effectiveness vary. The US system often emphasizes stakeholder involvement through public hearings and consultations (Cassidy Johnson, 2014), while Italy has explored more participatory planning techniques, such as co-designing strategic urban planning documents. However, challenges remain in ensuring meaningful community participation and addressing power imbalances in decision-making processes (Diana Contreras Thomas Blaschke, 2017; Mar Satorras Isabel Ruz-Malln, 2020).

The role of legislation and regulatory frameworks in shaping resilience planning also differs. The US system has a more extensive body of environmental regulations and disaster preparedness legislation (Henrik Ernstson Sander E. van der Leeuw, 2010), while Italy has been criticized for a lack of specific legislative references related to urban design and resilience planning (Federico DAscanio Donato Di Ludovico, 2016). This difference reflects the varying political and institutional contexts in which each system operates (Federico DAscanio Donato Di Ludovico, 2016; Henrik Ernstson Sander E. van der Leeuw, 2010).

The Italian planning system has several strengths, such as the top-down approach that can facilitate the dissemination of best practices and ensure consistency, and the hierarchical structure that may streamline data collection and reporting across different levels of government. However, it also faces limitations, including a rigid, conformative planning system that may hinder flexibility and adaptability, limited local autonomy that can restrict community engagement and responsiveness to specific needs, and a lack of specific legislation related to urban design and resilience planning.

In contrast, the U.S. planning system exhibits strengths in its decentralized approach, which allows for local customization and responsiveness to specific UHI challenges, as well as greater flexibility and adaptability in implementing innovative solutions. The U.S. system also has a strong emphasis on community engagement and stakeholder involvement, an extensive body of environmental regulations and disaster preparedness legislation, and a greater use of quantitative methodologies and technological tools for UHI assessment. However, it also faces limitations, such as fragmentation and inconsistencies across jurisdictions that can hinder regional coordination, and reliance on voluntary programs and incentives that may limit effectiveness in resource-constrained communities.

In summary, the integration of PIRS™ for Heat to address urban heat island challenges requires carefully navigating the nuances of each country's planning framework, considering both the strengths and limitations of their respective approaches (Moraci et al., 2018; Pietrapertosa et al., 2017, 2019). A tailored application of PIRS™ for Heat that recognizes and adapts to the unique characteristics of the Italian planning system will be crucial for its successful implementation and the identification of effective strategies to enhance heat resilience.

2.5.2. POTENTIAL CHALLENGES IN TRANSFERRING THE TOOL TO THE ITALIAN CONTEXT

Applying the PIRS for Heat methodology within a hierarchical planning framework presents several potential challenges:

- **Top-Down Approach:** Hierarchical systems often prioritize top-down directives, which may not align with the collaborative and community-driven nature of PIRS for Heat. The methodology's emphasis on local stakeholder engagement and bottom-up planning could clash with centralized decision-making processes.

- **Data Availability and Compatibility:** Hierarchical frameworks may rely on different data collection and reporting mechanisms across various levels of government. This can create challenges in gathering consistent and comparable data for the PIRS for Heat assessment, particularly when integrating information from different spatial scales and administrative boundaries.
- **Coordination and Communication:** Effective implementation of PIRS for Heat requires seamless coordination and communication between different levels of government. Hierarchical structures can sometimes hinder information flow and create bureaucratic barriers that impede collaboration and timely decision-making.
- **Implementation Capacity:** Local governments within a hierarchical system may have varying levels of capacity and resources to implement the PIRS for Heat methodology. This can lead to uneven application of the tool and limit its effectiveness in promoting equitable heat resilience outcomes.
- **Resistance to Change:** Established hierarchical systems can be resistant to adopting new methodologies and tools. Integrating PIRS for Heat may require significant adjustments to existing planning processes and workflows, which could face resistance from officials accustomed to traditional approaches. (Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022) discuss two approaches to applying PIRS for Heat, one minimizing community time requirements and the other involving iterative feedback. These approaches could be adapted to address some of the challenges within a hierarchical framework. For example, the first approach might be more suitable for top-down systems, while the second could facilitate greater local input.

2.6. CONCLUSION AND RESEARCH IMPLICATIONS

This literature review provides key insights into Urban Heat Island (UHI) dynamics and urban planning frameworks, emphasizing the need for integrated, context-specific strategies. Comparative analysis between Italian and U.S. systems highlights opportunities for mutual learning and the role of methodologies like the PIRS™ for Heat in addressing planning gaps. Implementing these insights can enhance urban heat resilience, fostering sustainable urban environments globally.

2.6.1. KEY FINDINGS OF LITERATURE REVIEW

- **UHI Dynamics:** The urban heat island effect describes the phenomenon where urban areas experience significantly higher temperatures than surrounding rural areas. This temperature difference is primarily caused by the abundance of heat-absorbing materials like asphalt and concrete, reduced vegetation cover, and waste heat released from human activities such as transportation and industry. Consequences of the UHI effect include increased energy consumption for cooling, elevated air pollution levels, and adverse health impacts, particularly for vulnerable populations, due to heat stress.
- **Addressing UHI.** Main strategies include Mitigation, Adaptation (Management), and Urban Planning. Mitigating the urban heat island effect involves strategies to

reduce heat absorption and increase heat dissipation. This includes increasing albedo with cool roofs and pavements (Larsen, 2015; Lemonsu et al., 2015), expanding green infrastructure like trees and vegetation for shade and evapotranspiration (Larsen, 2015; Lemonsu et al., 2015), reducing waste heat from buildings and transportation (Keith & Meerow, 2022), modifying urban design for better ventilation, raising public awareness about UHI, and promoting individual actions to reduce heat exposure. Adaptation, unlike mitigation, focuses on reducing the causes of UHI, such as implementing cool roofs or increasing green spaces. While both are crucial for addressing UHI, adaptation specifically addresses the impacts of existing and projected temperature increases (Brunetta & Caldarice, 2019). *Management(heat)* encompasses the ongoing process of planning, implementing, monitoring, and adjusting strategies to mitigate the causes and adapt to the impacts of elevated urban temperatures(Keith & Meerow, 2022). Effective UHI management requires a comprehensive approach that integrates various disciplines, stakeholders, and policy levels, and used as a term in the U.S. context only.

- **Planning Frameworks.** The planning systems in Italy and the U.S. exhibit both similarities and key differences in their approaches to urban heat resilience. A comparative analysis of the U.S. and Italian planning systems reveals key differences in their approaches to urban heat resilience. The U.S. system's decentralized, horizontal approach allows for local customization and community engagement but can lead to fragmentation and inconsistencies. Italy's centralized, vertical system promotes consistency and streamlines data collection but may limit local responsiveness and flexibility. Both systems, however, emphasize the significance of integrated planning methods to address urban heat resilience, despite the differing terminology and implementation approaches.
- **PIRS™ for Heat as a Bridging Tool.** The Plan Integration for Resilience Scorecard™ (PIRS™ for Heat) emerges as a potential tool to bridge planning gaps and enhance urban heat resilience by offering a structured, data-driven methodology(Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022). The following research explores the applicability of PIRS™ for Heat within the Italian context, recognizing not only the urge to mitigate UHI but also the need for adaptations to accommodate the specific characteristics and constraints of the Italian planning system.

2.6.2. RESEARCH IMPLICATIONS.

This research aims to make methodological contributions by adapting PIRS™ for Heat to the Italian planning system, providing insights into its applicability and transferability in diverse settings. By identifying policy gaps and proposing context-sensitive strategies in Turin, the study offers a model for analysis in other cities, both within and outside Italy. The research seeks to showcase the value of flexible, evidence-based methodologies in bridging the divide between planning theory and practice, fostering more effective and equitable heat resilience efforts. The following sections will describe the application of the testing methodology and present the results to answer the research question. The study will focus on evaluating the effectiveness of PIRS™ in mitigating and managing UHI issues in Turin, testing its application possibilities and defining the main planning challenges.

In conclusion, it is evident that both the US and Italy emphasize the significance of incorporating integrated planning methods to address urban heat resilience. The terminology may vary, but both approaches underscore the importance of integrating strategies for heat resilience into urban planning and development plans through comprehensive and multi-level systems. The US and Italy aim to enhance urban heat resilience through their planning efforts. However, the US emphasizes more inclusive and horizontal planning than Italy's vertical approach. Therefore, this study will focus on evaluating the effectiveness of the Plan Integration for Resilience Scorecard™ (PIRS™) in mitigating and managing Urban Heat Island issues in an Italian context, the city of Turin, to test the application possibilities and define the main planning challenges if the city.

In the following sections, the application of the testing methodology will be described, and the results will be shown to answer the research question posed.

CHAPTER III

INTRODUCTION

LITERATURE REVIEW

METHODOLOGY

RESULTS

DISCUSSION

CONCLUSION

ANNEXES

This chapter provides a step-by-step methodological guide on the application of the PIRS™ For Heat tool with specific to the context adjustments. The chapter first established the methodological structure to follow, then re-state the main rationale behind using the tool, after which dived into the application phases and steps. In the end, the main limitations and conclusions were made.

3. CHAPTER III: TESTING APPLICATION OF PLAN INTEGRATION FOR RESILIENCE SCORECARD™ (PIRS™) FOR HEAT IN THE CITY OF TURIN

Although awareness of heat risks is rising, planners encounter significant obstacles, such as limited research-based guidance, weak regulatory frameworks, and fragmented decision-making processes. Effective urban heat resilience planning requires an integrated approach that aligns strategies across various community plans and prioritizes vulnerable populations using the best available data.

In this chapter are discussed the methods and tools that were used to access the main practical problem - **Urban Heat Island effect in the city of Turin** and consequentially, reply **to the main question** of the research: on how the application of **the "Plan Integration for Resilience Scorecard™ (PIRS™) for Heat"** methodology **can help understand and evaluate the mitigation strategies for urban heat across** within a network of plans in the case of the city of Turin and furthermore**, assess Turin's heat vulnerability in order to provide actionable recommendations for enhancing urban heat resilience planning.**

3.1. RESEARCH ORIGINE

The research is based on the principle **of policy tool transfer** where the PIRS™ for Heat methodology was chosen as the main instrument for the paper. Thus, before diving dipper, it is important to understand the overall context of the PIRS™ for Heat methodology and why it was chosen as the main tool for this paper.

The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat is a versatile tool that helps communities assess how different plans and policies impact heat risks in various neighborhoods(Keith, Meerow, Berke, DeAngelis, Jensen, et al., 2022). Building on the original PIRS™ methodology, initially developed for flood hazards, PIRS™ for Heat guides communities in targeting heat mitigation efforts where they are needed most(Keith & Meerow, 2022).

The rationale behind choosing PIRS™ for Heat method and the reasons for its adjustment

The methodology of this study introduced few modifications to the original **PIRS™ for Heat method** in order to suit it within Italian planning framework and adjust according to the available data on the case study.

Discussed previuosly in literature review**, the Italian urban planning system** is highly hierarchical and rooted in the "conformative" model established by the 1942 National Planning Law. It operates across four administrative levels: national, regional, provincial/metropolitan, and municipal. The national level provides overarching strategies and plans, while municipalities focus on land-use plans that are legally binding, with little room for flexibility or public participation. This system is characterized by pre-allocated land use, rigid zoning regulations, and limited integration of environmental concerns into urban planning (Caldarice et al., 2021; Pietrapertosa et al., 2021). Despite these limitations, some cities have pioneered localized climate adaptation plans, but such efforts remain fragmented due to the absence of mandatory frameworks at higher levels.

In contrast, **the U.S. urban planning framework** is decentralized, granting local governments primary authority over land-use decisions. This bottom-up approach fosters flexibility and responsiveness to community-specific needs but can lead to fragmentation and inconsistencies across jurisdictions (Keith et al., 2019). Comprehensive plans in the U.S. are often more adaptable, with federal agencies like the Environmental Protection Agency providing resources without direct regulatory authority. While public participation and interdisciplinary approaches are emphasized, the reliance on voluntary programs and incentives limits the reach and equity of heat resilience initiatives (Keith & Meerow, 2022). These differences underscore how centralized versus decentralized governance influences planning priorities and integration of resilience strategies.

The PIRS™ for Heat in the Italian Context, what to expect? The Plan Integration for Resilience Scorecard™ (PIRS™) for Heat is particularly suited for application in Italy, given its capacity to evaluate the alignment and effectiveness of urban heat resilience strategies across fragmented planning systems. Italy's hierarchical planning framework, while rigid, could benefit from the scorecard's ability to reconcile inconsistencies across different administrative levels and sectors. For example, PIRS™ could help identify gaps in municipal plans where heat resilience strategies are absent or weakly integrated, facilitating vertical alignment with regional and national climate goals.

Moreover, the scorecard's emphasis on social vulnerability aligns well with Italy's need for equitable climate adaptation measures, especially in urban areas affected by the urban heat island (UHI) effect. The tool's flexibility enables adaptation to Italy's conformative planning model by promoting cross-sectoral coordination and proactive engagement in addressing heat risks. By leveraging PIRS™ for Heat, Italian municipalities could better integrate climate resilience into their legally binding urban general plans, ensuring a more comprehensive approach to urban heat challenges.

3.2. STRUCTURE OF THE CHAPTER OR HOW TO READ THE CHAPTER

The methodology was **divided into 3 main parts:** Preliminary Research; Method of the Analysis and Limitations and Conclusions.

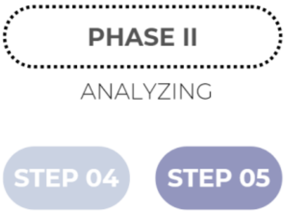
PRELIMINARY RESEARCH

The preliminary research phase established the foundation of the study, focusing on understanding the research problem and setting the stage for the investigation. The preliminary research aimed to explore the effectiveness of the PIRS™ for Heat methodology in improving urban heat resilience, applied to the city of Turin. This phase involved gathering initial data, outlining the scope of the study, and setting objectives to guide subsequent phases.

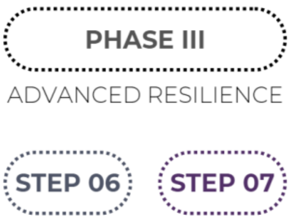
METHOD OF THE ANALYSIS

The methodology section detailed the systematic approach adopted to conduct the research, encompassing three main phases: Phase I: The Scorecard Making; Phase II: Vulnerability Analysis; Phase III: Analysis of the Scorecard Results and 7 main steps within them, **according to The Plan Integration For Resilience Scorecard™ (PIRS™) For Heat.**

Phase I: Creating Scorecard – This phase involved creating the PIRS™ for Heat scorecard, which included collecting relevant data and indicators to evaluate urban heat resilience. The steps in this phase were:
Step 01: Policy Tasks
Step 02: Policy Scoring
Step 03: Mapping Tasks



Phase II: Analyzing – This phase focused on analyzing the data collected in the scorecard making phase and comparing it to the physical and social vulnerability data of the city to identify areas of heat vulnerability within the urban context. The steps in this phase were:
Step 04: Physical Vulnerability
Step 05: Social Vulnerability



Phase III: Advancing Resilience – This phase utilized analytical data from the scorecard and vulnerability analysis to produce actionable insights for enhancing urban heat resilience. The steps in this phase were:
Step 06: Resilience through Planning
Step 07: Stories

LIMITATIONS AND CONCLUSION

This section clearly stated the limitations that the research hold, while conclusion shortly described the main findings of the methodological chapter.

Additionally:

Steps 03; 04; 05 are then divided into 4 fundamental parts for better comprehension of the methodology:

1) The **data** used and its sources,
2) The **software and/or tools** necessary for execution of the method,
3) The **processing** of that data, in this study case, **through mapping** of the data,
4) And **analysis** of the results acquired in each step.

Step 04 and Step 05 are also divided into 2 parts:

THE PIRS™ FOR HEAT METHOD	The description of the original methodology
THE ADJUSTED METHOD	The description of adjustments implemented to execute the method within the case study specifications.

Below you can see the schematic representation of the entire chapter.

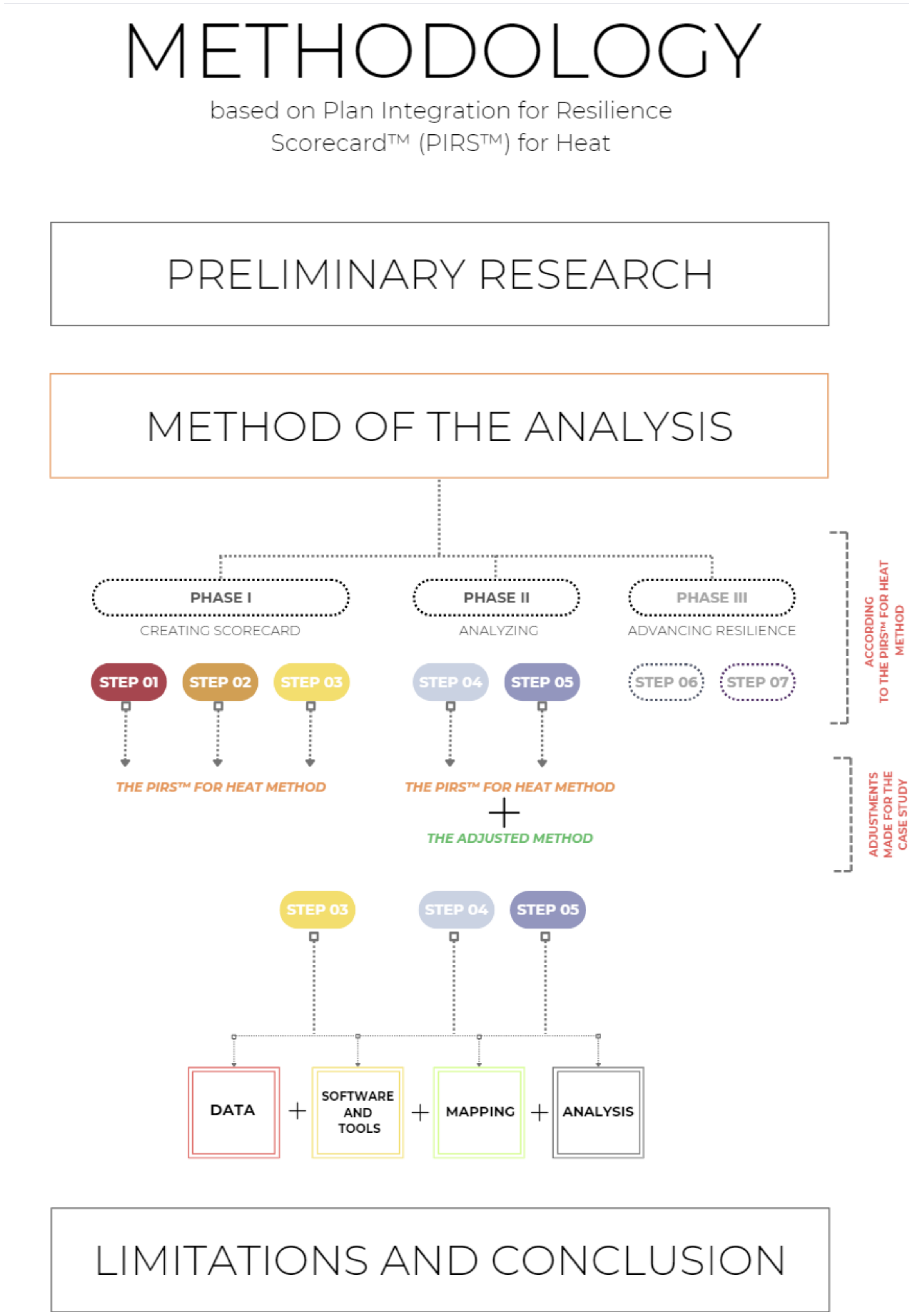


Figure 13. Schematic representation of the methodological chapter. Source: Personal elaboration.

3.3. METHODOLOGICAL APPLICATION

RESEARCH PHILOSOPHY, ITS APPROACH AND DESIGN.

The paper aligns within the **pragmatism research philosophy**, employing practical and problem-solving paths into the spectrum. It utilizes a **mixed-method approach** (Cohen et al., 2007; Holden & Lynch, 2004; Žukauskas et al., 2018), incorporating both the qualitative (analysis of the planning framework; application of PIRS for Heat methodology-tool, specifically 'Three-Point Test", categorization of actions and policies based on their impact on UHI; the assessment of the policy transfer effectiveness) and quantitative (scoring and mapping of the actions and polices; vulnerability assessment through spatial data mapping) methods. The integration of both methods is crucial to comprehensively address the UHI issue and to accurately apply the testing tool. Given that the research focuses on a particular place, the city of Turin, it falls under **a case study design** category (Coombs, 2022).

PRELIMINARY RESEARCH

3.4. PRELIMINARY RESEARCH

The initial research over urban heat islands and heat hazards definitions was carried out during this pre-phase. Using a variety of websites, journal articles, and reports, the subjects of the impact of UHI over various regions in various climates, the impact of heat hazard, including UHI over cities and population, and the primary approaches utilized to address the issue were understood.

Different approaches to addressing the UHI in the United States and the European Union were investigated, and main definitions of adaptation and mitigation strategies were defined (discussed in the literature review) to better understand how the application of the PIRS™ for Heat methodology, designed in the United States, could be applied over the European context.

In addition, the study included a review of the case study's urban design, population dynamics, and environmental characteristics. Finally, by studying the official webpages of the municipality and consulting the lecture materials from the previous year's course study, an understanding of the main planning techniques used in the city under study was developed.

3.5. THE TESTING OF THE PLAN INTEGRATION FOR RESILIENCE SCORECARD™ FOR HEAT

PHASE I **CREATING SCORECARD**

In first phase of the testing methodology the creation of scorecard was done through several steps: the identification of network of plans to include in the study and the identification of suitable actions and policies within them in step 1, the scoring of selected policies in step 2 and finally, mapping to create scorecard for resilience.

Between two equally useful approaches that could be undertaken - 'Minimizing the community's time required' and 'Maximizing the community's engagement' (Keith Ladd et al., 2022, p. 14), the first one was chosen, based on the academic nature of the study and restricted resources, for that reason, the feedback from the community, in face of municipality representative, was requested only at the beginning of the study, in form of online consultation.

STEP 01 **Policy Tasks**

3.5.1. POLICY TASKS

In the first step the selection of relevant heat-related plans was conducted and the identification of relevant policies within them was done to then use them in following step 2 of the research.

ASSEMBLE THE NETWORK OF PLANS.

At the beginning of the 'Policy Task' in purpose of having the base for scorecard creation most recent and updated border limits and census tracts were identified. Afterward, all related to urban heat resilience plans of the city were recognized, based on literature review, preliminary research, and additional readings. The plans were then selected based on the specific characteristics and based on their typology, according to the PIRS™ for Heat categorization (see Table 1 below).

- The relevance of the plan to urban heat resilience,
- Its importance in shaping build environment and development patterns of the city,
- and its potential to affect UHI (either increase or decrease it).

The characteristics that would contribute to the elimination of the methodology:

- The plans that are no longer actively referred to and/or considered dated,

- The plans on different from city scale (for example, regional and/or country scale)

Plan types	Considerations
Comprehensive or general plan	Typically the leading plan guiding future land use and development in a community and is typically important to include.
Hazard mitigation plan	Because of FEMA requirements, most communities have a hazard mitigation plan to reduce the risk of disasters. Heat is one hazard that may be addressed.
Climate action plan	Developed by many communities to address climate change, can include heat mitigation strategies and policies with co-benefits (e.g., promoting alternative forms of transportation).
Climate change adaptation, resilience, or sustainability plan	Some communities have developed these plans which may address heat directly, and even when they do not, many may include policies with heat mitigation co-benefits (e.g., green infrastructure).
Functional plan (e.g., parks and recreation, transportation, green infrastructure)	Communities develop many other functional plans that may contain policies that increase or decrease urban heat. Review the categories of policies and consider which functional plans (if any) are most relevant.
Small area or neighborhood plans	Small area or neighborhood plans may contain spatially explicit policies that would affect heat risk and, therefore could be relevant, but including them may be too time-intensive.

Table 1. Relevant community plans to include in the PIRS™ for Heat. Source: Keith Ladd et al., p.14.

COMMUNITY AND THE CITY'S AUTHORITY'S ENGAGEMENT AND FEEDBACK:

After the careful consideration and research of related plans, the consultation session was organized with one of the representatives of the municipality to get feedback and insightful recommendations on relevant plans to consider, and eventually, if needed modify the final list of plans suitable for inclusion in the PIRS™ for Heat methodology.

The final list of plans to include was then formed into a practical table (see tTble 2 below) before proceeding to their actions and polices analysis.

Selected community plans of the city of Turin for heat mitigation classification				
N	***Plan Types according to the PIRS™ for Heat***	***Considerations according to the PIRS™ for Heat***	***Plan Name in English and in original language***	***Abbreviation***

Table 2. Selected community plans for the PIRS™ for Heat methodology application. Source: Personal elaboration.

GENERATING LIST OF APPLICABLE POLICES.

After careful examination of each plan, only actions and policies that potentially influence land use, urban development and Urban Heat Island were selected. Using the worksheet (see Table 3 below), the process of selection of the actions and plans was conducted utilizing "Tree-point Test" by Malecha et al. (2019) and described as well in "the PIRS™ for Heat: Spatially evaluating network of plans to mitigate heat" by Keith Ladd et al. (2022, p.15).

Note:

- The "Three-point Test" is a criteria-based elimination tool used to determine whether a policy should be included in the evaluation process of the PIRS™ or the PIRS™ for Heat making.
  There are three criteria, should be met for action or policy to pass the test (important to note, that only actions and policies that met all 3 criteria could be considered suitable for inclusion in the PIRS™ or the PIRS™ for Heat) :
  1. The policy or action must potentially affect urban heat risk,
  2. The policy or action must be georeferenced or be place-specific.
  3. The policy or action must have specific identifiable policy tool or intervention to reach specific objective and/or goal.

The type of the plan'											
The name of the plan'											
Plan Actions and Policies related to UHI						Three-Point Test					
N	Category	Name or Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*	PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**

Table 3. The worksheet for the identification and selection process of the city plans' actions and polices related to UHI. Source: Personal elaboration based on the Plan Integration for Resilience Scorecard™ (PIRS™) for Heat Worksheet[1]

The data collected were then utilized in the following steps, therefore it was important to document a part of name and description of the policy, as well the reference in the plan and the geolocation, if presented for the future commodity.

Under "Noted" column were signed actions or policies from one plan that had relation or referred to another plan, strategy and/or project within the same city.

[1] Avaible via https://www.planning.org/media/document/9268420/

CATEGORIZING POLICES BY POLICY TOOL.

After identification of policies that passed “Three-point Test”, those were then transferred to original the PIRS™ for Heat Worksheet[2] and categorized by policy tool. The framework described in the original the PIRS™ guidebook by Malecha et al. (2019) and adapted by Keith Ladd et al. (2022) identifies eight policy tool categories for the actions and polices to be sorted in:

1. “Land use analysis and permitting process.”
2. “Capital improvements.”
3. “Development regulations.”
4. “Land acquisition.”
5. “Density transfer provisions.”
6. “Financial incentives and penalties.”
7. “Public facilities (including public housing).”
8. “Post-disaster reconstruction decisions.”
9. “Other”, used for the polices that could not be categorized elseway.

Each category had subcategories as well. Those were used in case one action or policy were characterized by 2 categories, where the strongest match would go under the main category column, where the other would be stated as subcategory.

CATEGORIZING POLICES BY HEAT MITIGATION STRATEGIES[3].

In the PIRS™ for Heat Worksheet the next categorization required consist of assigning to the selected actions and polices the heat mitigation strategies that they fall within. There are the four strategies that were defined by the PIRS™ for Heat:

1. Land use.
2. Urban design.
3. Urban greening.
4. Waste heat.

Each strategy had a subcategory. Only 1 policy tool could be applied to each action or policy, while multiple heat mitigation strategies could be suitable for it.

IDENTIFYING GEOSPATIAL INDICATORS FOR POLICIES.

Lastly, the geospatial reference of the action or plan was transferred to the PIRS™ for Heat Worksheet, therefore in the end the worksheet was filled and ready to use for I next scoring step.

[3] Termin used based on Keith & Meerow Sara (2022), U.S. terminology.

STEP 02 Policy Scoring

3.5.2. POLICY SCORING

In the step 02, after selection and categorization of actions and polices, they have been scored based on the PIRS™ for Heat scoring system.

a) Actions and polices were score with score [+1] if they would mitigate the UHI effect.
b) Actions and polices that would rather exacerbate the UHI effect were given score [-1].
c) Actions and polices with uknown effect on UHI, which means they would have an impact of heat but not enough data was provided within the plan to score them differently, would be given [U] as a score.
d) And, Actions and polices that would have both positive and negative effects on UHI within them would be score with [0].

The scoring process was done to access the actions and polices potential impact on urban heat and help understand better the plan integration and resilience of the city.

The scores then were filled in the PIRS™ for Heat Worksheet, where all the eligible actions and polices were already placed together with their geolocation and categorized.

At this stage, the resulting data was ready to either be mapped and/or accessed within the worksheet for further analysis.

STEP 03 Mapping Tasks

3.5.3. MAPPING TASKS

For the determination of the city areas in which policy tools are more concentrated than in others, the mapping process was executed.

DATA

DATA USED. Filled the PIRS™ for Heat Worksheet with results from Step 01 and Step 02 and Permanent census data of the population (ISTAT, 2023) as a shapefile.

DATA SOURCES. The Italian National Institute of Statistics (ISTAT)

SOFTWARE AND TOOLS

TOOLS USED

Microsoft Excel and GIS(ArcGIS) software

MAPPING

MAPPING PROCESS

Firstly, in the PIRS™ for Heat Worksheet with results for each policy, the unique 'Policy_ID' code was assigned (example: E1, E2, E3,....En...E20; M1, M2, M3,...Mn...M90).

Secondly, using the Permanent census data of the population with census tract borders, a base layer was created, within which in the 'Toggle Editing Mode' the new columns were created each for each policy ID from the PIRS™ for Heat Worksheet.

Consequently, always in the 'Toggle Editing Mode', each action and policy from the worksheet was manually delocalized within the census tract, and with 'Select Tool' and "Field Calculalor' each policy was registered in the dedicated column with their score (either [+1], or [-1], the [0] scored polices were not transferred, as well as [U] polices, as they would not affect the total score for each census tract).

One policy could have multiple census tracts scored, if it would be applied to larger than a single census tract area.

In the end, the Attribute Table of base layer with 1 column per 1 policy registered, would be done.

Next, using the 'Field Calculalor' tool the new column was created for the final score results. The sum of all columns was done, utilizing the formula:

```
array_sum(array_filter(array( "E1", "E2", "E3", "E4", "E5", "E6", "E7", "E8", "E9", "E10", "E11", "E12", "E13", "E14", "E15", "E16", "E17", "E18", "E19", "E20", ......"En". ) , @element not in (99)))
```

The formula was used, to eliminate the NULL fields in the total summary of the scores for each census tract, as the NULL value described that the census tract was not scored within specific field under policy or action, therefore, could not be considered in the total summary.

The modifications were then saved and using the 'Symbology Tool' visualized in the final map named "the PIRS™ for Heat Scorecard Map," with a unit of measurement being the net score per census tract.

PHASE II ANALYZING

In this Phase the PIRS™ for Heat methodology were adjusted to the city of Turin case specificity, mainly because of the lack of the required data within the Italian state and the city of Turin. Consequentially, 2 versions of each step in Phase 2 were explained, once applied in testing methodology and suitable for U.S. and other countries with open ready-to-use data, other, suitable for Italian case and the cities with data limitations.

For the analysis of the scorecard phase, the methodology proposes to access physical and social vulnerabilities of the case study by computing and mapping the relative data to subsequentially, compare them with scorecard data, retrieved from Phase 1.

Therefore, in the next steps were implemented the **physical vulnerability analysis**, which

STEP 04 **Physical Vulnerability**

is mainly determined via Urban Heat Island mapping or simply Land Surface Temperature mapping and **social vulnerability analysis**, which takes into consideration sociodemographic indicators for the assessment.

3.5.4. PHYSICAL VULNERABILITY ANALYSIS

It is important to note, that by general term 'physical vulnerability' the authors of the methodology mean specifically physical vulnerability for heat and therefore require spatial data on physical heat to assess it.

The assessment of physical vulnerability is an essential part of the Phase 2, by being the main tool for identifying the specific areas within the city that may be at higher risk of negative effects by heat hazards than others. From the literature review, we understood the importance of special heat assessment as well for planners and decision makers, as it could help plan more thoroughly the strategies for target interventions and hazard mitigation actions, such as creating cooling centers, green spaces and improving housing condition towards more heat resilience one (Keith & Meerow, 2022, p. 28).

THE METHODOLOGY PROPOSAL

DATA

DATA USED

Either remotely sensed land surface temperature (LST) data or UHI severity data (Keith Ladd et al., 2022, p.24).

DATA SOURCES

The Trust for Public Land; NIHHIS-CAPA UHI mapping campaign

Notes:

- The Trust for Public Land (TPL) [4] is a non-profit organization in the United States of America that works with communities to create, preserve, and protect outdoors environment, such as parks and public land of different kind. Their key activities enlist land conservation, urban greening and parks creation and policy advocacy.

[4] https://www.tpl.org/

- Urban Heat Island severity data[5] produced by TPL distributed by ESRI is 30-meter raster file that derives from Landsat 8 imagery band 10 (ground-level thermal sensor), according to ArcGIS webpage.
  The file is openly distributed and suitable for the United States territory only.

- The National Integrated Heat Health Information System (NIHHIS)
  - NIHHIS-CAPA UHI mapping campaign[6] is a volunteer-based community science field initiative organized to collect and map the Urban Heat Island data over communities within United States. Supported by CAPA Heat Watch and different partners and stakeholders, volunteers of the campaign collect temperature and humidity data using specific sensory tools. The data afterwords is collected and mapped to achieve high-resolution air temperature and humidity data with detailed analysis with it. The process combines the volunteer-done manual data collection with satellite imagery using a machine learning approach. Each year different communities are involved in the process in U.S. as well as abroad.

SOFTWARE AND TOOLS

TOOLS USED

GIS(ArcGIS) software and/or any statistical software (example: MATLAB; PYTHON; R and /or Microsoft Excel).

MAPPING

MAPPING PROCESS

For visual representation, it was important to map the results to the same census tract used in the previous step for Scorecard mapping.

The authors of the testing methodology suggested using the mean afternoon data and, by using the 'Zonal Statistics' tool in ArcGIS software, obtain the mean temperature for each district/census tract zone used for the case study.

Optionally, the results were exported as a spreadsheet and using any statistical software calculated via the Pearson correlation coefficient (Benesty et al., 2009; Mondal & Mondal, 2016), thus compared with results of Scorecard spreadsheet with net score per each census tract.

---

[5] Available via https://www.arcgis.com/home/item.html?id=339c93a11b7d4cf7b222d60768d32ae5, Credits: The Trust for Public Land, Descartes Labs, USGS
[6] https://www.heat.gov/pages/mapping-campaigns

Both methods could be used to compare Mean Afternoon Temperatures with Scorecard results, either visually as in the first case or statistically, as in the second one.

THE ADAPTATION OF THE ANALYSIS

Different approach was conducted for the Turin case study, mainly because of the data availability of the original method, as it was limited to the United States territory only. Furthermore, since the existing UHI maps for the city of Turin produced by different entities were outdated, the need for new up-to-date map of either mean land surface temperature or Urban Heat Island was defined.

Consequently, for the realization of new up-to-date map the research papers of (Abutaleb et al., 2015; Mutani & Todeschi, 2020) were taken as a base for the analysis of Land Surface Temperature (LST) and Urban Heat Island (UHI) subsequentially. Similarly, to the Urban Heat Island severity data produced by the Trust for Public Land, this method is based on remotely sensed satellite imagery, specifically on band layers of 'Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)'. The 'Landsat 8 – OLI/TIRS' satellite was chosen due to several factors positively affecting the analysis of LST, such as the microclimate conditions, cloud cover (less than 5%), the precision (30 m) and sufficient accuracy for the data processing on the city level. The 'Landsat 8 – OLI/TIRS itself consists of 9 spectral bands (United States Geological Survey, 2024) (see table 4 below), which were used for the LST calculations.

Bands	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal aerosol	0.43-0.45	30
Band 2 - Blue	0.45-0.51	30
Band 3 - Green	0.53-0.59	30
Band 4 - Red	0.64-0.67	30
Band 5 - Near Infrared (NIR)	0.85-0.88	30
Band 6 - Shortwave Infrared (SWIR) 1	1.57-1.65	30
Band 7 - Shortwave Infrared (SWIR) 2	2.11-2.29	30
Band 8 - Panchromatic	0.50-0.68	15
Band 9 - Cirrus	1.36-1.38	30
Band 10 - Thermal Infrared (TIRS) 1	10.6-11.19	100 (resampled to 30)
Band 11 - Thermal Infrared (TIRS) 2	11.50-12.51	100 (resampled to 30)

Table 4.Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) thermal bands Source: https://www.usgs.gov/faqs/what-are-band-designations-landsat-satellites#publications

According to Mutani & Todeschi (2020, p.10), the LST is the radiative temperature of land surface derived from solar radiation, however it is not the real temperature on the surface, therefore it is essential in comprehension of the land surface heat exchange processes, such as the heat absorption and release by the surface. The last, in turn, is linked to the type of land cover and the amount of vegetation present on the surface.

To calculate the LST calculation few parameters were taken, firstly the brightness temperature (BT) of the land surface, which measures how much energy the land is radiating. Thus, for BT calculation itself the Top of the Atmosphere (TOA) radiance calculation is needed, based on the band-layers from satellite imagery. Secondly, the Land Surface Emissivity (LSE) to measure how well the surface absorbs and releases the heat, which in its turn, calculated by using the Normalized Difference Vegetation Index (NDVI) and the Proportion of Vegetation (PV), that defines the percentage of green areas on the surface.

DATA

DATA USED

1. For the analysis of vegetation (NDVI) the spectrum **'band 4' (red)** and **'band 5' (near infrared (NIR))** as raster files were used, while for the analysis of LST the spectrum **'band 10'** and **'band 11'**, providing more accurate surface temperature(United States Geological Survey, 2024). Ambos derived from 'Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)' satellite.
2. For the mapping of the results permanent census data of the population (ISTAT, 2023) were used with census tracts borders layer from 2021 as a shapefile.

DATA SOURCES

The U.S. Geological Survey (USGS); The Italian National Institute of Statistics (ISTAT)

Notes:

- The U.S. Geological Survey (USGS)[7] is a governmental scientific agency within the United States Department of the Interior, that does map, research, assess and monitor natural resources and hazards of the United States and its territories. Provides open access to its data for the US government and its people.
  - The USGS EarthExplorer (EE) [8] is an online tool for satellite, aircraft, and other remote sensing data search and discovery. The tool works through an online platform with an interactive interface, which can be accessed prior to registration on the website. The data can be downloaded immediately from an online platform or by prior ordering.

DATA PROCESSING

[7] https://www.usgs.gov/
[8] https://www.usgs.gov/tools/earthexplorer

The data processing was conducted in a few steps, based on the Land Surface Temperature retrieval procedures by Mutani & Todeschi (2020, p.7; p.10-11) and Abutaleb et al. (2015, p.37-41).

SOFTWARE AND TOOLS

TOOLS USED

The USGS EarthExplorer (EE) online tool and GIS software (QGIS).

A. The acquisition of remotely sensed satellite imagery.

The first step was to search and download appropriate imagery from the web source. The step requires prior registration and login to the USGS EarthExplorer (EE) webpage.

1. Setting the criteria for download, using the 'Search Criteria' section of the toolbox:
   - In the 'Geocoder' section the studied area of Turin, Piedmont Region, Italy was chosen (this procedure could be also done using manual selection of the map via 'Polygon', 'Circle' or 'Predefined Area' tools.
   - In the 'Date Range' the range between 1st of June 2023 and 31st of August was set, as for the most recent summer period.
   - In 'Clous Cover' section the 'Cloud Cover Range' was set for 0%-2%, as for eliminating the results with excessive cloud cover, thus not eligible for Land Surface Temperature correct calculation.
2. Choosing the data set, using the 'Data Sets' section of the toolbox:
   - In the available list of data sets, the 'Landsat'-> 'Landsat Collection 2 Level-1' -> 'Landsat 8-9 OLI/TIRS C2 L1' was chosen.
3. No additional criteria were necessary, therefore after clicking the 'Results' button, in the ammoniums section from the list of data sets the hottest available[9] day was chosen for download.

The acquired file contained 11 layers each for Bandas number 1 to 11 were then processed in the next step.

B. The calculation of the Land Surface Temperature (LST).

For the calculation of LST, band 4 (red), band 5 (near infrared) , band 10 (thermal infrared) and band 11 (thermal infrared) were uploaded as raster files to the GIS software, where the 'Raster Calculator" Tool from 'Raster Analysis' category was used to do all the calculations. After each equation computed in 'Raster Calculator' a new raster file was created with appropriate to each equation name (ex.: "NDVI_21.08.2023.tif; "PV_21.08.2023.tif"), which were used for the next calculations.

Prior to the LST calculation, the necessary components of the equation were computed in advance, in the following order:

1. Calculation of the Top of Atmosphere Radiance (TOA).

[9] According to preliminary research of the methodology the hottest days in the summer 2023 in the city of Turin were during the African Heat wave between 18 and 24 of August 2023.

$$TOA(L_\lambda) = M_L \times Q_{cal} + A_L - Q_i \qquad [a]$$

where:

L_λ is the TOA spectral radiance for wavelength λ [W/(m2·srad· m)];
M_L is the band-specific (Band 10) multiplicative radiance rescaling factor from the metadata (found in file MTL for Band 10);
Q_{cal} is the quantized and calibrated pixel values (raster layer of Band 10);
A_L is the band-specific (Band 10) additive radiance rescaling factor from the metadata (found in file MTL for Band 10);
Q_i is correlation coefficient for Band 10, $Q_i = \mathbf{0.29}$

The result was saved in a raster file with a namesake title.

2. Conversion of the Top of Atmosphere Radiance (TOA) in Brightness Temperature (BT).
The at-satellite brightness temperature calculated, assuming that BT (T_b) was equal to (T_b) of a black body.

$$BT(Tb)\text{=}K2\ln(K1L\lambda\text{+}1)\text{–}273.15 \qquad [b]$$

where:

T_b is the at-satellite brightness temperature (◦C);
L_λ is the TOA spectral radiance for wavelength λ [W/(m2·srad· m)], **[a];**
$\ln$ is a natural logarithm;
$K1$ is band-specific (Band 10) thermal-conversion constants from the metadata (found in MTL file for Band 10);
$K2$ is band-specific (Band 10) thermal-conversion constants from the metadata (found in MTL file for Band 10).

The result was saved in a raster file with a namesake title.

3. Calculation of Land Surface Emissivity (LSE).
For the calculation of LSE, we first determined following:

    a. Calculation of the Normalized Difference Vegetation Index (NDVI).

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad [c]$$

where:

NIR is the near infrared wavelength (raster layer of spectral Band 5);
RED is the red wavelength (raster layer of spectral Band 4).

The result was saved in a raster file with a namesake title.

b. Calculation of the Proportion of Vegetation (PV).

$$PV(P_v) = (\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}})^2 \quad [d]$$

where:

P_v is the proportion of vegetation (-);
$NDVI$ is the Normalized Difference Vegetation Index, **[c];**
$NDVI_{min}$ is the Normalized Difference Vegetation Index minimal value (see the raster file for value);
$NDVI_{max}$ is the Normalized Difference Vegetation Index maximum value (see the raster file for value);

The result was saved in a raster file with a namesake title.

After computing the NDVI and PV, we then realized the computation for Land Surface Emissivity.

c. Calculation of Land Surface Emissivity (LSE).

$$LSE(\varepsilon) = 0.004 \times P_v + 0.986 \quad [e]$$

where:

ε is the Land Surface Emissivity
P_v is the proportion of vegetation (-), **[d];**

The result was saved in a raster file with a namesake title.

After computing the TOA, BT and LSE in point 1,2 and 3 accordingly, we proceeded to the calculation of Land Surface Temperature, using the raster files produced after each equation.

4. Calculation of Land Surface Temperature (LST).

LST = Tb/1+ $L\lambda \cdot Tb/p$ · ln(ε)

where:

T_b is the at-satellite brightness temperature (◦C), **[b];**
L_λ is the TOA spectral radiance for wavelength λ [W/(m2·srad· m)], **[a];**
ε is the Land Surface Emissivity, **[e];**
$p = \mathrm{h} \cdot \mathrm{c}/\sigma$ (1.438 × 10−2 mK),
where:

h is the Planck constant (6.626×10^{-34} Js);
σ is the Boltzmann constant (1.38×10^{-23} J/K);
c is the velocity of light (2.998×10^{8} m/s);

The result was saved in a raster file with a namesake title.

MAPPING

MAPPING PROCESS:

Similarly, to the testing methodology, the results were mapped in the GIS(QGIS) software. Using the 'Clip raster by extent' tool from 'Raster extraction' toolbox, the LST raster file was clipped to the extent of the case study area borders, in our case the limits of the city of Turin. After which, clipped LST raster file was converted to points using the 'Raster pixels to Point' tool from 'Vector creation' toolbox. The last resulted as vector point file, that contained LST data that could be transferred to census tracts net with 'Join attributes by location (summary)' tool using the *mean* values of LST. Resulting shapefile of mean Land Surface Temperature by census tract was then symbolized to best read the data from the map.

ANALYZING

ANALYZING PROCESS:

The visual comparison analysis was conducted between Urban Heat Island Map (aka Mean Land Surface Temperature map) and PIRS™ for Heat Scorecard Map (PIRS™ for Heat Net Scoremap) to identify the regions of the city where the physical vulnerability is higher while the policy score is lower, therefore understand in which areas of the city more policy attention is needed (based on physical vulnerability data).

Optionally, using any statistical software the correlation calculation between both parameters could be done, by exporting the mean LST data as a spreadsheet and comparing it with the Scorecard spreadsheet.

STEP 05 Social Vulnerability

3.5.5. SOCIAL VULNERABILITY ANALYSIS

It is important to note, that by general term 'social vulnerability' the authors of the methodology mean specifically social vulnerability for heat and therefore require spatial data on socially vulnerable population to assess it.

The social vulnerability assessment is the second parameter with which the comparison of the Scorecard results is done. As discussed in literature review, the socially vulnerable communities are at higher risk from heat hazard due to multiple factors, such as limited access to air conditioning and green spaces, pre-existing health condition or limited access to healthcare, lower quality of housing conditions with inadequate ventilation and insulation and more. All mentioned above increase the exposure of socially vulnerable population and place them at disproportional risk from heat hazards, as UHI itself. Therefore, the following analysis will help identify socially vulnerable population and geolocate them within the urban environment to further analyze the areas of the city which requires more attention from policy-makers within policy tools legislation (Keith & Meerow, 2022, p. 32).

THE TESTED METHODOLOGY PROPOSAL

The PIRS™ for Heat methodology proposed multiple ways to access the social vulnerability, through different indices available for the United States territory, where the original methodology was conducted. The possible tools that could be used for the assessment are: the U.S. Centers for Disease Control and Prevention (CDC)'s Social Vulnerability Index (SVI) (used in the testing methodology) and the U.S. Environmental Protection Agency (EPA)'s Environmental Justice Screening and Mapping Tool (EJScreen); any heat-related illnesses and mortalities data, provided by the state health departments; indoor cooling prevalence within the city and over-all housing quality – all could be used as a combination or separately for the more comprehensive analysis of the socially vulnerable communities spatially dispersed within the city (Keith Ladd et al., 2022, p. 26).

DATA

DATA USED

Social Vulnerability Index (SVI).

DATA SOURCES

The United States (U.S.) Centers for Disease Control and Prevention (CDC)

Notes:

- The U.S. Centers for Disease Control and Prevention (CDC)[10] is leading science-based service organization in the U.S. for the public health protection and an operating component of the U.S. Department of Health and Human Services.

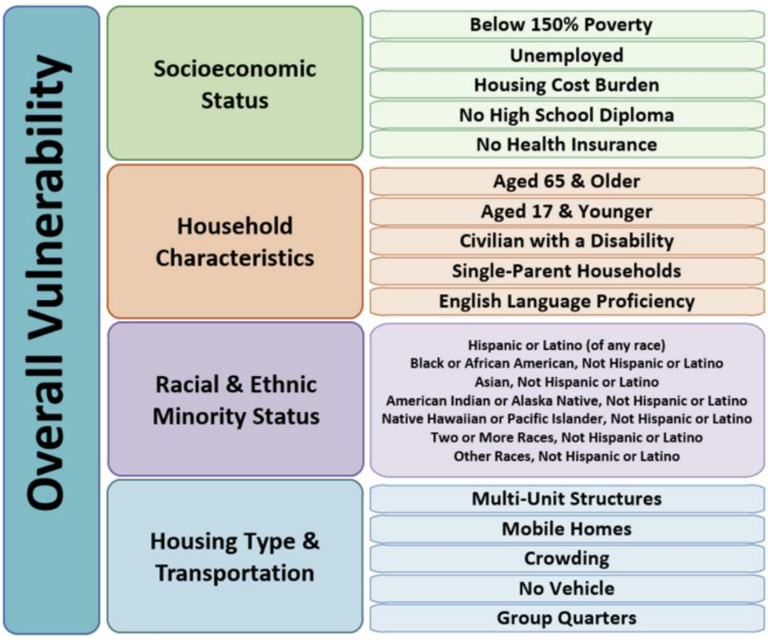


Table 5. American Community Survey (ACS), 2016-2020 (5-year) estimate data as variables for CDC/ATSDR Social Vulnerability Index (SVI). Source: www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html

[10] https://www.cdc.gov/

SOFTWARE AND TOOLS

- The U.S. Centers for Disease Control and Prevention (CDC)/Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI)[11] is a tool that combines 15 census variables on socioeconomic status, household composition and disability, minority status and language, and housing type and transportation in an index score per census tract of the U.S. cities, from 0 (lowest vulnerability) to 1(highest vulnerability (Keith Ladd et al., 2022, p. 26), (see Figure XX below).

TOOLS USED. GIS(ArcGIS) software and/or any statistical software (example: MATLAB; PYTHON; R and /or Microsoft Excel).

MAPPING **ANALYZING**

MAPPING AND ANALYZING PROCESS

The maps, used for this assessment were already in ready-to-use state, therefore the QGIS software were used only to further examine and analyses the data. The visual comparative analysis of the Social Vulnerability Index Map with the Scorecard Map was done to identify whether the selected previously actions and policies address the most vulnerable areas of the city or not.

Optionally, the statistical analysis could be done for the social vulnerability assessment to see whether areas of the city with higher social vulnerability also are those with higher policy scores. Therefore, the city addresses this specific issue, and if not, where the correlation does not match.

THE ADAPTATION OF THE ANALYSIS

Similarly to physical vulnerability assessment, the case study community did not have ready-to-use data. Therefore, some sort of interpretation of the required data was done. The PIRS™ for Heat suggested including as much data as possible; therefore, firstly, the analysis of data used for SVI and the EJScreen tool was done to understand which original data they were based on. Additionally, research for heat-related illnesses and mortality data was carried out. Thus, based on the most recent found census data per census tracts from ISTAT[12], only SVI could be interpreted and applied for the assessment.

DATA

DATA USED

Permanent census data of the population by census tracts of 2021 (ISTAT, 2023).

DATA SOURCES

The Italian National Institute of Statistics (ISTAT)

Notes:

[11] Available via https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

[12] https://www.istat.it/it/archivio/285267

- The Italian National Institute of Statistics (ISTAT)[13] is an independent public research organization that produces official statistical data for the Italian territory and provides those data to the scientific community and public organizations.

SOFTWARE AND TOOLS

TOOLS USED

Microsoft Excel and GIS (QGIS) software.

MAPPING

MAPPING PROCESS

Unlike the PIRS™ for Heat, the data needed to be processed prior to mapping and creating a social vulnerability map to proceed with the mapping process.

For that reason, the SVI was taken as an example of a collection of variables related to social vulnerability for heat.

Available census data - "Permanent census data of the population" by census tracts of 2021 of the city included data on:

- The total resident population.
- The total resident population by age group.
- The total resident population by age group and by gender.
- The total resident population (9 yr. and older) by educational level received.
- The total resident population (9 yr. and older) by educational level received and by gender.
- The total resident population (15 - 64 y.o.) by occupation.
- The total resident population (15 - 64 y.o.) by occupation and by gender.
- The Italian resident population.
- The Italian resident population by age group.
- The Italian resident population by age group and by gender.
- The Italian resident population (15 - 64 y.o.) by occupation and by gender.
- The total foreign and refugee resident population.
- The Foreigners and refugee's resident population by age group.
- The Foreigners and refugee's resident population by age group and gender.

[13] https://www.istat.it/

- The Foreigners and refugee's resident population by age group.
- The Foreigners resident population by the region of provenance (EU or Extra EU).
- The Foreigners resident population by the region of provenance (EU or Extra EU) and by gender.
- The Foreigners and refugee's resident population by age group and by occupation.
- The total resident families by number of components present in family.

Based on the data, the following categories were chosen to substitute some of the variables in SVI and, by doing so, create a separate vulnerability parameter.

Chosen data for the analysis		
Category associated	Describtion	Formulas operated in QGIS software
Socioeconomic Status	Unemployed	P1-P101-AD4-AD3
	No High School Diploma	P86+P87+P88
Household Characteristics	Aged 65 and Older	P27+P28+P29
	Aged 14 and Younger	P14+P15+P16
	Families with 5 members and	PF7+PF8
Racial and Ethnic Status	Forigners and refugees	ST1

Table 6. List of data variables chosen to be calculated, based on ISTAT census data. Source: Personal elaboration.

In the Table 6, the first column present 3 categories taken from SVI variables categorization (see Table 5); the second column present variable interpretation possible; the third column present the formulations used in QGIS software to calculate the variables based on 'Permanent census data of the population' by census tracts of 2021 dataset.

The results were then mapped, based on census tract division, and represented as Social Vulnerability Map for the studied city.

ANALYZING

ANALYZING PROCESS

The visual comparative analysis of the Social Vulnerability Index Map with the Scorecard Map was done to identify whether the selected previously actions and policies address the most vulnerable areas of the city or not.

Optionally, the statistical analysis could be done for the social vulnerability assessment, to see whereas the areas of the city with higher social vulnerability also are those with higher policy score, therefore the city addresses this specific issue, and if not where the correlation does not match.

PHASE III ADVANCING RESILIENCE

The aim of Phase III is to utilize the analytical data obtained from the research to enhance the urban heat resilience of the case study community. This phase involves the development of a series of analytical products derived from the results of the Scorecard making and the Vulnerability analysis conducted in Phase II. However, it is important to note that Phase III of the original methodology was not executed in the classical manner due to the constraints of this being a master's thesis. Instead, this phase has been included as an open question and discussion conducted in the last chapter of the study – Discussion and Conclusion.

STEP 06 Resilience through Planning

3.5.6. RESILIENCE THROUGH PLANNING

Based on the Scorecard map and Vulnerability analysis, a series of quantitative tables were produced. These tables aim to provide understandable data that can be used for future academic and/or community works. Additionally, the visual representation of the results of the study allows communities to independently evaluate them at a later stage. The intention is to facilitate an accessible platform for the city's community to engage with the data, thereby fostering a sense of ownership and proactive planning for urban heat resilience.

STEP 07 **Stories**

3.5.7. STORIES

The final step of the PIRS™ for Heat methodology involves sharing knowledge and results among different communities to foster learning and collaboration on urban resilience and heat planning. This step is intended to encourage a communal exchange of experiences and strategies, enhancing collective understanding and action. However, due to the constraints of this being a master's thesis, this step was not implemented in its entirety. The scope of community involvement was significantly limited, confined mainly to interviews with municipal representatives. While the original methodology emphasizes the importance of extensive community engagement for a comprehensive understanding and effective application of urban heat resilience strategies, this study's approach was necessarily more constrained. Consequently, the full potential of this step could not be realized, underscoring a key limitation of the research.

LIMITATIONS AND CONCLUSION

3.6. LIMITATIONS AND CONCLUSION

This research is constrained by several limitations.

- The study was conducted by a single researcher instead of a minimum of two, as recommended in the original methodology.
- Community involvement was minimal, restricted to interview with municipal representative, which limited the depth of community engagement and feedback.
- The research was constrained by data limitations as outlined in the introduction, affecting the comprehensiveness of the analysis.

These limitations highlight the challenges faced in fully implementing the methodology and suggest areas for improvement in future research.

In conclusion, this chapter started with the research problem and question restatement, followed by the argumentation of methodological approaches used, framed based on testing methodology the "Plan Integration for Resilience Scorecard™ (PIRS™) for Heat" as well as states why certain adjustments were implemented to the original method in order to fit the case study of Turin. Subsequentially, the research structure was described, with its sections, phases and steps.

In the following chapter, the results of the presented methodology over the case study – the city of Turin will be presented using comparative and statistical tools.

CHAPTER IV

In this chapter, are presented the findings of the PIRS™ for Heat approach, when applied to the city of Turin in Italy. The initial assessment of the city, together with the vulnerability analysis and the presentation of the Scorecard results, identifies the main challenges but also underlines the limitations of transferring the method to the Italian context, providing valuable insights for future discussion.

4. CHAPTER IV: RESULTS (CASE STUDY). THE CITY OF TURIN ASSESSMENT THROUGH THE PIRS™ FOR HEAT METHODOLOGICAL TOOL

The city of Turin provides an intriguing case study for evaluating heat mitigation policies and urban heat resilience planning using the PIRS™ for Heat approach. With its distinctive urban design and historical significance, Turin offers valuable insights into addressing urban heat islands and implementing effective strategies within the city planning system.

This chapter will examine the specific findings of the PIRS™ for Heat methodology application within the city of Turin, exploring the cities heat vulnerability and potential opportunities to enhance the city's urban heat resilience planning.

It aims to investigate how effectively this methodology can be utilized as a policy transfer tool to address the Urban Heat Island effect in Turin, delving into its unique context and seeking insights regarding UHI planning in the city. To achieve the aim, we have outlined **research objectives** that were met by **first assessing the contexts of the city and analyzing the current planning framework** with a focus on areas receiving significant policy attention **(1)**, after which **evaluating the city's heat exposure and social vulnerability to heat (2)**, and eventually, spatially analyzing results from implementing policy tools.

4.1. EVALUATION OF TURIN'S PLANNING FRAMEWORK THROUGH PIRS™ FOR HEAT

4.1.1. PRELIMINARY ANALYSIS

Urban fabric. The city of Turin is in the capital of the Piedmont region northwest of the Italian peninsula, with the total population of the city being approximately 847 398 as of 1st of January 2023; the city is considered the 4-the most populated city in Italy after Rome, Milan, and Naples (ISTAT, 2023).

Turin, with a history stretching back to the depths of ancient Roman civilization, has witnessed a complex evolution marked by shifting sovereignties from the Roman Empire to the Duchy of Savoy and subsequently to the Kingdom of Italy. This rich history has led to the present-day city, which is a composite of many influences where history and contemporary life are combined, thus giving the city a rich cultural and urban character, bringing cultural diversity and a distinctly urban atmosphere to Turin. The city is also known for its industrial past, particularly in the automotive sector, with factories and manufacturing plants that had a significant impact on the development of modern Turin.

Climate. The city of Turin, situated in northern Italy, demonstrates a mild continental climate (Köppen: Cfa), typified by cold, dry winters and warm, humid summers. This climate is significantly influenced by Turin's geographic location within the Po River Valley and its proximity to the surrounding Alps, which alter air circulation patterns and create distinctive microclimates across the urban area (Comune di Torino, 2022b; ISTAT, 2024).

The interplay between Turin's geographic features, such as its location in the Po River Valley and proximity to the Alps, and the urban environment creates conditions that foster the Urban Heat Island effect. This phenomenon leads to the city's temperature remaining elevated compared to the surrounding rural areas, particularly during the summer months.

This climate analysis provides foundational insights into temperature trends, precipitation variations, and their broader implications, essential for understanding and addressing the UHI effect in Turin.

Temperature Trends and Variations Over Recent Years. The city of Turin has shown a discernible warming trend over recent decades, with both maximum and average temperatures reflecting an upward trajectory(Comune di Torino, 2020b; PIANO STRATEGICO DELL'INFRASTRUTTURA VERDE (GREENPRINT), 2020). Between 1951 and 2019, average temperatures increased most prominently in summer and autumn, suggesting the impact of global climate change on seasonal weather patterns (Comune di Torino, 2020a). In the last two decades, maximum summer temperatures rose by approximately 5°C, leading to an increased number of "summer days" with temperatures above 25°C, while the frequency of frost days has declined, mirroring regional and global warming trends (Comune di Torino, 2020b).

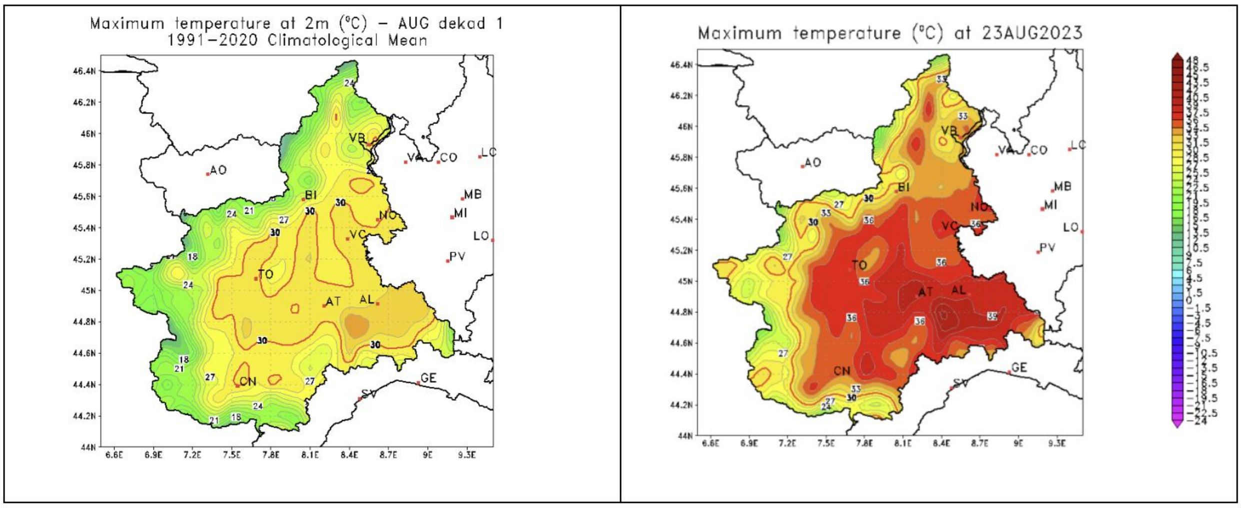


Figure 14. Maximum temperatures at 2 meters for the third decade of August averaged in the 1991-2020 thirty-year period on the left, and on the right, the maximum temperatures at 2 meters on August 23, 2023. Source: The meteorological network of ARPA Piemonte. (2023b)

Year 2022 marked a year of significant temperature anomalies, with a historic high of 39.6°C recorded on July 25, establishing the hottest day on record in Turin's climate history (Arpa Piemonte, 2022). During this period, the city recorded a peak apparent temperature of 40.3°C, indicating extreme heat stress conditions that compounded the UHI effect. The intense heatwaves experienced throughout 2022 amplified the city's vulnerability, with prolonged periods of high temperatures exacerbating the stress on infrastructure and public health systems.

Year 2023. In 2023, Turin continued to experience heightened summer temperatures, with an average summer temperature of 19.6°C, exhibiting a thermal anomaly of 1.1°C relative to the 1991-2020 climate baseline (ARPA Piemonte, 2023a). This year ranked as the seventh warmest summer on record in Turin's climate archive, spanning 66 years, underscoring a trend of frequent heatwaves and extreme temperatures. Notably, the second heatwave of the season, occurring between August 19 and 24, recorded peak temperatures of over 40°C, comparable to the notable heatwave of August 2003 (ARPA Piemonte, 2023b). Such data point to an intensifying heatwave season, marked by extreme values and prolonged high-pressure systems of African origin, which are reshaping the city's thermal landscape.

Year 2024. Although 2024 did not set new records in maximum temperatures, it ranks among the top three hottest summers historically, indicating a continued trend of elevated seasonal temperatures. This year's anomaly extended to precipitation patterns, where rainfall extremes increased, with multiple days classified under physiological discomfort levels due to apparent temperatures exceeding 27°C. Notably, Turin registered 12 days with considerable heat stress, highlighting the need for adaptive measures to address UHI impacts as part of urban climate resilience efforts (ARPA Piemonte, 2024).

Precipitation Patterns and Extremes. Despite relatively stable annual average rainfall, Turin has witnessed an escalation in intense rainfall events, particularly during the summer and autumn seasons (Comune di Torino, 2020b, 2020a; PIANO STRATEGICO DELL'INFRASTRUTTURA VERDE (GREENPRINT), 2020; Regione Piemonte, 2021). This shift towards heavier rainfall, interspersed with longer dry spells, signals a trend toward extreme weather patterns that could have implications for flood risk management and urban planning.

Year 2022: In 2022, precipitation patterns mirrored the broader trend of decreased rainy days but intensified rainfall, contributing to periodic urban flooding and water management challenges ((Comune di Torino, 2022a). The cumulative effect of fewer but heavier rainfall events is reshaping the region's hydrological dynamics, impacting stormwater infrastructure and urban resilience planning.

Year 2023: The summer of 2023 recorded several high-intensity rainfall events alongside extreme heat, with thunderstorms that caused flooding in various parts of Turin. This year underscores a dual risk of heatwaves and intense rainfall, illustrating how changing climate patterns are creating complex challenges for urban centers like Turin (ARPA Piemonte, 2023a).
occurring between August 19 and 24, recorded peak temperatures of over 40°C, comparable to the notable heatwave of August 2003 (ARPA Piemonte, 2023b). Such data point to an intensifying heatwave season, marked by extreme values

and prolonged high-pressure systems of African origin, which are reshaping the city's thermal landscape.

Year 2024: In 2024, Turin broke precipitation records during the summer, with substantial rainfall intensifying urban flood risks. While the temperature did not reach new highs, these concurrent rainfall extremes have underscored the need for adaptive measures within urban planning frameworks to enhance flood resilience, as the trend towards less frequent but more intense rain events continues (Comune di Torino, 2024).

Influencing Factors on Climate and UHI. Turin's geographic positioning within the Po Valley, encircled by the Alps, significantly influences the local climate. The Alps act as a natural barrier, modifying airflows and precipitation patterns, which contribute to Turin's distinct microclimates. These microclimates play a role in intensifying the Urban Heat Island (UHI) effect, especially in densely built areas with limited green space (Comune di Torino, 2020b; ISTAT, 2024). The extensive use of concrete and asphalt exacerbates heat retention, amplifying daytime heat and impeding nighttime cooling, which heightens the city's vulnerability to heat waves.

Turin's Heat waves records:

2022 Heat Waves in Turin

- **Strongest heat wave on July 20 – July 25, 2022**: Marked by intense heat, reaching a historic high of **38.2°C** on July 25, the hottest recorded day in Turin. The highest minimum apparent temperature (27.9°C) was also observed on July 20.
- **Overall Duration**: Seven distinct heatwaves were observed between May 15 and September 30, with 97 of the 139 days experiencing above-normal heat stress conditions. These events contributed to increased mortality among older residents (age 65+).

2023 Heat Waves in Turin

- **July 18 – July 19, 2023**: A prolonged heatwave period, caused by high-pressure conditions, particularly impacted western mountainous areas in Piedmont. Turin recorded a maximum temperature of 36.1°C on July 19, along with increased thermal discomfort.
- **Strongest heat wave on August 19 – August 24, 2023**: One of the most severe heatwaves of the year, due to a high-pressure system originating from Africa. On August 23, temperatures reached 37.9°C over all, with the Nizza Monferrato district recording an extreme 40.9°C.

2024 Heat Waves in Turin

- **Strongest heat wave on July 29 – August 2, 2024**: Though 2024 did not surpass past temperature records, this heatwave period was notably intense, contributing to significant mortality among residents aged 65 and over, especially during the last three days of July.
- **Summer Season Summary**: While 2024's summer temperatures didn't break records, it was still one of the hottest summers on record for Turin.

HEAT WAVES IN THE CITY OF TURIN BETWEEN 2022-2024 YEARS.				
year/	NUMBER OF DAYS WITH INTENSE HEAT	NUMBER OF HEAT WAVES	PERIODS	MAX REGISTERED TEMPERATURES
2022	83	7	1. From 15 to 30 May 2. From 2 to 9 June 3. From 12 to 23 June 4. From 2 to 28 July 5. From 3 to 13 August 6. From 25 August to 1 September 7. From 4 to 18 September	38,2°C on 25th of July
2023	62	6	1. From 26 to 30 June 2. From 8 to 13 July 3. From 15 to 22 July 4. From 11 to 28 August 5. From 2 to 22 September 6. From 27 to 30 September	37.9°C on 23th of August
2024	16	3	1. From 29 July to 2 August 2. From 6 to 13 August 3. From 28 August to 1 September	35.3°C on 12th of August

Table 7. Summary of the Heat Waves detected in the city of Turin during summers of 2022, 2023, 2024. Source: Personal elaboration, based on Arpa Piemonte (2022),(2023a).

HEAT MORTALITY AND SOCIAL VULNERABILITY

Heat Mortality 2022: In the summer of 2022, Turin recorded a total of 3,662 deaths, with 91% occurring among residents over 65 (Arpa Piemonte, 2022). Excess mortality analyses attributed a substantial number of deaths to heat-related conditions, particularly during prolonged heatwaves. This mortality data provides critical insight into the human impact of elevated temperatures, reinforcing the necessity of focused interventions for elderly residents.

Heat Mortality 2023: The year 2023 continued to underscore the impact of high temperatures on mortality, with similar trends observed. Between August 19 and 24, the heatwave led to record mortality rates, emphasizing the heightened vulnerability of Turin's aging population during extreme weather conditions (Arpa Piemonte, 2023).

Heat Mortality 2024: In 2024, another significant heatwave between July 28 and August 4 was associated with increased mortality among the over-65 age group. This trend reaffirms the critical importance of targeted measures to mitigate heat stress among the city's vulnerable populations.

TURIN'S GREEN INFRASTRUCTURE: A SUSTAINABLE APPROACH

The city of Turin stands out within Italy, boasting the highest percentage of public green areas. According to the Strategic Plan for Green Infrastructure (Comune di Torino, 2022a), 37% of the city's total area, equivalent to 48 km^2, consists of green spaces. This translates to 55.43 m^2 of greenery per inhabitant, and an impressive 85% of the population resides in areas with more than 25 m^2 of green space per inhabitant within 300 meters of their residence. This commitment to green infrastructure positions Turin as a city actively fostering sustainable living spaces to address the challenges of changing climatic patterns.

Assessing the Cooling Effects. The existing vegetation and reduced soil sealing in Turin contribute to a current cooling effect of 0.65 °C, mitigating the Urban Heat Island effect. Furthermore, the study by Lauwaet et al. (2024), suggests that if optimal greening and soil unsealing strategies were fully implemented, Turin could achieve an additional cooling effect of 0.41 °C. This indicates that while Turin is already benefiting from current measures, there is still significant potential for further cooling through enhanced vegetation and soil unsealing.

The climate analysis of Turin reveals a **consistent trend towards warmer**, more extreme summers and increasingly erratic precipitation patterns. These shifts present **pressing challenges for urban resilience planning**, particularly in addressing the UHI effect. The city has demonstrated a commitment to investing in green infrastructure and urban greening initiatives, which have generated measurable cooling effects.

4.1.2. FRAMEWORK OVERVIEW AND SELECTION RESULTS

The literature review outlined the overarching planning framework in Italy, which follows a top-down approach. This framework is primarily guided by national-level legislation, such as the New Building Code and various sustainability strategies. The Urban General Plan emerged as the primary binding planning instrument for local authorities, providing a framework for the city's development, including land use zoning, transportation networks, and urban infrastructure. This gave us a preliminary understanding of the planning context in Turin.

The primary planning tool in Turin is the General Municipal Plan, which holds a binding legal status and provides the city's development framework, encompassing zoning, transportation, and urban infrastructure. In contrast, the other plans examined in this research, including hazard mitigation, climate action, and climate adaptation strategies, are non-binding in nature.

For this research, the focus was specifically on analyzing the city's climate adaptation and hazard mitigation plans, or any other relevant to the Heat Resilience plans, to evaluate how they addressed the Urban Heat Island phenomenon and related heat vulnerability in the city.

Based on **the 6 categories** identified as a guideline of the PIRS for Heat, the following policy tools were selected for the analysis (Table 8).

First selection of community plans of the city of Turin for heat mitigation classification				
N	***Plan Types according to the PIRS™ for Heat***	***Considerations according to the PIRS™ for Heat***	***Plan Name in English and in original language***	***Abbreviation***
I	Comprehensive or general plan	Typically the leading plan guiding future land use and development in a community and is typically important to include.	General Municipal Master Plan of Turin *Piano Regolatore Generale Comunale di Torino*	PRG
II	Hazard mitigation plan	Because of FEMA requirements, most communities have a hazard mitigation plan to reduce the risk of disasters. Heat is one hazard that may be addressed.	Action Plan for Sustainable Energy and Climate *Piano d'Azione Per l'Energia Sostenibile e il Clima*	PAESC
III	Climate action plan	Developed by many communities to address climate change, can include heat mitigation strategies and policies with co-benefits (e.g., promoting alternative forms of transportation).	Action Plan TORINO 2030 *Plano d'Azione TORINO 2030*	-
IV	Climate change adaptation, resilience, or sustainability plan	Some communities have developed these plans which may address heat directly, and even when they do not, many may include policies with heat mitigation co-benefits (e.g., green infrastructure)	Climate Resilience Plan *Piano di Resilienza Climatica*	-
V	Functional plan (e.g., parks and recreation, transportation, green infrastructure)	Communities develop many other functional plans that may contain policies that increase or decrease urban heat. Review the categories of policies and consider which functional plans (if any) are most relevant.	Strategic Plan for Green Infrastructure *Piano Strategico dell'Infrastruttura Verde*	GREENPRINT
			Urban Plan for Sustainable Mobility *Piano Urbano Della Mobilita Sostenibile*	PUMS
VI	Small area or neighborhood plans	Small area or neighborhood plans may contain spatially explicit policies that would affect heat risk and, therefore could be relevant, but including them may be too time-intensive.	No plan was chosen	

Table 8. First selection of community plans of the city of Turin for THE PIRS™ for Heat application. Source: Personal elaboration, based on Keith Ladd et al., p.14.

POLICIES AND PLANS ADDRESSING HEAT-RELATED CHALLENGES IN TURIN. Overview.

NAME OF THE PLAN: **Piano Regolatore Generale Comunale di Torino (PRG)**

NAME IN ENGLISH: General Municipal Master Plan of Turin (PRG)

YEAR OD ADOPTION: 1995

DESCRIBTION:

The General Municipal Master Plan of Turin is the primary legal and binding urban planning instrument that outlines the long-term spatial development of the city, addressing land use, transportation, and infrastructure(Piano Regolatore Generale Di Torino, Relazione Illustrativa - Volume I: Descrizione Del Piano, 1995). Due to the outdated and no longer relevant nature of the existing plan, a new Technical Proposal of Preliminary Project (Proposta Tecnica di Progetto Preliminare - PTPP) has been developed to incorporate updated goals, strategies, and principles focused on sustainability and resilience for the future edition of the General Municipal Master Plan of Turin(Torino Cambia, n.d.), expected to be issued in the coming years.

Figure 15. Planning tool card: General Municipal Master Plan of Turin. Source: Personal elaboration based on General Municipal Master Plan *(Piano Regolatore Generale Di Torino, Relazione Illustrativa - Volume I: Descrizione Del Piano, 1995)and Torino Cambia (Torino Cambia, n.d.).*

NAME OF THE PLAN: **Piano d'Azione Per l'Energia Sostenibile e il Clima(PAESC)**

NAME IN ENGLISH: Action Plan for Sustainable Energy and Climate

YEAR OD ADOPTION: 2023

DESCRIBTION:

The non-binding Action Plan for Sustainable Energy and Climate outlines a comprehensive strategy that integrates both mitigation and adaptation measures. It encompasses actions such as improving energy efficiency, adopting LED technology, and promoting alternative modes of transportation. Going beyond the initial TAPE plan, PAESC demonstrates a stronger emphasis on climate change adaptation. The plan's 68% reduction target is informed by factors like energy consumption trends, the National Integrated Plan for Energy and Climate, and the CO2 absorption potential of urban greenery. Spanning various sectors, the PAESC commits to integrating initiatives across domains like energy, waste, transportation, and smart city development, aligning with the city's pursuit of becoming a "Climate Neutral and Smart City" within the European mission(Comune di Torino, 2023).

Figure 16. Planning tool card: Action Plan for Sustainable Energy and Climate. Source: Personal elaboration based on Comune di Torino (2023).

NAME OF THE PLAN: **Plano d'Azione TORINO 2030**

NAME IN ENGLISH: Action Plan TORINO 2030

YEAR OD ADOPTION: 2019

DESCRIBTION:

The non-binding "Torino2030" plan emphasizes prioritizing citizen well-being and quality of life, pursuing a positive balance across social, economic, and environmental dimensions. It acknowledges the city's historical transformations and aims to continue its development by cultivating a dynamic urban environment that addresses the evolving needs of its residents. The plan is centered on inclusivity, prioritizing fundamental rights such as housing, health, employment, food, culture, and a clean environment. It delineates critical areas for development, including fostering a participatory city, a livable city with a focus on green spaces and accessibility, and a solidary city that upholds citizens' rights and promotes social inclusion (TORINO 2030. PIANO D'AZIONE, 2019).

Figure 17.Planning tool card: Action Plan TORINO 2030. Source: Personal elaboration based on TORINO 2030. PIANO D'AZIONE (2019).

NAME OF THE PLAN: **Piano di Resilienza Climatica**

NAME IN ENGLISH: Climate Resilience Plan

YEAR OD ADOPTION: 2020

DESCRIBTION:

The non-binding Climate Resilience Plan establishes a comprehensive local adaptation strategy to address the vulnerability of both the geographic area and the population, safeguarding their health, well-being, and the city's livability. It prioritizes the needs of the most vulnerable individuals within the city's climate policy framework. Ratified by the local executive body, the plan identifies critical regional vulnerabilities and proposes approximately 80 short-term and long-term adaptation measures. These measures aim to mitigate the impacts of climate change, with a specific focus on heat waves and floods. Additionally, the plan includes monitoring indicators for each proposed action, and services are committed to conducting annual assessments to integrate the plan into sectoral strategies, operational planning, and investment programming, ensuring ongoing resilience to climate-related vulnerabilities (Comune di Torino, 2022b).

Figure 18. Planning tool card: Climate Resilience Plan. Source: Personal elaboration based on .Comune di Torino (2022b).

NAME OF THE PLAN: **Piano Strategico dell'Infrastruttura Verde (GREENPRINT)**

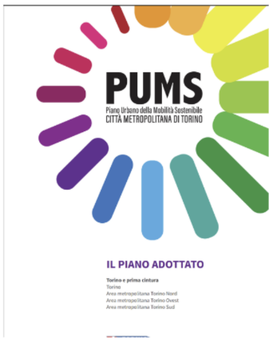
NAME IN ENGLISH: Strategic Plan for Green Infrastructure

YEAR OD ADOPTION: 2021

DESCRIBTION:

The non-binding Strategic Plan for Green Infrastructure provides a comprehensive assessment and strategic planning framework for enhancing and managing the public urban green system in Turin over the coming decades. The plan offers an in-depth examination of Turin's urban greenery, identifying strengths, weaknesses, and opportunities, and outlining medium to long-term strategies and actions to guide investment in new projects and maintenance interventions. It employs two main analytical approaches: the "greenprint," which offers quantitative and qualitative analysis of the entire public green system, and a quantitative and economic evaluation of the ecosystem services generated by the city's green infrastructure. The plan also addresses the role of public green spaces in emergency management and explores diverse approaches to green care and public-private partnerships (Comune di Torino, 2022a).

Figure 19. Planning tool card: Strategic Plan for Green Infrastructure*. Source: Personal elaboration based on* Comune di Torino (2022a)*.*



NAME OF THE PLAN: **Piano Urbano Della Mobilita Sostenibile (PUMS)**

NAME IN ENGLISH: Urban Plan for Sustainable Mobility

YEAR OD ADOPTION: 2022

DESCRIBTION:

The non-binding Urban Plan for Sustainable Mobility outlines seven interconnected priority strategies associated with themes that comprehensively address various mobility components. It incorporates time-bound scenarios and periodic assessments to evaluate the impacts of its implementation. As a flexible plan with an approximately 10-15 year timeline, the PUMS allows for the integration of actions and measures over time, provided they align with its underlying principles. The plan encompasses strategic interventions, with a focus on constructing key transportation infrastructures such as completing the railway bypass and expanding metro lines. Furthermore, it includes widespread measures emphasizing improved accessibility, safety, and environmental considerations for urban spaces, in addition to managerial actions influencing the utilization of mobility services and traffic regulation(Città Metropolitana di Torino, 2023).

Figure 20. Planning tool card: Urban Plan for Sustainable Mobility*. Source: Personal elaboration based on* Città Metropolitana di Torino (2023)*. From the five scenarios present in the plan for this research, only 'The plan scenario' (PRG) was considered, as it is obtained by recombining the actions from individual first-generation scenarios that have proven to be more effective in achieving the plan's objectives (PUMS, 2022) and based on the significant number of actions included within it in comparison with other scenarios*

UNDERSTANDING THE CONNECTIONS BETWEEN SELECTED PLANS

All the plans aim to improve Turin's sustainability, resilience, and livability through urban mobility, green infrastructure, climate resilience, and energy management. Understanding of their connections between each other was crucial to understand the framework and the coordination between them.

1. **The General Regulatory Plan (PRG)**: serves as a broad framework, guiding land use, zoning, and long-term urban development. Each of the corresponding plans has projects and actions that contribute to PRG's goals of urban sustainability, climate resilience, and livable public spaces. In the following context, **the REVISION of the General Regulatory Plan** was analyzed.
2. **Strategic Plan for Green Infrastructure:**

- This plan aligns with the PRG by setting a framework for managing and expanding green infrastructure. The PRG supports creating ecological zones and prioritizing high-value ecological areas, enhancing connectivity and renaturalization in urban planning (Sugoni, 2022).
- The strategic green plan specifically references the PRG in designating areas for ecological corridors, prioritizing urban reforestation, and ensuring that any development within these zones complies with green space preservation standards set by the PRG (Comune di Torino, 2022a).

3. Climate Resilience Plan:
    - The PRG is referenced in the Climate Resilience Plan in relation to soil management, where it is critical for maintaining permeability and reducing urban heat island effects. The PRG sets standards for impermeable surface limits and promotes green infrastructure, which this resilience plan integrates to mitigate climate risks(Comune di Torino, 2022b).
    - The PRG also plays a role in defining climate-adaptive building standards, encouraging "climate-proof" construction practices, such as green roofs and walls, which the Resilience Plan emphasizes to handle urban temperature increases and flood risks (Comune di Torino, 2022b).
4. Piano d'Azione TORINO 2030:
    - The PRG supports this plan's goals of sustainable and equitable urban development by prioritizing mixed-use neighborhoods, accessible green spaces, and active public spaces. The PRG revision emphasizes the creation of "complete neighborhoods" that support both housing and commercial needs, aligning with the TORINO 2030's aim for a more participatory and interconnected urban community (TORINO 2030. PIANO D'AZIONE, 2019).
    - In promoting proximity-based urbanism, the PRG complements TORINO 2030 by setting spatial guidelines for vibrant, walkable areas with accessible services and public spaces within every neighborhood(TORINO 2030. PIANO D'AZIONE, 2019).
5. Piano Urbano della Mobilità Sostenibile (PUMS):
    - The PRG contributes to the Sustainable Urban Mobility Plan by facilitating sustainable mobility infrastructure, including expanding pedestrian and cycling pathways. The PUMS and PRG jointly aim to reduce car dependency by prioritizing public transport, cycling, and walkability in urban design (Città Metropolitana di Torino, 2023)
    - There is also a collaborative focus on reducing greenhouse gas emissions, where PRG zoning and transport planning intersect with PUMS objectives to integrate eco-friendly transport solutions across city infrastructure (Città Metropolitana di Torino, 2023).

6. **Piano d'Azione per l'Energia Sostenibile e il Clima (PAESC)**:
   - The PRG collaborates with PAESC in aligning land-use planning with climate and energy policies, supporting renewable energy and energy efficiency in building and urban designs. The PRG mandates regulations for new buildings to incorporate sustainable practices, such as passive solar designs, which PAESC promotes for achieving emission targets (Comune di Torino, 2020a).
   - PAESC also depends on the PRG's guidelines for managing urban heat islands through increased green cover and permeable materials in new developments, enhancing environmental sustainability in line with climate action goals (Sugoni, 2022).

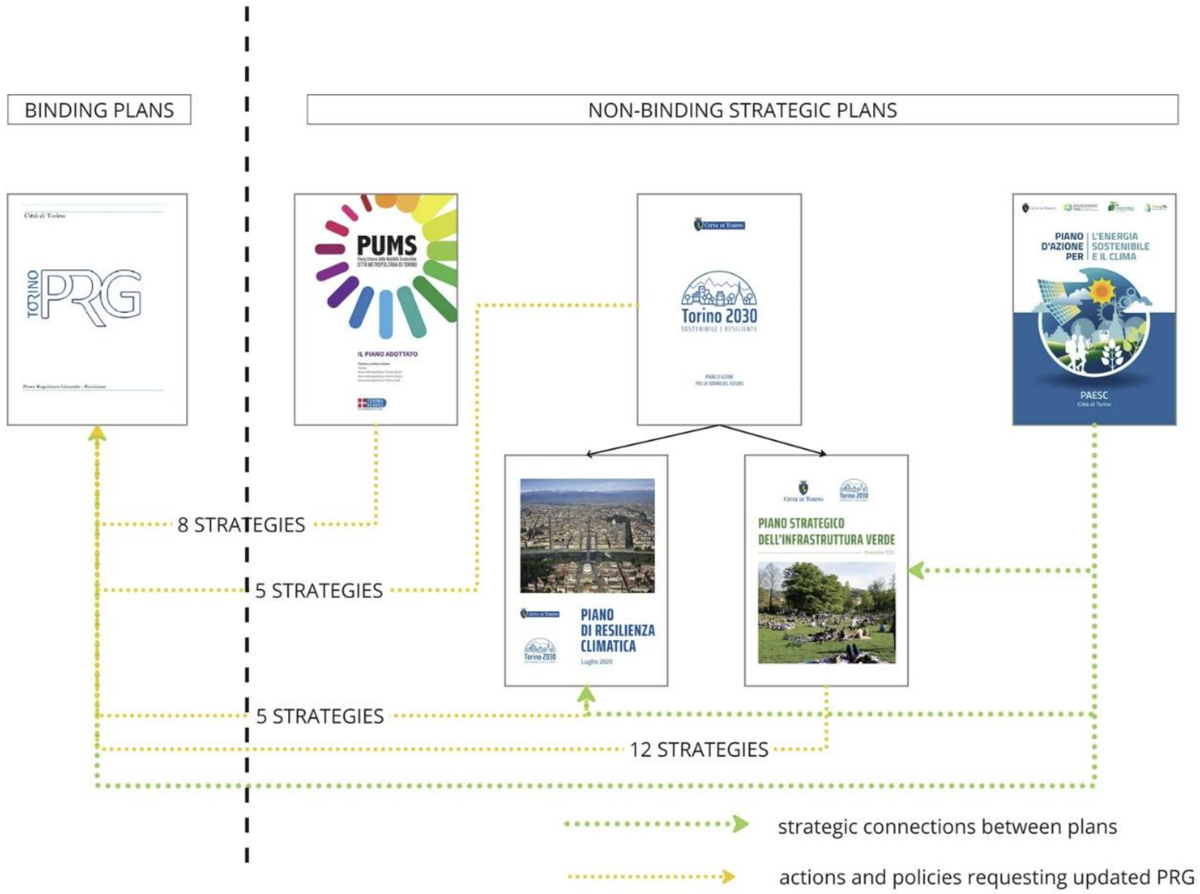


Figure 21. Illustration of the connection between Turin's plans through their strategies and actions. Source: Personal elaboration based ona thorough literature review (Città Metropolitana di Torino, 2023; Comune di Torino, 2020b, 2020a, 2022a, 2022b, 2023; Piano Regolatore Generale Di Torino, Relazione Illustrativa - Volume I: Descrizione Del Piano, 1995; PIANO STRATEGICO DELL'INFRASTRUTTURA VERDE (GREENPRINT), 2020; TORINO 2030. PIANO D'AZIONE, 2019; Sugoni, 2022)

Cross-Plan Actions and Strategies:

The various urban plans and initiatives showed some degree of integration, with their respective strategies and policies demonstrating alignment and interconnectedness.

For instance, actions within the climate resilience and green infrastructure plans, such as the installation of rain gardens, green roofs, and permeable surfaces, directly address issues of urban heat and flooding, indicating a coordinated approach to tackling these challenges. This suggests a cohesive planning framework where the plans are designed to complement and reinforce each other's objectives and strategies.

These integrations illustrate how the PRG acts as a foundation across urban planning initiatives with other plans being the considerable strategies to address UHI issue.

FIRST SELECTION PROCESS RESULTS

After the first overview, according to the PIRS™ for Heat methodology, only related, actualized plans could be included in the analysis. Therefore, the PRG was noted to be eliminated because of its dated issue and, together with the new Technical Proposal, because of the plan's general strategic essence.

Thus, The Action Plan TORINO 2030 was noted to be eliminated as it is structured as a strategy-driven document with no specific action but overall strategic development recommendations. Nevertheless, other plans, such as the Climate Resilience Plan and Strategic Plan for Green Infrastructure, are considered derivates from the TORINO 2030 strategic plan, thus being included in the further analysis.

Final selection of community plans of the city of Turin for heat mitigation classification				
N	***Plan Types according to the PIRS™ for Heat***	***Considerations according to the PIRS™ for Heat***	***Plan Name in English and in original language***	***Abbreviation***
II	Hazard mitigation plan	Because of FEMA requirements, most communities have a hazard mitigation plan to reduce the risk of disasters. Heat is one hazard that may be addressed.	Action Plan for Sustainable Energy and Climate *Piano d'Azione Per l'Energia Sostenibile e il Clima*	PAESC
IV	Climate change adaptation, resilience, or sustainability plan	Some communities have developed these plans which may address heat directly, and even when they do not, many may include policies with heat mitigation co-benefits (e.g., green infrastructure)	Climate Resilience Plan *Piano di Resilienza Climatica*	-
V	Functional plan (e.g., parks and recreation, transportation, green infrastructure)	Communities develop many other functional plans that may contain policies that increase or decrease urban heat. Review the categories of policies and consider which functional plans (if any) are most relevant.	Strategic Plan for Green Infrastructure *Piano Strategico dell'Infrastruttura Verde*	GREENPRINT
			Urban Plan for Sustainable Mobility *Piano Urbano Della Mobilita Sostenibile*	PUMS

Table 9. Plans passed the first selection to be included in the PIRS™ for Heat methodological application. Source: personal elaboration.

———————————————————————————————

NOTE: During the interview (see ANNEX III), Report with representatives of the municipality of Turin, the plans from the selection process and the PIRS™ for Heat methodology were presented. This was to receive feedback and approval on the final list of plans to be assessed. The central planning instrument of Turin, the General Municipal Master Plan, along with the Technical Proposal for a new master plan and the Action Plan TORINO 2030, were confirmed to be excluded from the assessment list.

———————————————————————————————

PLANS SELECTED FOR THE METHODOLOGY APPLICATION:

The final list of plans assessed with the PIRS™ for Heat methodology in the city of Turin includes:

1. The Action Plan for Sustainable Energy and Climate (PAESC) consists of 37 mitigation actions and 30 adaptation strategies, for a total of 68 analyzed (ANNEX I).
2. The Climate Resilience Plan consists of 40 heat-related actions and 37 Flood actions, for a total of 77 actions analyzed (ANNEX I).
3. Strategic Plan For Green Infrastructure (GREENPRINT) consists of 25 actions analyzed. (ANNEX I).
4. Urban Plan For Sustainable Mobility (PUMS) consists of 400 total plans, within which 149 plans falling into the PRG scenario and within the municipality of Turin administrative limits were considered for the analysis. (ANNEX I)

THE *"THREE-POINT TEST"* SELECTION RESULTS:

After the first round of analysis, the plans were filtered through the "Three-Point Test" selection process:

Plan Name in English and in original language	***Abbreviation***	***Total number of actions***	***Number of Heat related actions***	***Number of actions passed "Three-point Test"***
Action Plan for Sustainable Energy and Climate Piano d'Azione Per l'Energia Sostenibile e il Clima	PAESC	**68**	**48**	**20**
Climate Resilience Plan Piano di Resilienza Climatica	-	**77**	**45**	**0**
Strategic Plan for Green Infrastructure Piano Strategico dell'Infrastruttura Verde	GREENPRINT	**25**	**17**	**0**
Urban Plan for Sustainable Mobility Piano Urbano Della Mobilita Sostenibile	PUMS	**149***	**107**	**90**

***Total number of actions considered only for the city of Turin and within PRG scenario**

Table 10. Plans actions analysis through the lens of 'Three-Point Test' of the PIRS™ for Heat method. Source: personal elaboration.

EXCLUDED. From the four plans selected, only two passed the "Three-Point Test" as none of the actions within the Climate Resilience Plan, and GREENPRINT met the 'place-based' criteria of the approach and were excluded from the following analysis (ANNEX II).

NOTE: It is important to note that even if the Climate Resilience Plan and GREENPRINT didn't pass the "Three-Point Test," they did have a 44 out of 77 and 17 out of 25 heat-related policies accordingly.

SELECTED PLANS. The two plans that passed the "Three-Point Test" and were fully evaluated using the PIRS™ for Heat methodology are: the Action Plan for Sustainable Energy and Climate and the Urban Plan for Sustainable Mobility, were further analyzed through the PIRS™ for Heat framework.

Therefore, 110 actions were identified for inclusion in the analysis: 20 actions and policies from PAESC and 90 actions from PUMS.

4.1.3. POLICY ANALYSIS RESULTS

110 polices in total were scored, where:

- 85 policies (77.3%) were scored as +1.
- 4 policies (3.6%) were scored as -1.
- 21 policies (19.1%) were marked as Unknown due to incomplete details.

From the PUMS plan, only 4.4% of actions (4 out of 90) received a score of -1, as they consist of the new development of private transportation ways around the city and, consequentially, the amount of impervious surface. Thus, 16.7% of actions (16 out of 90) were scored as Unknown, as they consist of new public and private transportation parking lots, where the aim was to introduce interchangeable parking, but there were no specifications on which kind of surface planned to use.

The remaining 78.9% of actions receive a score of +1, as they are mainly designed to promote new or update existing public transportation ways with lower or zero carbon emissions and permeable surfaces.

Only two actions from the PAESC plan received an Unknown score. One was constructing a new parking lot to promote interchangeability and, therefore, accessibility of public transportation, with no specific mention of materials planned to be used.

The rest of the actions got the score +1, meaning that they decreased the UHI effect with a wide range of actions, from energy requalification of districts to reforestation interventions to tree management and new public green spaces.

Policy Tool Categorization. The scored policies were also categorized within the Land Use Policy Tool Categorization(see Table XX). All of the policies fell under the category of capital improvements, where the transportation infrastructure and transit infrastructure combined dominate over other sub-categories, accounting for 95 out of the 110 total policies.

Land Use policy tool categories			
Policy Tool Category	***Number of Policies***	***Sub-category***	***Number of Policies***
Capital Improvements	110/110	Transportation infrastructure	57
		Transit infrastructure	38
		Urban forestry	7
		Weatherization	6
		Parks	2

Table 11. Results of plans categorization within Land Use policy tool. Source: Personal elaboration.

This is because 90 of the 110 policies are from the PUMS plan and primarily relate to new or updated public transportation infrastructure and policies regarding car/bike parking spot construction.

The remaining 15 policies under capital improvements fall under the public green space category and consist of interventions to urban forests and tree management, as well as new green spaces and parks defined in the PAESC plan.

Heat Mitigation Strategies Categorization. Policies were also coded into heat mitigation strategy categories. Table 3 shows the breakdown.

Heat Mitigation strategy categories			
Heat Mitigation strategyCategory	***Number of Policies***	***Sub-category***	***Number of Policies***
Land Use	92	Roadways and parking lots	92
Urban Greening	9	Urban Forestry	6
		Vegetated parks and open space	2
		Green stormwater infrastructure	1
Waste Heat	9	Building energy efficiency	6
		Transportation	3

Table 12. Results of plans categorization within Heat Mitigation strategy tool. Source: Personal elaboration.

The findings demonstrate that the majority of the 110 actions analyzed (92 out of 110) were categorized under the land use heat mitigation strategy, followed by the urban greening and waste heat strategies.

4.1.4. SPATIAL ANALYSIS RESULTS

The results of the PIRS™ for Heat scoring process were visualized in Map XX below. From 110 actions within the city administrative borders, where only policies with the score of +1 and -1 were mapped, the net scores ranged between 5 and 13, with higher scores representing the areas of the city with more policy attention to heat hazard mitigation.

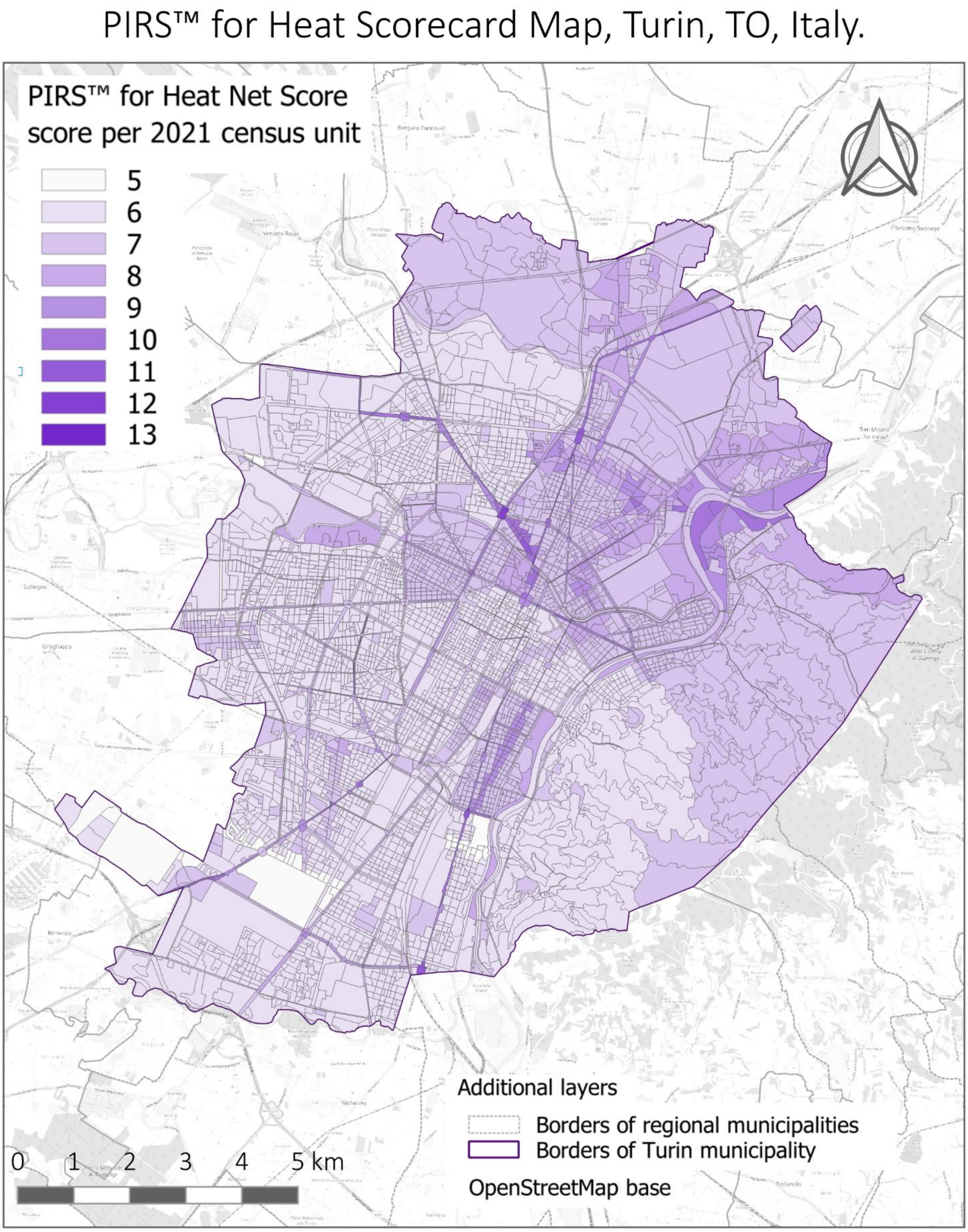


Figure 22. THE SCORECARD MAP. Source: personal elaboration based on the PIRS™ for Heat methodology.

The highest-scoring census tracts are located along the major roads, as most policies originate from the mobility plan. Other areas with the highest scores are situated in the northeastern part of the city, within the 6th and 7th districts, such as Aurora, Vanchiglia, Barriera di Milano, Falchera, Barca, Bertolla, and Sassi. These areas saw planned actions on river parks, reforestation, and upgrades to district heating systems within the PAESC plan.

Distinct high-scoring census tracts are visible on the map, including the Meisino and Pellerina river parks, the new Torino-Ceres tramway, the San Salvario neighborhood, Bengasi Square, and Derna Square. Key road corridors with high scores include Corso Regina Margherita, Corso Grosetto, and Corso Orbassano.

The lowest-scoring census tracts, situated in the southern industrial zones, hilly areas, and western border of the city, demonstrate a comparatively lower level of policy attention to heat hazard mitigation. These census tracts, with scores ranging from 5 to 7, are located in the Mirafiori Nord and Sud districts, the Cavoretto and Borgo Po neighborhoods in the Turin hills, as well as the Lucento, Vallette, and Parella areas along the western edge of the municipality

4.1.5. PHYSICAL VULNERABILITY - THE UHI MAP

Using the PIRS™ for Heat framework, the physical and social vulnerability assessment of the city of Turin was conducted.

Urban Heat Island Map, Turin, TO, Italy.

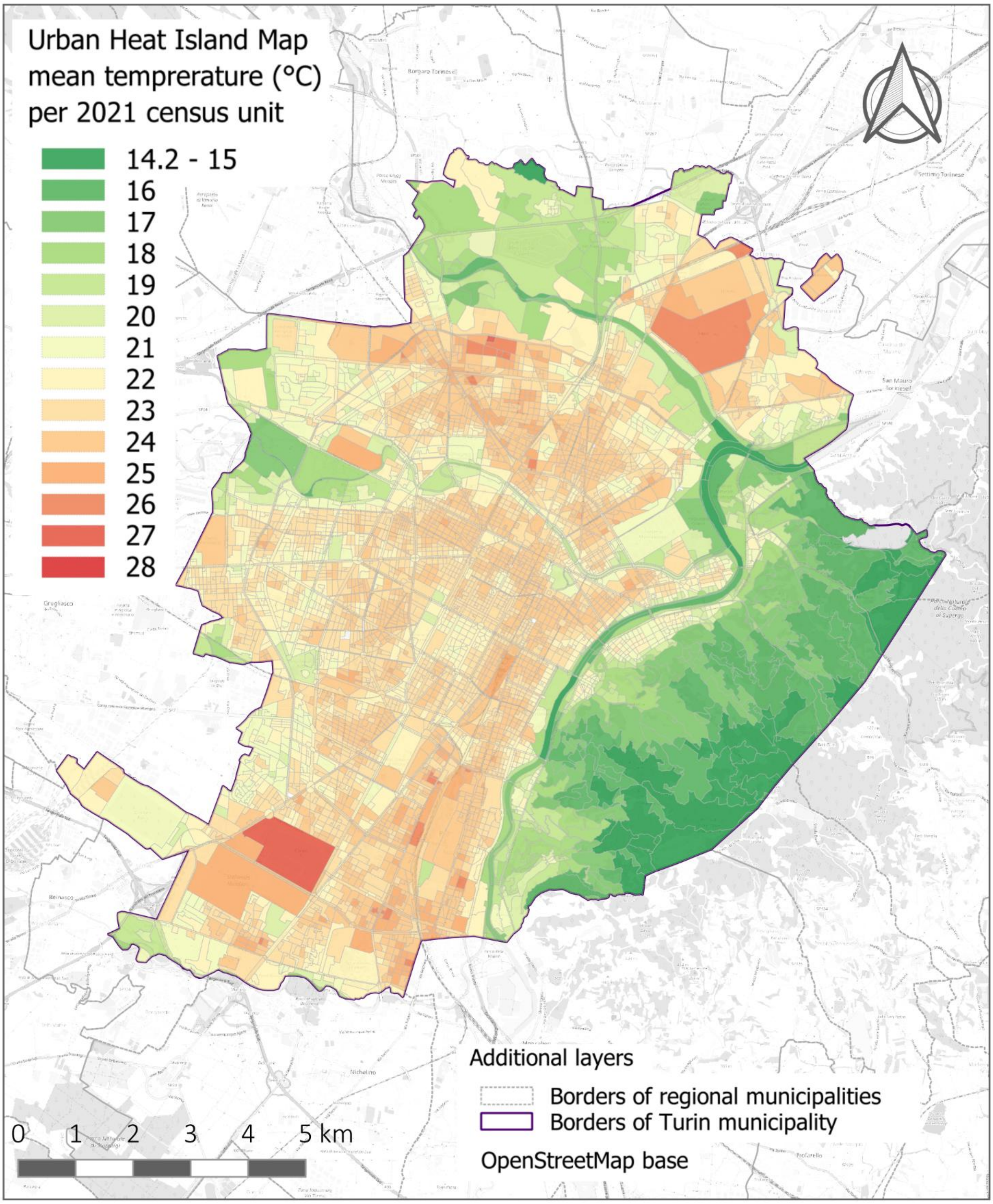


Figure 23. THE URBAN HEAT ISLAND MAP. Source: Personal elaboration.

Physical Vulnerability assessment represented with Mean Land Surface Temperature map, called as well as Urban Heat Island, was executed considering the cloud cover range between 0-2% at 10.00 on 23 of August 2023, the third hottest day In Piedmont region since 1958 during the African Heatwave that reached Piedmont region and Turin between 19-24 of August of 2023.

The physical vulnerability assessment revealed that the former industrial zones in Mirafiori Sud and the Barca district, including the IVECO industrial zone and the area between Via Reiss Romoli and Corso Grosseto, were the hottest areas in the city.

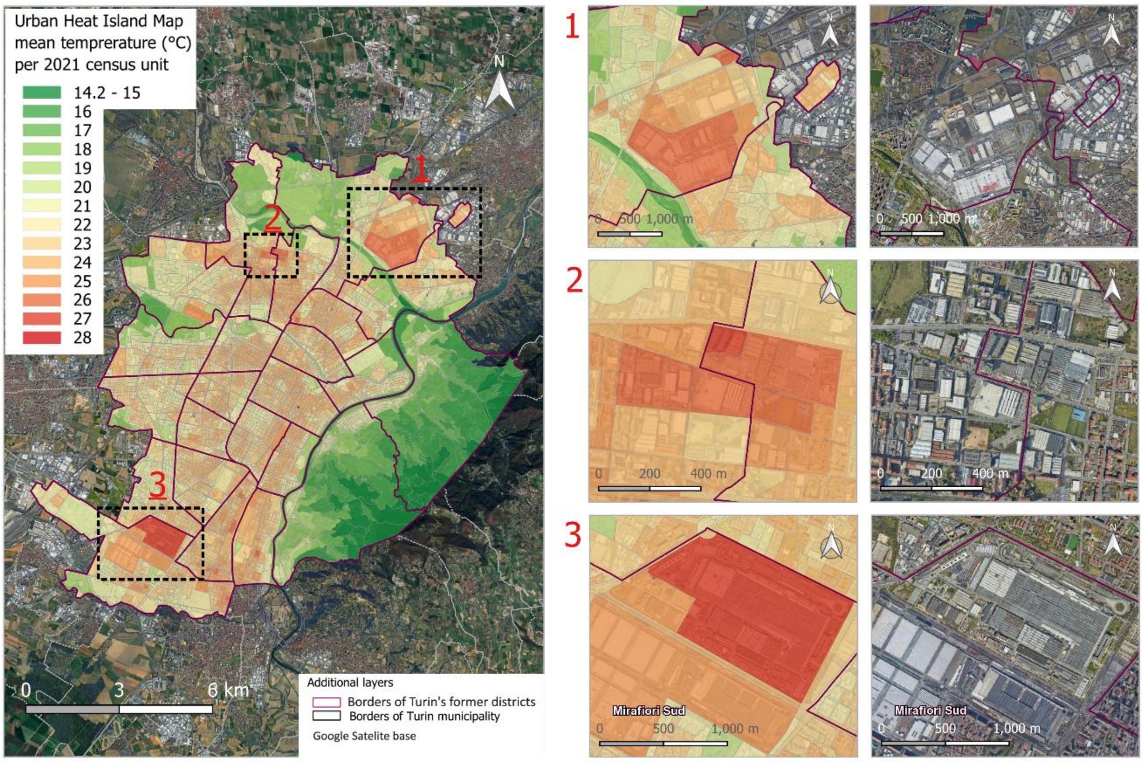


Figure 24. Series of UHI maps in the city of Turin: Industrial zones. Source: Personal elaboration.

In addition to the former industrial zones, other high-temperature areas included dense residential neighborhoods like San Salvario, Barriera di Milano, and Lingotto. The city center districts of Centro and Crocetta also had mean temperatures above 25°C. The high-density urban districts, such as the central district and northern districts of Barriera di Milano, Borgo Vittoria, and Madona di Campagna, as well as the central and southern districts of Centro, Crocetta, San Salvario, Zona Lingotto, and Mercati Generali, were the next warmest.

In contrast, the less heated areas were primarily located in the hilly parts of Turin, such as Borgo Po, Cavoretto, Madonna del Pilone, and Sassi districts, as well as the surrounding river parks along the Po river.

4.1.6. SOCIAL VULNERABILITY - THE SV MAP

The social vulnerability assessment was conducted by evaluating factors that reflect the capacity of vulnerable populations to respond to and recover from heat events, including age, socioeconomic status, race/ethnicity, housing quality, and access to resources.

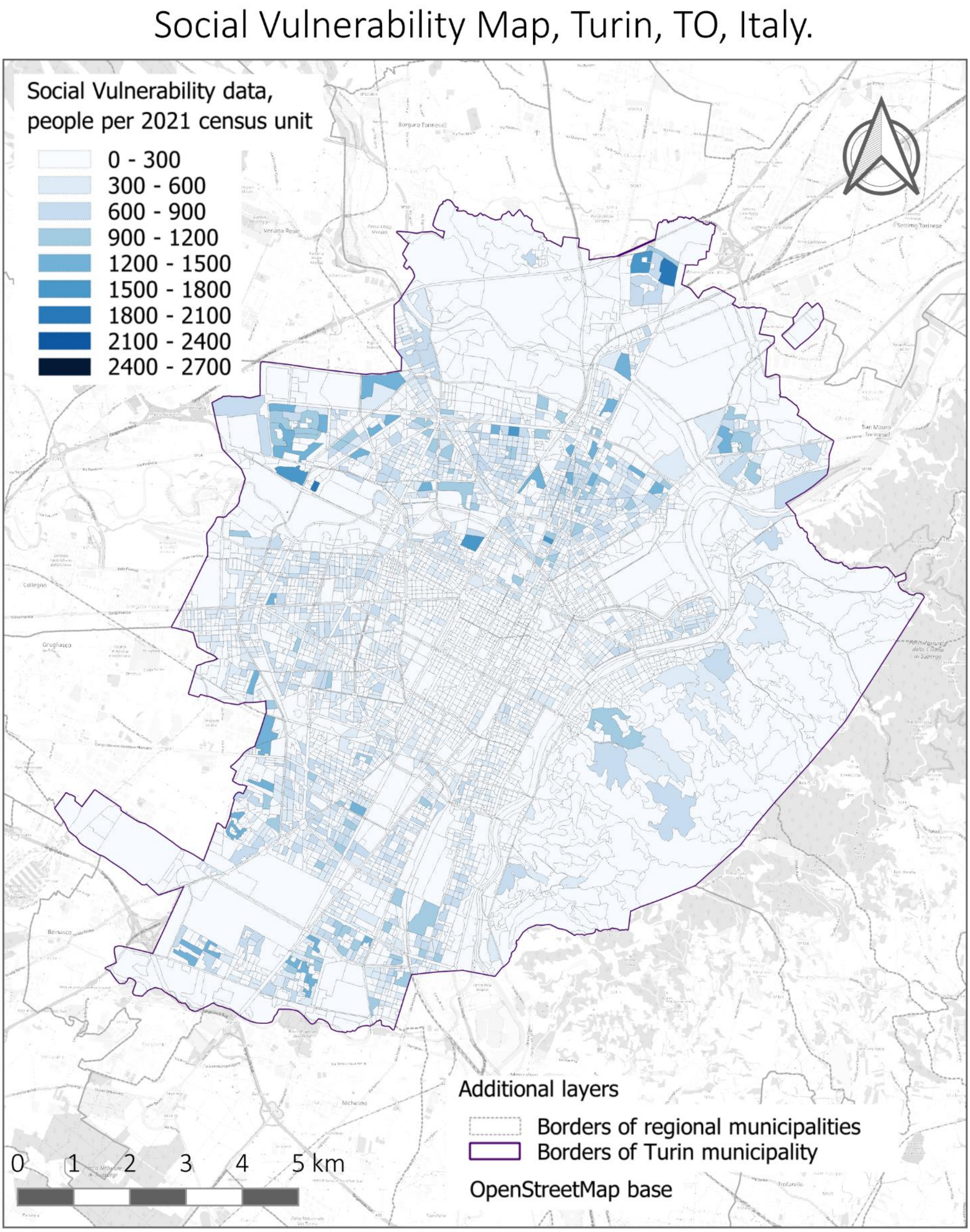


Figure 25. THE SOCIAL VULNERABILITY MAP. Source: personal elaboration based on ISTAT (2023)

The social vulnerability assessment was based on 2021 census data, which reflected the distribution of vulnerable populations within the city of Turin. The census tracts with darker shading indicate areas with a higher concentration of socially vulnerable residents.

The analysis reveals that the vulnerable population is dispersed across the city, with higher numbers of vulnerable residents residing outside the city center, compared to districts such as Centro, Crocetta, San Donato, Cit Turin, and Cenisia, that score with 300 or less citizens considered, vulnerable.

Based on the data, the most vulnerable population can be found more in he northern districts, including Rebaudengo, Barriera di Milano, Bertolla, Borgo Vittoria, Madonna di Campagna, Lucento, and Vallette, as well as the southern districts of Nizza Milefonti, Filadelfia, Mirafiori Nord, and Mirafiori Sud, demonstrate a higher concentration of socially vulnerable individuals.

4.1.7. PLANNING FRAMEWORK ANALYSIS THROUGH MAPPING VULNERABILITY

The last section of the chapter presents the visual comparative analysis between the physical vulnerability, social vulnerability maps and the the PIRS™ for Heat Scorecard map. This analysis aimed to identify relationships between the location and intensity of heat hazards, social vulnerability, and the existing policy landscape.

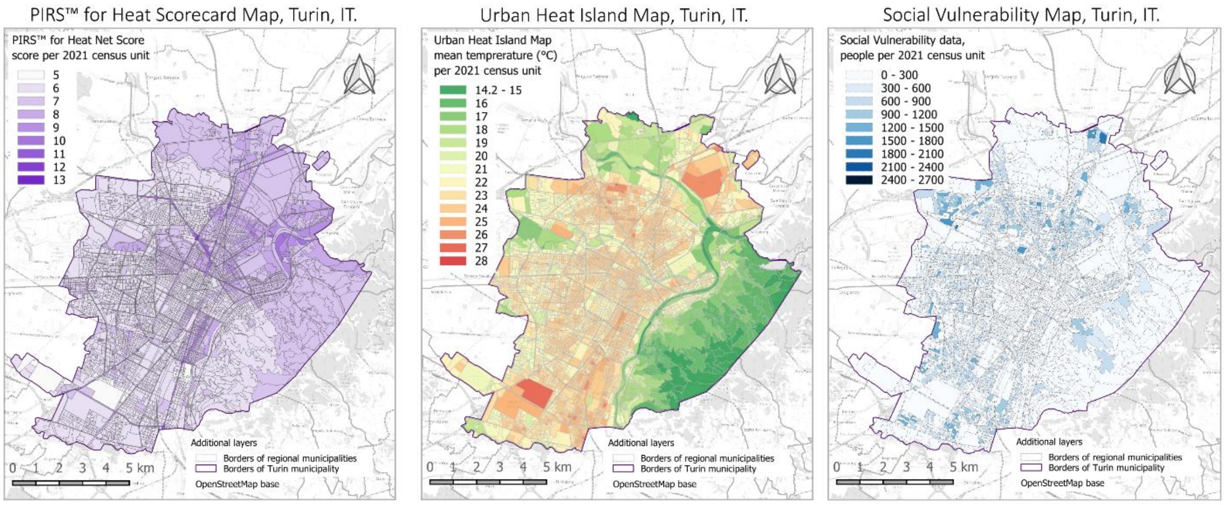


Figure 26. The Scorecard for Heat Comparative Analysis. Source: Personal elaboration.

The overlay analysis demonstrates that the areas with the highest physical and social vulnerability do not necessarily align with the census tracts that have received the greatest policy attention for heat mitigation.

The correlation analysis results reveal that the correlation coefficients between the map variables are all negative, indicating no significant relationship between them. However, this does not mean the relationship does not exist, and further investigation using visual comparison of the data is required.

The Pearson Correlation coefficients	
Between UHI and SV	-0.007393992
Between Score and UHI	-0.028732308
Between Net Score and SV	-0.03124143

The visual analysis of the results suggests that the use of 2021 census data fragmented the results across small district boundaries, making it difficult to facilitate visual comparison. To address this, an additional layer of the former quarters of the city of Turin was added to visualize the misalignment between the heat distribution, the location of vulnerable populations, and the targeted policies.

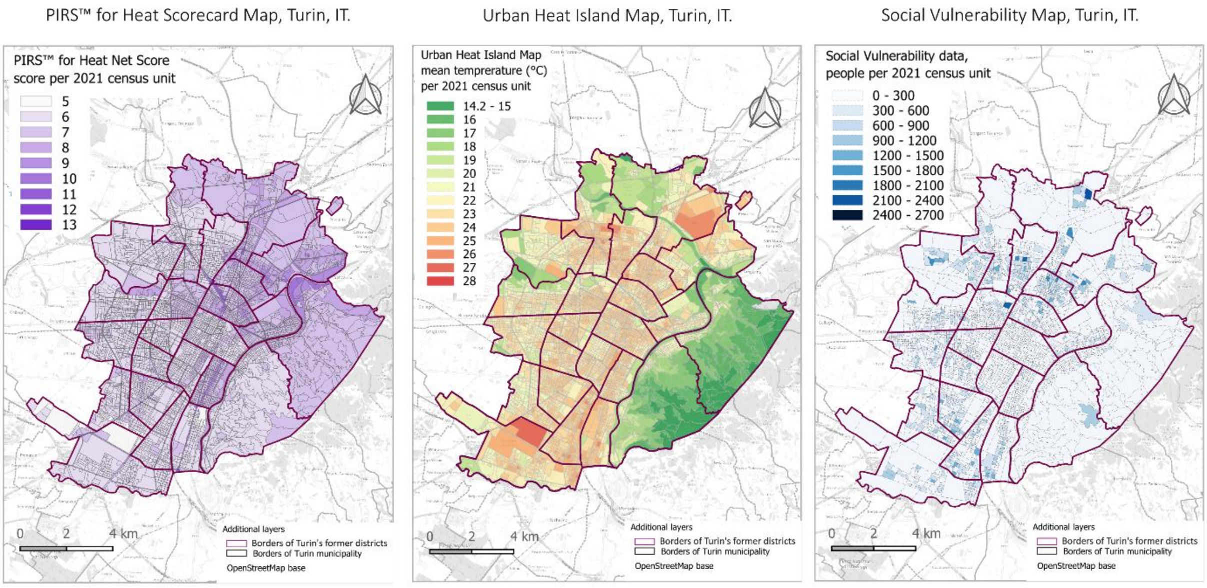


Figure 27. The Scorecard for Heat Comparative Analysis with Turin's former quarters division. Source: Personal elaboration.

The visual comparative analysis reveals a critical misalignment between the PIRS™ for Heat Scorecard results and the actual patterns of physical and social vulnerability in the city of Turin. The PIRS™ Scorecard, which aims to assess the policy landscape, does not reflect the realities on the ground as depicted in the Urban Heat Island and Social Vulnerability maps.

The analysis shows that the hottest urban areas, often located in former industrial zones and dense residential neighborhoods, do not receive the highest levels of policy attention and intervention.

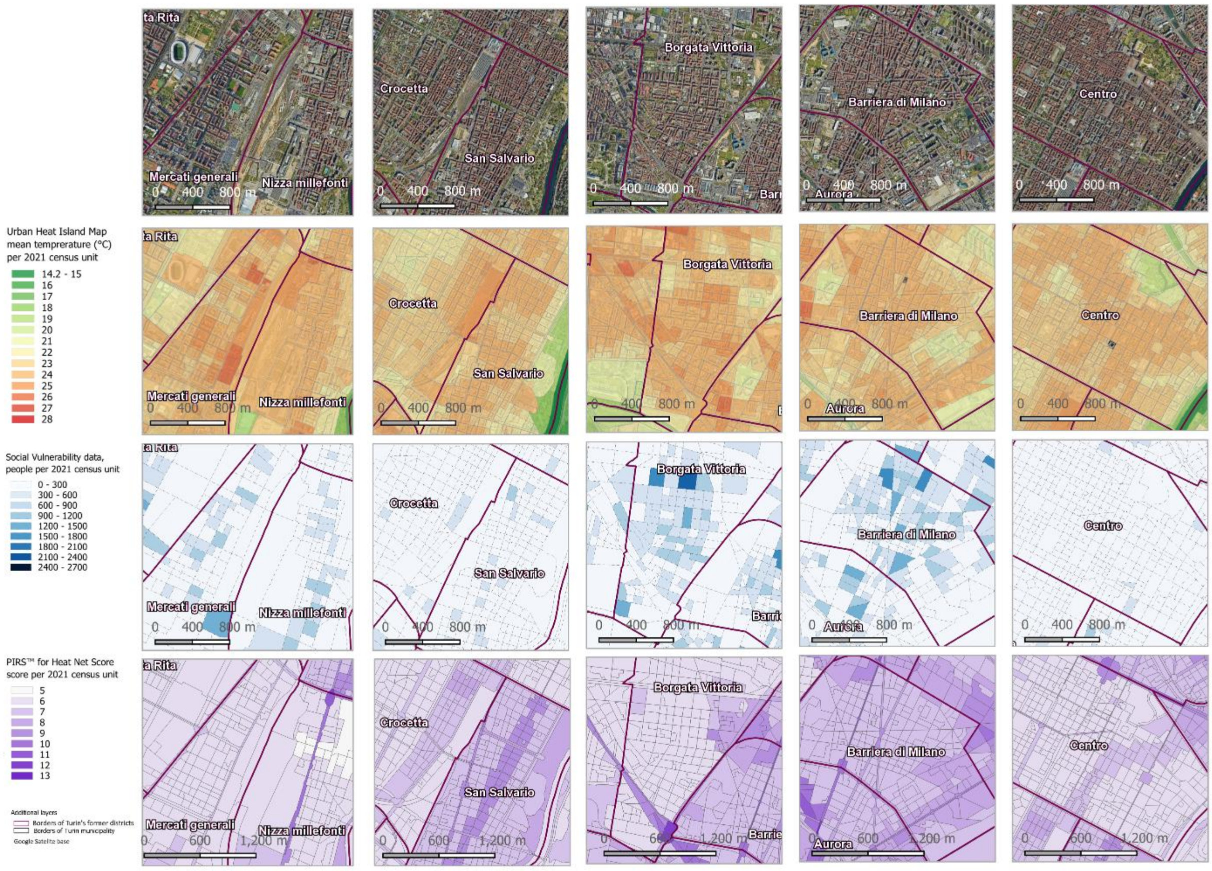


Figure 28. The Scorecard for Heat Comparative Analysis of Residential Areas with Highest Heat Vulnerability. Source: Personal elaboration.

Similarly, the districts with the greatest concentrations of socially vulnerable populations, such as those in the northern and southern parts of the city, are not the primary focus of the current planning framework.

This disconnect suggests that the existing urban heat resilience planning in Turin is not effectively targeting the areas and communities most at risk from the Urban Heat Island effect.

4.2. CASE STUDY LIMITATIONS AND CONCLUSIONS

During the application of the PIRS™ for Heat methodology, several limitations and challenges were encountered:

- **The reliance on an outdated planning too**l posed significant challenges in fully understanding the current policy landscape.
- The application of the PIRS™ for Heat methodology in Turin was hindered by the use of **national census data** as the primary source for the social vulnerability assessment. While the census data provided valuable demographic information, its infrequent updates, occurring once every decade, made it challenging to capture the rapid changes in the city's social landscape.
- Additionally, In contrast to the U.S.-based case studies, where the census tract and city structure were divided into larger territories, the use **of small administrative**

district boundaries fragmented the data, making it difficult to conduct a meaningful comparative analysis between the physical, social, and policy dimensions of heat vulnerability.

These limitations highlight the need for a more adaptive and flexible approach to heat resilience planning that can better accommodate the unique context of each city, utilizing more frequent and granular data sources to capture the dynamic nature of urban communities.

In conclusion, the application of the PIRS™ for Heat methodology in Turin has provided a comprehensive understanding of the city's policy landscape, climatic challenges, and vulnerability dynamics. Key insights include the identification of effective interventions, such as urban greening and public transportation upgrades, alongside critical gaps in addressing heat-related risks. This assessment has helped identify patterns in the effectiveness of the city's heat planning efforts, rather than highlighting specific areas requiring improvement or potential interventions. However, the findings highlight systemic limitations in aligning policy efforts with areas of greatest need. The misalignment between high-risk zones and policy focus areas underscores the necessity for a more targeted, adaptive planning approach. This requires integrating real-time data, addressing social inequities, and revising outdated frameworks to reflect the dynamic interplay of physical and social vulnerabilities.

Enhancing urban heat resilience in Turin necessitates a two-pronged approach: First, strengthening the spatial coordination between policy interventions and areas of heightened vulnerability; Second, leveraging interdisciplinary collaborations to foster policy coherence across climate adaptation, green infrastructure, and transportation domains. By addressing these challenges, Turin can advance towards a robust, equity-focused model for urban heat resilience planning, offering lessons for similar European contexts.

In the following chapter, the presented findings will be examined, concentrating not only on the efficacy of applying the PIRS™ for Heat methodology to the Turin case, but also on understanding the specific framework challenges and necessary changes. Additionally, the unique obstacles faced by Turin in urban heat planning will be explored, and actionable recommendations will be made to strengthen heat resilience within the city's planning framework.

CHAPTER V

INTRODUCTION

LITERATURE REVIEW

METHODOLOGY

RESULTS

DISCUSSION

CONCLUSION

ANNEXES

In this chapter, the study discusses the main results and summarizes the key findings to then provide a base for further discussion and subsequentially answer the research questions together with recommendations for future research and limitations.

5. CHAPTER V: DISCUSSION AND CONCLUSION

This research addresses the urgent need for effective strategies to mitigate the UHI effect in the city of Turin, Italy. The primary objective of this study is to evaluate the efficacy of the "Plan Integration for Resilience Scorecard™ (PIRS™) for Heat" methodology in assessing and enhancing heat resilience planning within Italian city of Turin.

This chapter, discusses the main findings of the research and their allignment with the existing data within the literature in **Part I**and their possible future implications and recommendations for the mitigation and adaptation for Urban Heat Resilience in the city of Turin, Italy in **Part II.** In the end, the chapter provides an overview on key limitations and potential future research directions derivatives of the study.

The research aims to assess the Urban Heat Island (UHI) challenges in Turin and enhance urban heat resilience planning by evaluating the PIRS™ for Heat methodology. The objectives include evaluating the effectiveness of Turin's planning framework, mapping heat vulnerability across the city, and identifying challenges along with actionable recommendations for improving heat resilience. Key questions focus on the effectiveness of the current planning framework, identifying the most heat-affected and vulnerable areas, and addressing challenges to urban heat planning with potential solutions.

5.1. ANALYSIS OF THE RESULTS

The application of the PIRS™ for Heat methodology in the city of Turin revealed several key findings within the city's Urban Heat Resilience planning framework. Main findings from the research are categorized within 4 main topics:

1. **Climatic and Urban Challenges** of the Turin, as a base for heat resilience planning.
2. **Planning framework analysis** through the lens of the PIRS™ for Heat methodology.
3. **Physical and Social Vulnerability Assessment**.
4. **The Scorecard results and the evaluation** of the effectiveness of the planning framework of the city of Turin towards the UHI issue.

5.1.1. BACKGROUND STUDIES: CLIMATIC AND URBAN CHALLENGES

- **The combination of Heat and humidity** during summer months in the city of Turin (sources)
- **Urban density,** as a contradictory element for the sustainability but positive feature for urban heat resilience, according to the literature (sources).
- **The geographical features, such as river Po and its legs and the mountains around the city** affect the local microclimate (sources).
- **Heat waves** as a direct thread to the vulnerable population.

- **Heat mortality.** Luck of the specific data, but important aspect to give a priority to the problem

The humidity, the mountainous character of the region around, the hillside and multiple river dominance within the city together with the density does make planning for Urban Heat Hazard a **more complicated matter** rather than combating the rising temperatures and **gives to the already complicated issue more layers to consider on the planning for Urban Heat efforts.**

5.1.2. TURIN'S PLANNING FRAMEWORK EVALUATION

Analysis of the city's planning framework as per the PIRS™ for Heat methodology highlighted that while Turin has demonstrated a thorough understanding of the UHI challenge and incorporated heat-related strategies in various plans, there are significant gaps and limitations in the city's overall planning framework. In order to assess the planning framework each plan was evaluated through the process individually and in complex through the lens of the PIRS™ for Heat methodology in few stages.

PLANS COORDINATION AND ORGANIZATION.

As a part of the analysis prior to implementation of the PIRS™ for Heat, the study reviewed and analyzed the city of Turin's existing planning documents, including:

1. **Municipal or General Regulatory Plan (PRG)**;
2. **Strategic Plan for Green Infrastructure (GREENPRINT);**
3. **Climate Resilience Plan;**
4. **Action Plan TORINO 2030;**
5. **Sustainable Urban Mobility Plan (PUMS);** and
6. **Action Plan for Sustainable Energy and Climate (PAESC)**.

The initial review highlighted that Turin has a relatively well-developed planning framework that addresses the UHI challenge from various angles, including land use, green infrastructure, transportation, and climate resilience.

However, **5 out of 6 plans** have non-binding character, leaving only the main **General Regulatory Plan (PRG) as a binding instrument in the framework.**

Nevertheless, **all plans consisted of strategies**, policies and actions **related to the UHI issue**, including references to the implementation of cool materials, urban greening, regulation of built density, and promotion of low-carbon mobility.

Plans demonstrated the relationship between each other in the strategies related not only to the **General Regulatory Plan (PRG) but also to actions and policies referring to each other,** therefore forming **connections between plans** within the framework.

This initial assessment underlines **the cities attemnt on coordinating** the plans between each other, yet the central and the only binding role of **the General Regulatory Plan urges the need for a stronger integration** of other plans into this key document.

FIRST SELECTION PROCESS OF PLANNING INSTRUMENTS

Based on the PIRS™ for Heat methodology, only the most recent and relevant plans were included in the analysis.

- **The General Regulatory Plan** was excluded due to its outdated nature, and the new Technical Proposal was also excluded as it was a high-level strategic document.
- Similarly, **the Action Plan TORINO 2030** was eliminated because it lacked specific actions, focusing more on overall strategic recommendations. However, other plans, such as the Climate Resilience Plan and Strategic Plan for Green Infrastructure, were considered derivatives of the TORINO 2030 strategic plan and were included in further analysis.

The first elimination posed significant limitations to the analysis, as **the General Regulatory Plan is the central and only binding instrument** in the planning framework, where the implementation of the rest of the plans was related to the PRG. Thus, eliminating this document **may have limited the understanding and assessment of the overall effectiveness of the planning framework** in addressing the UHI issue. **However,** the rationale for this choice was to focus the analysis on the most recent and relevant plans, which are more likely to provide a clear and comprehensive picture of the current state of heat-related planning in Turin.

The PIRS™ for Heat methodology was then applied to the remaining 4 plans, including the Climate Resilience Plan, Strategic Plan for Green Infrastructure, Sustainable Urban Mobility Plan, and Action Plan for Sustainable Energy and Climate.

THE “THREE-POINT TEST” SELECTION RESULTS

- **The Climate Resilience Plan,** the city plan, specifically designed to mitigate urban heat and flooding, consist of 44 heat-related and 37 flood-related actions, of total of 77 actions analyzed. All 44 heat-related action aimed to mitigate the UHI, therefore potentially could be eligible for scoring and make a valuable difference in the city efforts in addressing Heat Hazard. All 77 actions consisted of a measurable unit for tracking the progress. **However,** the absence of clear spatial allocation of this actions, **transformed the plan from actuable to rather indicative,** with a need for update and detalization.
- **The Strategic Plan For Green Infrastructure (GREENPRINT)** consists of 25 actions analyzed, with 17 heat-relatedactions. As well as the Climate Resilience Plan, the GREENPRINT is designed to implement green solutions to the cities diverse climate issues, including heat. **Nevertheless,** non of the actions had a clear spatially allocated implementation.

Both plans, are part of the TORINO 2030 Climate Action plan, and **were designed to complement each other**, creating the effective network **to address climate issues and hazards** by the city, **therefore showing another attempt on coordination** between plans within the framework. However, because the plans lack of clear spatially-defined actions to ensure accountability and significant impact, they were ultimately eliminated from the scorecard plan's evaluation list.

This finding shows the gap in the city's framework to comprehensively **integrate the planning instruments**, such as the Climate Resilience Plan and GREENPRINT, into the planning framework **due to the incompleteness** of the instruments themselves, therefore **diminishing the potential of the tool** to reduce the UHI threat efficiently and be considered as a mitigation and adaptation tools for the city planners and stakeholders.

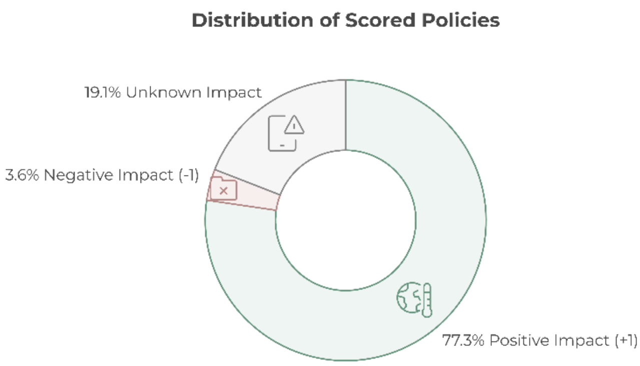
THE SCORING OF THE REMAINING PLANS

From the initial 6 plans related to planning for Urban Heat in the city of Turin, only 2 passed the 'Three-Point Test' Selection:

- **The Action Plan for Sustainable Energy and Climate (PAESC),** that consists of 37 mitigation actions and 30 adaptation strategies, for a total of 68 analyzed actions. Out of those, 48 were Heat related and only 20 passed the 'Three-Point Test'.
- **The Urban Plan For Sustainable Mobility (PUMS),** consists of 400 total plans, within which 149 plans fall into the PRG scenario within the municipality of Turin administrative limits were considered for the analysis. Out of 149, only 107 are heat-related and 90 passed the 'Three-Point Test'criteria.

The total of 110 actions from both instruments passed the 'Three-Point Test', with 90 actions from PUMS and only 20 from PAESC. The selection process, where only 2 plans passed the necessary criteria to be considered in the Scorecard evaluation, demonstrated that **the cities efforts** to address the Urban Heat issue through formal planning instruments is **concentrated around the urban mobility and energy-related domains**, while the efforts directly targeting UHI mitigation through landscape based solutions are not sufficiently integrated within the cities central planning framework. **WIth the 90 out of 110 policies and action coming from PUMS** the responsibility for managing urban heat is still predominately addressed through mobility, transport and infrastructure planning rather than more holistic landscape and green infrastructure based solutions.

POLICY ANALYSIS RESULTS



110 polices in total were scored, where:

- 85 policies **(77.3%)** were scored as +1.
- 4 policies **(3.6%)** were scored as -1.
- 21 policies **(19.1%)** were marked as Unknown due to incomplete details.

PUMS: From the PUMS plan, only 4.4% of actions (4 out of 90) received a score of -1, as they consist of the new development of private transportation ways around the city and, consequentially, the amount of impervious surface. Thus, 16.7% of actions (16 out of 90) were scored as Unknown, as they consist of new public and private transportation parking lots, where the aim was to introduce interchangeable parking, but there were no specifications on which kind of surface planned to use.

The remaining 78.9% of actions receive a score of +1, as they are mainly designed to promote new or update existing public transportation ways with lower or zero carbon emissions and permeable surfaces.

PAESC: Only two actions from the PAESC plan received an Unknown score. One was constructing a new parking lot to promote interchangeability and, therefore, accessibility of public transportation, with no specific mention of materials planned to be used.

The rest of the actions got the score +1, meaning that they decreased the UHI effect with a wide range of actions, from energy requalification of districts to reforestation interventions to tree management and new public green spaces.

In summary, with 77.3% of total scored policies being evaluated positively, the research shows **that the current planning efforts**, even if **not fully developed and detailed, still aim towards climate resilience** and heat mitigation overall.

POLICY TOOL CATEGORIZATION

All of the policies fell under the category of capital improvements, where the transportation infrastructure and transit infrastructure combined dominate over other sub-categories, accounting for 95 out of the 110 total policies. This is because 90 of the 110 policies are from the PUMS plan and primarily relate to new or updated public transportation infrastructure and policies regarding car/bike parking spot construction. The remaining 15 policies under capital improvements fall under the public green space category and consist of interventions to urban forests and tree management, as well as new green spaces and parks defined in the PAESC plan. Consequentially, the analysis reveals that because of the past actions deriving majorly from PUMS, the city's efforts to address urban heat are shown to **primarily focus on mobility and transportation planning** rather than a more holistic approach incorporating landscape-based green infrastructure solutions. Therefore, **a diversification of the actions policy tool category** would be needed to better address the UHI challenge.

HEAT MITIGATION STRATEGIES CATEGORIZATION

Similarly to the results of the policy tool categorization, the heat mitigation strategies categories showed the prevalence of the PUMS actions related to the Land Use - Roadways and parking lots over the rest. Nevertheless, some Urban Greening and Waste Heat strategies were also identified, mainly coming from the PAESC plan.

In summary, the analysis of the heat mitigation strategies underlines again the city's efforts on focusing on transportation and infrastructure planning, while **landscape-**

based solutions, **urban greening** and **urban design** together with **waste heat management** are in lack of attention from the current eligible planning instruments.

From the scoring and categorization process, the study sshows that a more balanced and integrated approach is needed, one that considers the multi-disciplinary and multi-scalar nature of UHI, to effectively address the heat island challenges in Turin.

In conclusion, the city's planning framework should be expanded **to integrate additional policies** that **take a multidisciplinary, place-based approach** to addressing urban heat island challenges. This includes policies focused on urban design, green infrastructure development, and waste heat management, with clearly defined and measurable outcomes.

5.1.3. PHYSICAL AND SOCIAL VULNERABILITY ANALYSIS

- High temperatures are concentrated in former industrial areas and densely built neighborhoods, such as Mirafiori Sud, San Salvario, and Lingotto.
- Social vulnerability is more pronounced in northern and southern districts with higher concentrations of elderly and low-income populations.

Overlaying the physical and social vulnerability maps highlights that some of the most severely heat-impacted areas in the city, such as Mirafiori Sud and Barriera di Milano, also have high social vulnerability characteristics, thus majority does not have any relationship.

The results show that the city's most vulnerable populations are not necessarily located in the hottest areas, indicating that the current planning efforts may not be fully accounting for the complex socio-spatial dynamics of urban heat island effects. Thus, majority of the urban dense areas are on the hottest side of the city spectrum.

This implies that to effectively address heat resilience, the city should consider a **more integrated, equity-focused approach** that **considers both the physical and social dimensions of vulnerability.**

5.1.4. THE SCORECARD RESULTS AND KEY TAKEAWAYS

The results from the policy evaluation and categorization process indicate that the current planning efforts in Turin, Italy are primarily focused on transportation and infrastructure planning rather than a more holistic, integrated approach to addressing urban heat island challenges.

The city's planning approach tends to be mono-focused, which is clearly visible in the PIRS™ for Heat Scorecard Map, with the highest-scoring census tracts primarily **located along major roads**, as most policies originate from the city's mobility plan (PUMS). Other high-scoring areas are situated in the northeastern districts, where planned actions include river parks, reforestation, and upgrades to district heating systems. In contrast, the lowest-scoring census tracts are found in the southern industrial zones, hilly areas, and western border of the city, suggesting a lower level of policy attention to heat hazard mitigation in these regions.

COMPARISON/ALIGNMENT OF POLICIES WITH THE MOST VULNERABLE AREAS OF THE CITY.

The overlay analysis of the heat vulnerability and policy integration maps highlights a critical **misalignment between the city's planning efforts** and the **most vulnerable neighborhoods.** The areas with the highest social vulnerability, such as **Barriera di Milano, Mirafiori Sud, and San Salvario**, do not coincide with the locations that have the greatest policy integration scores.This analysis reveals a **disconnection between the policy interventions** and the **actual patterns of physical and social vulnerability in Turin.** The hottest urban areas and the districts with the highest social vulnerability are not the primary focus of the current planning framework. This disconnect suggests that the existing urban heat resilience planning is failing to effectively target the most at-risk areas and communities.

Finally, the city should consider expanding its planning approach to incorporate a more equitable, place-based strategy that directly addresses the complex socio-spatial dynamics of urban heat island effects.

Summary of key findings from the testing application:

Category	Key Findings	Meaning
Planning Framework	Turin has a relatively developed planning framework but lacks binding mechanisms for most plans.	Stronger integration of non-binding plans into the General Regulatory Plan (PRG) is needed.
Plan Evaluation	Only 2 out of 6 plans met criteria for detailed evaluation; focus on recent, actionable plans.	Emphasis on mobility and energy plans shows gaps in spatial clarity and holistic green solutions.
Policy Implementation	77.3% of actions positively scored; transportation actions dominate over green infrastructure.	Current efforts prioritize transport planning, neglecting balanced integration with landscape-based solutions.
Heat Mitigation Strategies	Urban greening and waste heat management strategies are underutilized in favor of transport solutions.	Need for diversification of strategies to address UHI effectively through multidisciplinary approaches.
Vulnerability and Equity	High physical and social vulnerabilities in areas like Mirafiori Sud are poorly aligned with policies.	Misalignment of policies and vulnerable zones indicates inequities in current planning efforts.

Overall, the main takeaway from the application of the testing methodology in Turin is that the city's current planning framework and policy implementation do not adequately address the complex socio-spatial dynamics of urban heat island challenges.

5.1.5. LITERATURE RECOMMENDATIONS AND THE RESULTS

Alignment with Literature. The research analysis highlights that Turin's planning framework, while relatively comprehensive in addressing the Urban Heat Island (UHI) issue, demonstrates significant gaps in implementation and integration. These findings align with the observations in the literature that Italian cities often face structural and institutional challenges in integrating climate resilience strategies (Caldarice et al., 2021).

The literature emphasizes the lack of legal obligations for adaptation plans in Italy, a finding echoed in the research analysis where most of Turin's climate-related plans, such as the Climate Resilience Plan and GREENPRINT, are non-binding. This structural limitation hinders the operationalization of strategies, reinforcing the need for reforms that mandate local adaptation plans (Pietrapertosa et al., 2023).

Key Differences from Literature. While the literature advocates for integrating climate actions into sectoral plans for enhanced effectiveness (Grafakos et al., 2020), the research analysis reveals a mono-focus in Turin's framework, with a disproportionate emphasis on transportation and infrastructure planning. The PUMS dominates UHI mitigation efforts, contributing 90 of the 110 evaluated policies, whereas landscape-based solutions such as urban greening remain underutilized. This divergence underscores a gap between theoretical recommendations for holistic, multi-disciplinary planning and Turin's current practice.

Furthermore, the research analysis identifies a misalignment between policy focus and areas of highest vulnerability. Vulnerable districts such as Barriera di Milano and Mirafiori Sud are not prioritized in the planning framework, contrasting with the literature's call for equity-focused approaches that integrate social and physical dimensions of vulnerability (Caldarice et al., 2021).

CRITICAL NOTE ON THE PLANNING FRAMEWORK

An important divergence between the research findings and the literature relates to the application of the PIRS™ for Heat methodology. While the literature emphasizes **that PIRS™ for Heat could succeed** in the Italian context due to its top-down, conformative, and rigid analytical approach the findings demonstrate otherwise.

In theory, the centralized nature of Italian planning, with its reliance on structured tools and resources, **could benefit from the PIRS™ for Heat methodology's flexibility and adaptability(source)**. However, **in practice**, the analysis revealed **a fundamental mismatch.** The main binding tool, the General Regulatory Plan (PRG), failed to pass even the first selection process within the PIRS™ methodology due to its outdated character.

Consequently, the entire framework under analysis lacked coordination and cohesion, resembling a house without a base. **This structural weakness undermines the practical**

applicability of PIRS™ for Heat in Turin, as the lack of a strong, up-to-date binding framework **hinders its effectiveness in guiding coordinated planning efforts.**

5.1.6. INTERPRETATION OF FINDINGS

The findings suggest that while Turin demonstrates awareness of UHI challenges, its reliance on sectoral approaches and non-binding plans undermines the potential for impactful interventions. The literature advocates for robust integration and coordination across governmental levels, emphasizing vertical and horizontal integration to enhance resilience planning (Pietrapertosa et al., 2021).

Additionally, the lack of spatially explicit actions in plans such as the Climate Resilience Plan and GREENPRINT limits their effectiveness, despite their inclusion in the broader TORINO 2030 framework. This observation aligns with the literature's critique of Italy's fragmented governance, which impedes the practical application of comprehensive strategies (Caldarice et al., 2021).

5.2. LIMITATIONS OF THE STUDY

The key limitations of the study include:

- **Limited data availability.** Many changes to the original methodology were implemented due to data unavailability, specifically for vulnerability analysis. If physical vulnerability could be assessed using remote sensing data, instead of readily available open data as in the U.S. context, the social vulnerability analysis went through more extensive adjustments. The SVI (Social Vulnerability Index) for the United States was an extensive tool for understanding the social vulnerability allocation in cities within the U.S. However, its application within the Italian context was limited, and alternative open-data indicators had to be sought to create a tool comparable to the SVI. Therefore, the amount of data used for such analysis might not be as comprehensive as the one in other contexts, limiting the detalisation of the findings. In addition, such important indicators, such as Heat Mortality, are not available due to Italian health and safety laws regarding the publication of such sensitive data.
- **The single reviewer for the scoring process.** The methodology implemented majorly relies on the scoring process, which was originally supposed to be conducted by a minimum of 2 reviewers for scoring reliability. However, due to the academic character of the research, the study was conducted by a single author, which may introduce potential biases and scoring inconsistencies. This limitation can be addressed in future implementations of the methodology by involving multiple reviewers perspectives.
- **Limited involvement of the community in their search.** The level of community involvement in the research was limited and restricted to interviews with municipal representatives, which constrained the depth of community engagement and feedback obtained.

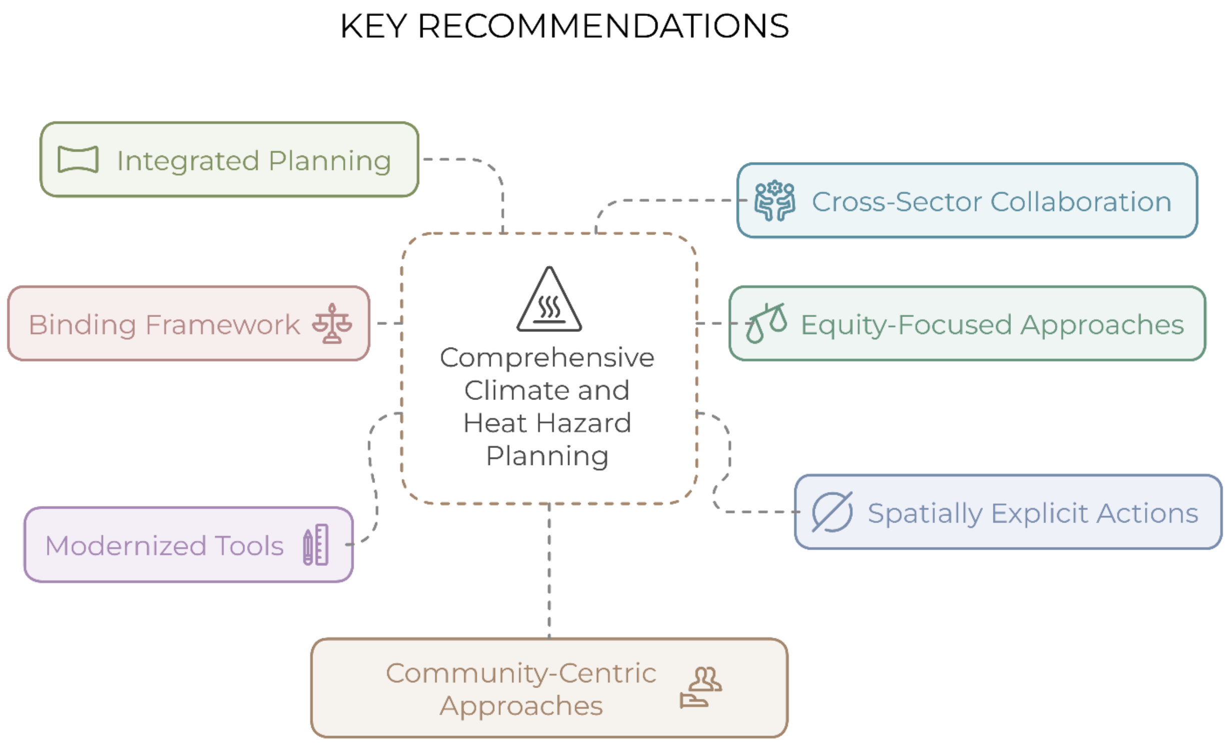
- **Limitation regarding the PIRS™ for Heat methodology.** The methodology's purpose is to assess the effectiveness of a community's planning framework in addressing heat hazard risk within its territory, ultimately identifying the areas of the city that are more socially and physically vulnerable to heat while not targeted with specific actions within the city planning framework. Thus, the actions and policies are analyzed based on their mitigation and/or management influence to the urban heat, the magnitude and over-all effectiveness is not considered in their examination as well as what resilient strategies is implemented—mitigation or adaptation/management. Therefore, the results provide an overview analysis but can not be considered as an absolute evaluation of the effectiveness of analyzed plans, which gives space for future research to implement the additional tools for measuring the depth within each plan.
- **The comparison grid.** The census net used for the analysis was introduced as a new city division with the census data in 2021. The new census grid consist of the more detailed division of the city to the segments, often corresponding to the single street and/or city block with only few buildings in it. This fact made it challenging to directly compare the results between the scorecard analysis and the vulnerability analysis, because of the fragmented nature of the grid itsef. Therefore, an alternative city grid, though not the official one, was introduced to enable more accessible visual analysis. This grid utilized census tracts of former historic quarters in Turin, which are well-known among citizens and still commonly referenced in everyday discourses.

5.3. RECOMMENDATIONS

Based on the literature and research findings, several recommendations emerge:

- **Require Legal Mandates:** Adopt **binding legal requirements** for both mitigation and adaptation plans to ensure accountability and consistent implementation, following the example of countries like France (Pietrapertosa et al., 2023).
- **Prioritize Equity-Focused Approaches:** Prioritize interventions in socially vulnerable areas **to address disparities in heat resilience**, aligning with the literature's call for holistic, equity-driven planning (Caldarice et al., 2021).
- **Update towards Spatially Explicit Actions:** Update existing plans with clear, spatially defined actions to enhance accountability and measurable outcomes, addressing gaps identified in both the research analysis and literature.
- **Modernize Central Tools:** Ensure the PRG and similar binding instruments are updated regularly to reflect contemporary challenges and enable their integration into advanced methodologies like PIRS™ for Heat.
- **Focus on Community-Centric Approaches**: Turin's efforts under Torino Cambia can be informed by the participatory mechanisms employed in Copenhagen and Phoenix, fostering greater buy-in from residents.

- **Implement Cross-Sector Collaboration**: Lessons from Milan and Bologna highlight the importance of collaboration among stakeholders, including local governments, academic institutions, and private enterprises, for effective implementation.
- **Move towards Integrated Planning:** Strengthen the integration of landscape-based solutions into urban planning frameworks, as emphasized in resilience strategies like Milan's Climate Plan (Comune di Milano, 2020).



Therefore, **Turin does not need just 1 binding tool** to address climate and specifically Heat Hazard, but a web of interconnected plans that together form **an integrated, comprehensive approach.** Because of the Nature of UHI and general climate hazards, no single plan can be expected to address the issue holistically, not new and updated PRG or any Climate Action plan, even if given binding character. Rather, the update and binding role needs to be given to already existing planning tools with a broad range of directions, from energy to mobility planning to the urban landscape design, integrated through a multi-level, multi-stakeholder governance mechanism with clear accountability, enforceable goals, and monitoring/review cycles. The UHI issue is so complex and urging that all plans need to work towards addressing it from different fronts in order to effectively target this specific problem, thus, all with updates, place-specific and binding policies to act on.

5.4. FUTURE RESEARCH

5.4.1. POTENTIAL USES OF THE RESEARCH

- **Using the heat and social vulnerability mapping** to guide targeted implementation of UHI mitigation strategies and/or initiatives towards the most affected areas in the city and **to help prioritize the resource allocation and work as a tool for a holistic view over the targeted issue - UHI mitigation and adaptation.**

- **Using the detailed list of actions and their evaluation for the future updates** of evaluated plans and policies and provide missing information to the specific action, in order to impove its mitigation and/or adaptation role within the planning for Urban Heat Resilience.

- **Applying the adaptation of PIRS™ for Heat methodology to manage and report the progress** in the future updates of the evaluated planning documents, through the comparable assessment of the city's actions over time.

- **Applying the adaptation of PIRS™ for Heat methodology** to assess the planning frameworks **in other cities, specifically those with binding** climate action or resilience plans, to enable cross-city comparisons of heat preparedness and inform urban climate adaptation. Furthermore, conducting this same analysis in **other small-medium-large-sized** cities in Italy or elsewhere allows for a comparative analysis of heat planning approaches and effectiveness.

5.4.2. FUTURE RESEARCH OPPORTUNITIES

- Implementing the PIRS for Heat methodology with more data sources to get a more comprehensive understanding of heat resilience planning with the city. Integrating the physical and social vulnerability assessment with **health data on heat-related mortality and morbidity** to more comprehensively evaluate the impacts of UHI and inform targeted interventions. This kind of addition to the existing study may work as a valuable tool to not only improve the accuracy of the analysis but moreover give an important weight to the importance and urgency of addressing UHI issue in the public and stakeholders eyes.

- Expanding the research by **analysing** not only the city planning instruments, but also **private and/or volunteering initiatives** towards the Heat mitigation and adaptation in the city. The research could give an another level of depth and detalization to the analysis.

- Conducting a **deeper analysis on the challenges identified in the planning system**, such as the lack of cross-department coordination, to provide more targeted recommendations.

- **Evaluating the level of mitigation and adaptation** of the proposed plan policies and actions in the Turin planning framework, in order to provide a more detailed and focused analysis on the effectiveness of the planning process.

- **Evaluating possible future scenarios** using modern compiutationan tools in order to understand better the impact of different urban planning strategies on the evolution of UHI within the city.
- **Including the community in the evaluation process** of social vulnerability to Heat in order to better understand the social perception and needs of a community in relation to heat-related risks.

In summary, the Duscission chapter provides a comprehensive analysis of the research conducted, highlighting its strengths, limitations, and potential applications for urban planners and policymakers. The chapter also provides a clear direction for future research opportunities to build upon the current study and further advance the understanding and mitigation of urban heat island effects in cities like Turin, Italy.

The conclusion section of the research will provide final remarks and answers to the main research questions, and research aim.

CONCLUSION

This section will summarize the main findings of the research and provide concluding thoughts for future research and practice. Finally, the chapter will conclude with a brief overview of the study's aim and responses to the research questions posed.

The study aimed to evaluate the effectiveness of the Plan Integration for Resilience Scorecard™ (PIRS™) methodology in assessing and enhancing urban heat resilience in Turin, Italy. It sought to **answer three key questions:** the effectiveness of the current planning framework in addressing the urban heat island (UHI) effect, the identification of heat-vulnerable areas, and actionable recommendations for improvement.

The key findings indicate that the city of Turin has partially incorporated heat-related concerns and mitigation and adaptation strategies within its planning framework, particularly in more recent planning tools. However, the analysis reveals significant gaps and limitations in the city's approach, such as a lack of cross-departmental coordination, insufficient prioritization of vulnerable communities, and a disconnect between proposed policies and their effective implementation.

In summary, the PIRS™ for Heat methodology has proven to be both effective and limited in the context of Turin:

- **It is effective in identifying gaps** and reframing UHI challenges through a new lens.
- **It is limited due to differences in planning frameworks** and data availability, which reduce its applicability and the effectiveness of framework assessments in Italy compared to the U.S.

Therefore, while the methodology may not be as effective in its original U.S. context, it remains a valuable tool for catalyzing innovative perspectives and improving urban heat planning in Turin. The application of the PIRS™ for Heat methodology in Turin demonstrated its potential to support evidence-based, inclusive, and comprehensive planning for urban heat island mitigation and adaptation. Nonetheless, the research highlights the need for strengthening the overall planning framework to enable more effective implementation of heat resilience strategies.

In conclusion, the study emphasizes the necessity of a comprehensive, integrated, and flexible equity-focused approach to addressing UHI in the city of Turin. By adopting multidisciplinary frameworks with binding tools and prioritizing vulnerable areas, Turin can serve as a model for urban heat resilience planning. recommendations for future research and practice. Finally, the chapter will conclude with a brief overview on the aim of the study and reply to the posed research questions.

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LIST OF FIGURES AND TABLES

LIST OF ANNEXES

ANNEX I:
EVALUATION OF THE HEAT-RELATED PLANS OF TURIN, ITALY FOR THE PIRS™ FOR HEAT

Category IV. Climate change adaptation, resilience, or sustainability plan

Climate Resilience Plan

N	Category			Name of Action or Policy	Describtion	Reference (in the plan)	Location	Three-Point Test: Potentially Affect Heat Risk?	Three-Point Test: Place-specific?	Three-Point Test: Specific tool or intervention with objectives and outcomes?	PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
					HEATWAVES RISK related actions								
1	Preparation for HEATWAVES	RESILIENT ADMINISTRATION	Urban planning rules for a more resilient city	Revision of the PRG	Executive Urban Planning Tools: introduction of official guidelines that legitimise the adoption of design solutions to reduce heat islands	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	Revision of PRG
2				Revision of the Energy-Environmental Annex	Revision of the Energy-Environmental Annex to the Building Regulations	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	Revision of Building Regulations
3			Exiting silos for a coordinated approach	Internal working group	Internal working group supporting the preparation and monitoring of the adaptation plan and connecting with the general planning	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
4				Vertical governance	Constructing vertical institutional relations (state-region) and integrated working methods	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
5				Horizontal governance	Constructing horizontal institutional relations (municipality-municipality-city) and integrated working methods; international experiences with the city of Portland	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
6			In search of innovative solutions	Professional development	Launch a technical training programme specific to public and private construction	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
7				Technical construction manuals	Provide technicians with manuals forconstruction design with technicalspecifications and examples of solutions already implemented	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
8		EMERGENCY COMMUNICATION AND MANAGEMENT	Knowing so you can act	Dissemination ofheat alert bulletin	Sending high heat anomaly alerts to support functions and structures (codes 2 and 3) and publication of the bulletin on the institutional site for citizens	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
9				Public preparation	Widespread information activities on the various risks, aimed both at the citizens but also at the administration services	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
10				Awareness-raising	Awareness-raising activities for citizens on the correct behaviour to adopt during the hottest days	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
11				Social support strategies for the most vulnerable groups	Raising the awareness of local communities to protect the most fragile population from extreme events, stimulating a more active role, including through the identification andinvolvement of community hubs that are recognised and recognisable at a local level (pharmacies, spaces for the elderly, etc.)	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
12			Assistance for living better	Heat Emergency Plan	Implementation of the annual Heat Emergency Plan (for 3 months from June to September) targeting the "fragile" self-sufficient elderly, accompanied by local communication activities on the available projects	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	Heat Emergency Plan proposed
13				Public events support	Civil Protection intervention on the occasion of events that concentrate a large number of people in a limited area	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	
14				Municipal Emergency Plan Update	Update of the municipal emergency plan, in which heat waves are recognised as a climate risk to be managed	Annex 1, p.2	-	YES	NO	YES	**NO**	**YES**	Update of Municipal Emergency Plan
15		A COOLER CITY	Greenery that shades	Strategic Green Infrastructure Plan	Preparation of the Strategic Green Infrastructure Plan	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	Preparation in coherence of Strategic Green Infrastructure Plan
16				Increase the number of trees in the city	New tree plantings	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	
17				Increase in trees	Planting of trees along the sidewalks, on noses, in parking spaces	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	
18				River parks	Rehabilitation of river banks with the creation of river parks (Torino Città d'Acque [City of Waters])	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	Relation to Torino City of Waters Plan
19				Tree management	Management activities for healthy shade trees	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	
20				More resistant tree species	Updating the greenery regulation with the preparation of a manual of tree species that are more resistant and better adapted to new climate conditions.	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	
21				Private tree census extension	Implementation of the tree census with the private green heritage diversifying it and cataloguing the functions associated with them	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	
22				Cool road surfacing	Cooling of urban road surfaces through the use of innovative materials (draining materials, coloured asphalts, etc.)	Annex 1, p.3	-	YES	NO	YES	**NO**	**YES**	

Category IV. Climate change adaptation, resilience, or sustainability plan

Climate Resilience Plan

N	Category			Name of Action or Policy	Describtion	Reference (in the plan)	Location	Three-Point Test: Potentially Affect Heat Risk?	Three-Point Test: Place-specific?	Three-Point Test: Specific tool or intervention with objectives and outcomes?	PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
23	City Adaptation for HEATWAVES		Bilding for coolness	Solutions forblue cooling	Implementation of solutions with presence of water in squares or streets (e.g., cascading water, pools, fountains)	Annex 1, p.3	-	YES	NO	YES	NO	YES	
24				Toret relocation	Relocation of current torets, including evaluating their positioning near stops or in areas with greater vulnerability	Annex 1, p.3	-	YES	NO	YES	NO	YES	
25				Draining areas	Construction of rainwater drainage areas along the road, with green surface arrangement	Annex 1, p.3	-	YES	NO	YES	NO	YES	
26				Green tracks	Conversion of decommissioned tracks and, where possible, tram tracks in use into green tracks	Annex 1, p.3	-	YES	NO	YES	NO	YES	
27				Temporary covers	Temporary covers for the summer period in the squares or other rest areas	Annex 1, p.3	-	YES	NO	YES	NO	YES	
28		A MORE LIVEABLE CITY	Cool and comfortable public transport	TPL [Local Public Transport] Priorities	Transit signal priority for TPL	Annex 1, p.4	-	YES	NO	YES	NO	YES	
29				TPL air conditioning	Air conditioning of TPL vehicles	Annex 1, p.4	-	YES	NO	YES	NO	YES	
30				TPL stops covered	Covered stops or other shade systems	Annex 1, p.4	-	YES	NO	YES	NO	YES	
31				TPL comfort stops	Ventilation and/or atomisation solutions at the stops	Annex 1, p.4	-	YES	NO	YES	NO	YES	
32				Redesigning TPL stops	Design the TPL stops in such a way as to facilitate getting on/getting off fast	Annex 1, p.4	-	YES	NO	YES	NO	YES	
33				Shaded cycle lanes	Construction of shaded cycle lines	Annex 1, p.4	-	YES	NO	YES	NO	YES	
34			Greenery as a climate refuge	The hill as a refuge area	Think of the hill as a "refuge" area, providing rest areas, checking the access routes, and increasing services	Annex 1, p.4	-	YES	NO	YES	NO	YES	
35				Horizontal signposting of refuge areas	Map of the green areas, to be positioned also in the TPL stops, and signposting to reach climate shelters	Annex 1, p.4	-	YES	NO	YES	NO	YES	
36			Cool and comfortable schools and public	Green roofs	Conversion of roofs in public and private areas through the creation of green roofs	Annex 1, p.4	-	YES	NO	YES	NO	YES	
37				Green walls	Creation of green walls with a suitable choice of wood able to ensure reduced maintenance, also consider the possibility of creating a cavity between the green wall and the building, technological or conventional green walls (shading deciduous or evergreen creepers)	Annex 1, p.4	-	YES	NO	YES	NO	YES	
38				Reflective paints	Cooling of building roofs by laying materials with a high SRI (solar reflectance index) such as paints or reflective membranes	Annex 1, p.4	-	YES	NO	YES	NO	YES	
39				Cooling systems for public buildings	During extraordinary maintenance operations, installation of low-energy cooling systems in office buildings	Annex 1, p.4	-	YES	NO	YES	NO	YES	
40				Shield systems	Use of shield systems (including automated) to reduce insolation on buildings	Annex 1, p.4	-	YES	NO	YES	NO	YES	
	FLOODS RISK related actions												
41		RESILIENT 'ION	Urban planning rules for a more resilient city	Revision of the PRG	Revision of the PRG with the inclusion of standards/indices in order to reduce land consumption, ensure hydraulic invariance in new transformations, and increase permeable areas	Annex 1, p.5	-	NO	NO	YES	NO	NO	Revision of PRG
42				Revision of the Building Regulations	Revision of the Building Regulations	Annex 1, p.5	-	NO	NO	YES	NO	NO	Revision of Building Regulations
43				Rainwater drainage regulation	Identification of some simple solutions for rainwater drainage to be approved with a regulation	Annex 1, p.5	-	NO	NO	YES	NO	NO	
44			Exiting silos for a coordinated approach	Internal working group	Internal working group supporting the preparation and monitoring of the adaptation plan and connecting with the general planning	Annex 1, p.5	-	NO	NO	YES	NO	NO	
45				Governance tool with AIPO (the Interregional Agency for the Po River) or other competent body	Identify an effective governance tool with AIPO or other competent body on the waterways crossing the city in order to coordinate prevention works and management	Annex 1, p.5	-	NO	NO	NO	NO	NO	
46				Vertical governance	Construction of vertical institutional relations (state-region) and integrated working methods	Annex 1, p.5	-	NO	NO	YES	NO	NO	
47				Horizontal governance	Constructing horizontal institutional relations (municipality-municipality-city) and integrated working methods; international experiences with the city of Portland	Annex 1, p.5	-	NO	NO	YES	NO	NO	

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48	HOW TO PREPARE		In search of innovative solutions	Specific technical internal training	Specific technical training on designing drainage areas and raingardens and good practices for whitewater management as an alternative or as a supplement to the network of rainwater drainage	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
49				Technical manuals	Providing technical manuals for urban planning with technical specifications and examples of solutions already implemented	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
50				Sample of possible solutions for planners	Define a sample of actions to support design, including of private individuals, to cope with the increase in heavy rainfall	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
51				Training and internal sharing of solutions already adopted	Internal sharing of solutions already adopted by the city, including on an experimental basis	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
52			A careful look to the future	Mapping of the main critical areas	Integration of available maps identifying critical areas in the region both for the risk of overflowing waterways and flooding phenomena caused by intense precipitation events or because of the presence of critical infrastructure (e.g., tanks, plants, etc.)	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
53				Preventive measures in hilly areas	Monitoring and visual reconnaissance of the hilly areas, especially in the areas close to the houses, checking the presence of any critical points (landslides, mudslides, etc.)	Annex 1, p.5	-	not directly	NO	YES	**NO**	**NO**	
54				Economic reporting related to extreme events with damage to public greenery and municipal buildings	Evaluate the costs incurred due to extreme weather events and the potential costs related to the increased frequency and intensity of the events	Annex 1, p.5	-	not directly	NO	YES	**NO**	**NO**	
55				Monitoring of the storm drains and periodic cleaning	Monitor the condition of the storm drains to clean them regularly to reduce storm drain malfunction due to leaf accumulation or heavy rain.	Annex 1, p.5	-	NO	NO	YES	**NO**	**NO**	
56		EMERGENCY COMMUNICATION AND MANAGEMENT	Knowing so you can act	Implementation of a widespread preventive communication campaign aimed at citizens	Inform citizens about what to do to inform and protect themselves and about the risks in the vicinity of their home, workplace, and commute. Inform citizens about the collection areas (highlighting them with appropriate signposting)	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
57				Dissemination of the weather and hydrological alert bulletin	Transmission of the weather and hydrological alert bulletin to the Municipal Office of Civil Protection and subsequent transmission to the contacts identified by the body, as well as dissemination to citizens	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
58				Define a structured communication and behavioural procedure (during or following an event)	Provide citizens, through data and communications, with information on events that have occurred in the city (e.g., in the case of fallen trees or parks closing due to uninhabitable situations) and raise awareness regarding the adoption of behavioural practices that reduce the risk (what not to do when there is an extreme weather event in progress)	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
59				Communication activities on new solutions for draining rainwater	Communication activities to explain the objective of testing new solutions for draining rainwater	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
60			Assistance for living better	Municipal Emergency Plan Update	Updating the Municipal Emergency Plan, taking into account the interaction with the other services of the city (e.g., green management in case of emergencies)	Annex 1, p.6	-	not directly	NO	YES	**NO**	**NO**	Municipal Emergency Plan Update
61				Define an internal operating procedure for managing one-off emergency events	Definition of the procedure and coordination for an immediate management of rapid events, specifying how to interact with the other parties involved (Civil Protection, Municipal Police Operations Centre, Fire Brigade, Bridge and Waterway Service), how to intervene and who does so	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
62				Civil protection exercises	Programming and management of regular civil protection exercises for rapid and sudden flooding or rain events	Annex 1, p.6	-	NO	NO	YES	**NO**	**NO**	
63			Long-term green	Sategic Green Infrastructure Plan	Preparation of the Strategic Green Infrastructure Plan	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	Referiment to Strategic Green Infrastructure Plan

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64			and land solution	Green drainage areas along the roads	Rainwater drainage areas along urban road infrastructure	Annex 1, p.7	-	YES	NO	YES	**NO**	**YES**	
65				Rain garden	Green areas for rainwater collection and subsequent runoff	Annex 1, p.7	-	YES	NO	YES	**NO**	**YES**	
66				Removal of waterproofed spaces	Increase in soil permeability	Annex 1, p.7	-	YES	NO	YES	**NO**	**YES**	
67		A CITY IN HYDROLOGICAL BALANCE		Use of draining materials	Use of draining materials in areas undergoing transformation (exiting experimentation phase)	Annex 1, p.7	-	YES	NO	YES	**NO**	**YES**	
68			Hydraulic invariance principle of every transformation	Adaptation of the stormwater drains	Regularly clean the stormwater drains and replace, where possible, with curbside storm drains to reduce the risk of clogging from leaves	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
69				Rainwater collection	Rainwater collection on roofs to allow its subsequent reuse, including through the construction of green roofs	Annex 1, p.7	-	YES	NO	YES	**NO**	**YES**	
70				Forms of facilities/incentives	Provide forms for facilities/incentives (e.g., savings on water bills) for those who do not discharge white water into the whitewater drainage system	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
71	HOW TO ADAPT THE CITY			Removal of hazard and disturbance elements from the river banks	Removal of hazard and disturbance elements from the river banks, such as unregulated gardens, business activities/storage, and unauthorised housing developments	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
72			The hill that flows safely	Inspections of hill streams encased in pipes	Inspections and cleaning of hill streams encased in pipes	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
73				River cleaning	Removal of debris/branches/wood that would be transported downstream creating weirs and increasing the impact on infrastructure	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
74		A SAFE CITY		Natural lamination solutions in areas far from urban areas	Intercept, upstream, suitable areas for the Dora and Stura; coordinate with AIPO and solicit interventions for the Po. Use the River Contract tool	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
75				Implementation of structural prevention works	Implementation of structural prevention works such as bank defences, embankments, raising of banks (financed with state funds following the flood of 2000) to reduce the risk of flooding	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
76			Protected waterways	Construction of the embankment on the left bank of the Po River	Construction of the embankment on the left bank of the Po River	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	
77				Assessment of possible embrasures	Check the need for possible embrasure of sections of waterways encased in pipes in order to reduce critical points for small riverbed cross-sections	Annex 1, p.7	-	NO	NO	YES	**NO**	**NO**	

***Notes related to the connection between action or policy to another city plan or project**

'-' - missing or not enough information provided in plan for evaluation

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Strategic Plan for Green Infrastructure [GREENPRINT]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
1	GREEN ROOFS	Intensive green roofs	Also called rooftop gardens or terraces, they are composed of lush vegetation and are based on a relatively deep and nutrient-rich substrate. They can support large plants and conventional lawns.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
2	GREEN ROOFS	Extensive green roofs	Characterized by a shallow, self-sustaining cultivation medium and a low-maintenance plant system covering the entire roof surface. They are sometimes referred to as "sedum roofs." There are two main types of extensive green roofs: 1) mat-based systems, which have very shallow soil depths (typically 20-40mm) and are pre-planted to provide 100% instant coverage; 2) substrate-based systems: generally 75-150mm in depth, consisting of a porous substrate or similar reused aggregates.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
3	Vertical Greening Systems (VGS)	Traditional green facades	Woody or herbaceous climbing plants usually planted at the base of a wall.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
4	Vertical Greening Systems (VGS)	"Double-skin" green facades	An engineered support structures for climbing vegetation with an insulating air layer between the foliage and the building's wall	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
5	Vertical Greening Systems (VGS)	Green or living walls	Generally more complex than facades, they are based on a supporting structure with various attachment methods, such as panels, planters, or a cultivation substrate in fabric (felt) where vegetation grows	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
6	Vertical Greening Systems (VGS)	Vertical forest	A model of sustainable building design that incorporates various trees, shrubs, and plants into the structure of the building.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
7	-	Street trees and green paths	Planting vegetation next to high-capacity infrastructure such as highways and railways.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
8	-	Green rails	Ground cover or grassing of tram circulation areas.	Annex 6, p.2	-	YES	NO	NO	**NO**	**YES**	
9	-	Green areas	Urban parks, forests, and other green spaces in cities. Green corridors designed to enhance urban ventilation.	Annex 6, p.2	-	YES	NO	NO	**NO**	**YES**	
10	Component of the Sustainable Drainage System (SuDS)	Rain gardens	Small vegetated depressions in the ground that can infiltrate water drained from the roof and other clean surface waters. Also known as "bioretention areas." Typically implemented at the individual property level, near buildings.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
11	-	Green urban furniture	Biomaterials in benches and other outdoor public furnishings.	Annex 6, p.2	-	YES	NO	YES	**NO**	**YES**	
12	-	Urban gardens	Urban and community gardens.	Annex 6, p.3	-	YES	NO	YES	**NO**	**YES**	
13	-	River restoration for flood control	Measures to restore the natural state and function of rivers: riverbed renaturalization (or riverbed restoration); renaturalization of riverbed material; removal of bank protection.	Annex 6, p.3	-	NO	NO	NO	**NO**	**NO**	
14	-	Floodplain and riparian woodland creation	Transitions between terrestrial and aquatic ecosystems, including floodplains and adjacent terraces.	Annex 6, p.3	-	NO	NO	NO	**NO**	**NO**	
15	Component of the Sustainable Drainage System (SuDS)	Rainwater harvesting	Collection and conservation of rainwater for subsequent use. Traditionally collected from roofs, it can also be retained from all other impermeable surfaces, such as industrial buildings or parking lots. It is stored in individual barrels, underground tanks, or large storage tanks. Various collection systems exist, including gravity-based or pump-assisted systems.	Annex 6, p.3	-	NO	NO	NO	**NO**	**NO**	
16	Component of the Sustainable Drainage System (SuDS)	Pervious surfaces	Permeable surfaces (or sidewalks) allow rainwater to infiltrate through the surface and into the underlying layers.	Annex 6, p.3	-	YES	NO	NO	**NO**	**YES**	
17	Component of the Sustainable Drainage System (SuDS)	Infiltration basins	Shallow vegetated depressions designed to store surface runoff and gradually infiltrate it into the soil.	Annex 6, p.3	-	YES	NO	YES	**NO**	**YES**	
18	Component of the Sustainable Drainage System (SuDS)	Infiltration trenches	Shallow excavations filled with debris or stones that allow water to infiltrate from the surrounding ground.	Annex 6, p.3	-	NO	NO	YES	**NO**	**NO**	
19	Component of the Sustainable Drainage System (SuDS)	Soakaways	Square or circular underground spaces filled with rubble or lined with bricks or polyethylene rings that store surface runoff in the soil.	Annex 6, p.3	-	NO	NO	YES	**NO**	**NO**	

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Strategic Plan for Green Infrastructure [GREENPRINT]

Plan Actions and Policies						*Three-Point Test*			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
20		Swales	Shallow, wide, and vegetated channels that store and/or transport runoff between different stages of a sustainable drainage system. They can also be designed to promote infiltration where soil and groundwater conditions allow.	Annex 6, p.3	-	YES	NO	YES	**NO**	**YES**	
21		Planted channels and rills	Shallow channels that collect surface runoff. They can be integrated at the outset of a Sustainable Drainage System (SuDS). They can slow down water flow, capture pollutants, and convey runoff to downstream SuDS components.	Annex 6, p.4	-	YES	NO	NO	**NO**	**YES**	
22		Detention basins	Vegetated depressions designed to store and slow down the flow of water. Sediments and other pollutants in the stored water can be filtered, absorbed by the surrounding soil, or biodegraded, while the stored water can be slowly drained into a nearby watercourse using a discharge control structure to regulate the flow. Detention basins generally do not allow for infiltration. Detention basins are typically dry except during and immediately after a storm and can function as recreational or other types of structures. Detention basins are usually positioned toward the end of the SuDS, so they are used if extended treatment of runoff is needed or for wildlife or landscape reasons.	Annex 6, p.4	-	YES	NO	YES	**NO**	**YES**	
23		Retention ponds	Ponds designed with additional storage capacity to provide runoff attenuation during rainfall events. They consist of a permanent pond area with naturalistic shores.	Annex 6, p.4	-	NO	NO	YES	**NO**	**NO**	
24		Geocellular storage systems	Highly porous plastic modular units assembled to form a structure for the temporary underground storage of water before controlled release or reuse.	Annex 6, p.4	-	NO	NO	YES	**NO**	**NO**	
25	-	Blue roofs	They retain and release rainwater runoff slowly using various types of flow control devices or structures.	Annex 6, p.4	-	NO	NO	YES	**NO**	**NO**	

***Notes related to the connection between action or policy to another city plan or project**

'-' - missing or not enough information provided in plan for evaluation

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
MITIGATION actions											
1	Incentivization and awareness-raising	RT 1: Adaptation of building regulations and environmental energy annex	The Energy-Environmental Appendix to the Building Regulation (approved by Resolution C.C. 2018 02466 on July 2, 2018) outlines both mandatory and voluntary requirements to improve the energy and environmental aspects of construction. Voluntary requirements incentivize projects exceeding minimum standards, offering up to a 50% discount on development charges. An update is planned to address regulatory, technological, and market changes.	p.52	-	not directly	NO	YES	**NO**	-	Adaptation of Building Regulations and Environmental Energy Annex
2		RT 2: Information and awareness of citizens and operators with respect to incentives and energy saving opportunities	The action aims to assess the introduction of an Energy Desk, drawing from past experiences of the Administration (e.g., progetTo Energia) or ongoing regional initiatives (Energy Desk Piemonte, https://www.sportelloenergia.envipark.com/). To achieve the goals of the PAESC, direct private involvement, such as building rehabilitation projects, requires tools to support and guide them in decision-making. The desk should provide consultation on financing opportunities, tax incentives, legislative insights at national and regional levels, energy efficiency criteria, renewable sources, energy certification systems, lists of local professionals, certified standards for interventions, reference price lists, and energy supply contracts.	p.53	-	not directly	NO	YES	**NO**	**YES**	
3		RT 3: Application of CAM in SEA procedures	The aim of this action is to provide practical guidelines for Strategic Environmental Assessment (SEA) procedures on plans with cost-exempt works or public use. It includes adherence to legislative articles, city plans, and protocols. The action introduces design specifications within SEA procedures, aligning with Turin's participation in the APE protocol for Ecological Public Procurements. Guidelines will be defined for municipal sectors in cases of plan variations or new constructions subject to SEA, encouraging coherence with environmental criteria. These guidelines will apply in SEA phases, ensuring compliance with established criteria. Specific focus areas include reducing the "summer heat island" effect, primary infrastructure, sustainable mobility, and energy supply.	p.54	-	not directly	NO	YES	**NO**	-	Updates to Article 34 of Legislative Decree 507/2016, Climate Resilience Plan, Strategic Plan (and Action Plan) on Urban Sustainable Water Management Plan, Action Plan for Sustainable Energy and Climate (PAESC), Relazione di valutazione dei Servizi Ecosistemici, ITACA protocol.
4	Enhancement of the District Heating Network	TLR 1: Extension of the district heating network	This action involves expanding the current district heating network to the San Salvario neighborhoods and the North-East area of Turin. Overall, the action includes the construction of over 70 km of new network from 2021-2027, connecting a volume of 73,235,351 m³ to 87,440,000 m³ and generating an additional 200 GWh/year of energy.	p.56	San Salvario, Torino Nord-Est	YES	YES	YES	**YES**	-	
5		TLR 2: Construction of a storage power plant in progress Salvemini	The action involves creating a new Iren heat storage and solar thermal system in Mirafiori Nord, at the corner of Corso Salvemini and Via Guido Reni, previously occupied by the old thermoelectric power plant. The site includes integrated systems: a heat storage system with three tanks totaling approximately 2500 m³, a pumping station with three electric pumps for heat distribution, a solar thermal system with a nominal power of 411 kW connected to the district heating system of Mirafiori Nord, and a 45 kWp photovoltaic system on the building's roof.	p.57	Corso Selvemini corner via Guido Reni (Mirafiori Nord)	YES	YES	YES	**YES**	-	
6	Public Housing	EP 1: Energy requalification through project financing	IREN Smart Solution Spa plans to implement a "project financing" initiative for 821 municipal buildings. This involves the concession for the upgrading of plant and energy systems to enhance the efficiency of the city's properties, including their management and energy supply. The IREN project outlines a long-term financing operation (27 years) covering a majority of buildings with various efficiency and energy upgrading services. The aim is to achieve significant cost savings for both the city and the users of the leased/concessioned spaces.	p.58	-	not directly	NO	YES	**NO**	-	Referiment to IREN's Energy Efficiency Action Plan

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7		EP 2: Energy requalification of libraries and buildings of historical and cultural interest	Energy efficiency improvements are planned for 25 historically and culturally significant buildings or buildings used as libraries, using funds obtained from projects and funding competitions.	p.59	Buildings leased at Via Foligno 10, Via Abeti 12/2, Via Le Chiuse 80, Via Verolengo 29; Offices and multipurpose hall at Centro Rete; Libraries: at the mausoleum of Bela Rosin, Tesoriera, Villa Amoretti, Calvino, Geisser; Cultural building at Via Viterbo 169; Former Superga factory; CPG on Strada delle Cacce, Via Rubino 24, Corso Siracusa 225; Passerin d'Entreves, Marchesa, Bonhoeffer, Ginzburg libraries; Spazio 4 Neighborhood House and Marchesa Auditorium; Murazzi del Po (Student Zone / Arcades).	YES	YES	YES	**YES**	-	Relation to CO-City Project, PIU-PNRR, Public works plan 2021-2023, PIU M5C2
8		EP 3: Energy requalification of school buildings	Energy efficiency measures are planned for 8 municipal school buildings.	p.60	Corso Vercelli 157, Via Cecchi 16/18, Via Beinasco 34; Via Vallauri 24, Via Lussimpiccolo 36/A, Via Randaccio 60, Via San Sebastiano Po 6, Via Ada Negri 21 – 23.	YES	YES	YES	**YES**	-	Public works plan 2021-2023, PIU M5C2
9		EP 4: Energy requalification of social housing	ATC Central Piedmont plans to potentially redevelop 248 social housing buildings, including 56 owned by the City of Turin. Estimated heated volumes vary with different technologies: 605,000 m³ with district heating 116,500 m³ with wall boilers (methane) 480,200 m³ with centralized methane-powered systems. The action involves public notices for proposals from ESCOs. Assuming an average energy class of E and achieving class C after interventions, the estimated annual energy savings are: 6,691,300 kWh for district heating-connected buildings 1,223,250 kWh for buildings with wall boilers 5,042,100 kWh for buildings with centralized methane-powered systems.	p.61	-	YES	-	YES	**NO**	**YES**	Referents to ATC (Agenzia Territoriale per la Casa del Piemonte Centrale) requalification programs
10		EP5: Energy requalification of municipal office buildings	Energy efficiency improvements are planned for 2 significant municipal buildings.	p.62	Municipal building at Piazza San Giovanni and Municipal Police, the Department of Environment and Ecological Transition offices at Via Padova 29/Via Bologna	YES	YES	YES	**YES**	-	PON Metro 2014-2020 Energy efficiency program, European Probis project, Public works plan 2021-2023
11		EP 6: Energy requalification of barracks and police stations	It involves the energy redevelopment of the Provincial Fire Department Command Headquarters on Corso Regina Margherita, with the replacement of existing 800 kW condensing boilers and connection to the city's district heating network.	p.63	Headquarters of the Provincial Fire Department, Corso Regina Margherita	YES	YES	YES	**YES**	-	
12	Public Lighting	IP 1: Replacement of light points with LED technology	The action, part of the "LED for Turin" project (a continuation of the Torino LED project started in 2015), involves continuing the replacement activities for the lighting fixtures in the public lighting network with LED technology-equipped lamps. The overall replacement of 3,250 public lighting lamps is planned, transitioning from current 400W discharge lamps to 275W LED lamps, with the goal of reaching 62% of LED lighting among the total 96,289 city light points. The project aims to achieve a reduction of 4,550 tons of CO2.	p.64	-	not directly	NO	YES	**NO**	-	Relation to the Project "LED per Torino"
13		IP 2: Replacement of traffic lights with LED technology	The action, part of the "LED for Turin" project (a continuation of the Torino LED project started in 2015), involves continuing the replacement activities for the traffic light fixtures, transitioning from the current three 60W incandescent lamps (per lantern) to 8W LED lamps. The overall replacement of 12,000 traffic light lanterns is planned, with the goal of reaching 100% LED lanterns among the total 18,869 present in the city.	p.65	City of Turin	not directly	YES	YES	**NO**	-	Relation to the Project "LED per Torino"
14	Utilization of Renewable Energy Sources	FER 1: Purchase of electricity from FER	It is planned to renew the agreement with CONSIP for the purchase of 100% certified energy from renewable sources with Guarantee of Origin (GO).	p.66	-	not directly	NO	YES	**NO**	-	Relation to the Project "LED per Torino", Policies for the GPP (Green Public Procurement) of the City of Turin

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

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15	Energy Management	GEST 1: ISO 50001 certification by the Municipality of Turin	Completion of the implementation and certification process of the City of Turin's energy management system for utilities and properties, according to the ISO 50001:2018 standard. The certification covers the design and delivery of educational and didactic, registry and socio-assistance, technical-administrative, sports, and cultural services.	p.67	-	not directly	NO	YES	**NO**	-	Special project "ISO 50001 energy management system"
16	Enhancement of Public Transportation Infrastructure and Services (TPL)	TPL 1: Strengthening the use of interchange car parks	The action aims to increase the level of intermodality in the private transport sector by promoting the use of park-and-ride facilities managed by GTT (Venchi Unica, Stura, Caio Mario, Bengasi), resulting in a reduction in private car usage. The action involves increasing the average occupancy rate (28% in 2018) through coordinated initiatives between the City of Turin and GTT.	p.68	Park-and-Ride parkings: Venchi Unica, Stura, Caio Mario, Bengasi	not directly	YES	YES	**NO**	-	
17		TPL 2: Underground public parking in Piazza Bengasi	The intervention aims to encourage interchangeability between private and public transportation. The project extends metro line 1 with a terminal station at Piazza Bengasi, providing an opportunity to shift people to public transport. The plan includes an underground parking facility beneath the square, offering 639 car and some motorcycle spaces. This interchange parking is expected to increase public transport usage, reducing 590 daily vehicles over an 8 km stretch.	p.69	Piazza Bengasi	NO	YES	YES	**NO**	-	Relation to Public works plan 2021-2023
18		TPL 4: Implementation of Metro Line 2 – Lot 1	Line 2, configured in a "Y" shape, will connect 32 stations along a total route of 27 km, divided into three main sections: a central 16 km section with 23 stations, starting from Rebaudengo to Anselmetti; a southward extension from Anselmetti to Orbassano, spanning 6 km and connecting 5 stations; a northward extension of the same length with 4 stops, reaching Pescarito/S. Mauro. Line 2 will integrate with existing public transportation through three interchange points. At Zappata and Rebaudengo stations, it will connect to the Metropolitan Railway System, while at Porta Nuova Station, it will intersect with Metro Line 1. Additionally, four interchange parking facilities for public and private vehicles are planned to enhance the intermodality of the transport system at Orbassano, Anselmetti, San Mauro, and Rebaudengo stations. Lot 1 covers the Rebaudengo–Politecnico section.	p.71	LOTTO 1 plan of Metro Line 2 between Rebaudengo – Politecnico stations, interchange parking in stations Orbassano, Anselmetti, San Mauro e Rebaudengo	YES	YES	YES	**YES**	-	Relation to Public works plan 2021-2024
19		TPL 5: Completion and enhancement of the SFM (SFM line)	The Metropolitan Railway System (SFM) is a project aimed at reorganizing local railway services in the Turin area. Currently consisting of 8 metropolitan railway lines, the service operates with trains running every 30 minutes throughout the day. Key features include interconnected and coordinated lines, regular service intervals without interruptions throughout the day, and high train frequency in the central urban area (every 8 minutes during peak hours). The action involves completing the underground connection through an artificial tunnel between the historic Turin-Ceres railway and the Metropolitan Railway, with interconnection to Porta Susa station and the Turin transport network. The project also includes the construction of the underground Grosseto station near Largo Grosseto, replacing the existing Madonna di Campagna station, which is no longer part of the new railway line. Along Corso Grosseto, between Largo Grosseto and Parco Sempione, a 2.1 km bike path is planned, along with interventions to reorganize parking areas. This profile highlights the emission reduction benefits associated with the completion of the entire Metropolitan Railway System project.	p.72	Underground Grosseto station near Largo Grosseto; connection between the Turin-Ceres railway and the Metropolitan Railway, with an interconnection to Porta Susa station	not directly	YES	YES	**NO**	**NO**	Relation to Public works plan 2021-2025
20	Enhancement of Alternative Mobility to Private Vehicles	MA 1: Expansion of the cycling network	The action includes a series of interventions for the extension and creation of new bike paths, implemented within projects related to various sectors: mobility, land development, infrastructure construction, urbanization, and green areas. In total, this involves 68.3 km of new bike paths, categorized into both one-way and two-way paths	p.73	-	YES	NO	YES	**NO**	**YES**	Relation to Public works plan 2021-2026, Decreto Ciclovie and Projects REACT
21		MA 2: Installation of new bike racks	The action involves creating new spaces for bicycle parking and maintenance stations. The latter, designed for minor bike repairs, will be strategically placed along the most frequented bike paths. Additionally, 1,300 new bicycle parking spaces will be installed in suitable and highly frequented locations: along bike paths, in front of gathering places such as squares, neighborhood centers, schools, public offices, and near metro stations and Gtt lines.	p.74	-	not directly	NO	YES	**NO**	**NO**	

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

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22		MA 3: Enhancement and promotion of station-based bike-sharing	The action involves reactivating the To Bike service with 120 operational stations. Out of the previous 170 stations, 70 will be decommissioned, 100 will be refurbished, and 20 new ones will be created	p.75	-	YES	NO	YES	**NO**	**YES**	Service To-Bike
23		MA 4: Promotion of free-floating mobility sharing services	Activation of a free-flow shared mobility service with traditional bicycles, electrically assisted bicycles, electric scooters, and innovative electric-powered vehicles (such as electric scooters or Segways).	p.76	-	YES	NO	YES	**NO**	**YES**	
24		MA 5: Strengthening and promotion of car-sharing	The action involves selecting operators for an environmentally friendly car-sharing service through a public notice. The service is planned to run from September 1, 2021, to August 31, 2024, with the option to renew. Each fleet must consist of a minimum of 200 vehicles, which cannot be diesel-powered and must comply with the highest emission standards set by EU regulations - Euro 6 and subsequent standards. Vehicle types can include Plug-in Hybrid Electric Vehicles (PHEV) with a minimum electric-only range of 50 km, Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), vehicles powered by Liquefied Petroleum Gas (LPG) with dual fuel capability (petrol-LPG), and vehicles powered by Compressed Natural Gas (CNG) with dual fuel capability (petrol-CNG).	p.77	-	not directly	NO	YES	**NO**	**NO**	
25		MA 6: Installation of public electric vehicle charging stations	The action involves expanding the network of electric vehicle charging points on public land in the city. This expansion will be carried out through the implementation of procedures for evaluating requests, authorization, installation, and activation of charging stations, as outlined in the 2018 call for expressions of interest from private entities. The process consists of two phases: Analysis of projects and acquisition of technical opinions within the multidisciplinary technical committee. Issuance of building permits, authorizations, and concessions. The ultimate goal is to activate 500 charging points (considering 2 charging points per station) by 2023 and 800 by 2024.	p.78	-	YES	NO	YES	**NO**	**NO**	
26		MA 7: Installation of bike stations	Construction of a bicycle parking lot (velostation) consisting of 100 stalls, in Via Nizza near Porta Nuova. The stations are made up of various double-height metal stalls, seven of which are equipped with electric charging stations to allow those in possession of an electric bike to recharge it. Inside this space there is an area intended for a cycle workshop for the repair or rental of bicycles.	p.79	Via Nizza near Porta Nuova station	YES	YES	YES	**YES**	-	
27		MA 8: Promotion of new forms of mobility (MaaS (Mobility as a Service))	The intervention involves a series of actions aimed at testing the MaaS (Mobility as a Service) model, a model for providing people transport services based on a single technological platform which, by combining the various shared mobility services, maximizing the simplicity of access and optimizing economic convenience, intends to constitute an even more efficient and advantageous alternative to the use of a private car. The following actions are planned: - Experimentation for a year of mobility vouchers via a MaaS platform, with a project managed by the City of Turin in collaboration with 5T (https://www.muversiatorino.it/it/maastorino/) - BIPforMaaS project: For the period from June to September 2022, through the BIPforMaaS app, various mobility options will be made available to encourage shared and collective mobility. - MaaS for Italy project: involves investment in the digitalisation of mobility services (in particular public transport) which will be integrated with the national platform proposed by the Ministry; encouraging citizens towards new ways of moving, smarter, more sustainable and more digital through the use of vouchers, discounts and cashbacks, to create a Living Lab on "Cooperative, connected and automated mobility", to test innovative solutions of local transport.	p.80	-	YES	NO	YES	**NO**	**NO**	

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28		MA 9: Rationalization of urban goods distribution	Renewal of Protocollo di Intesa (the Protocol of Understanding) for the logistics and rationalization of the urban distribution of goods between the city of Turin, CCIAA(Chamber of Commerce, Industry, Crafts and Agriculture) and the Associations, integrating and updating the sustainability criteria. The Protocol must be aimed at achieving the sustainability of the distribution of goods in the city through a progressive accreditation process of vehicles and logistics platforms, through actions such as: - reorganization of the loading-unloading times of goods within the Central Limited Traffic Zone (ZTL), establishing an accreditation process through which commercial vehicles will be registered according to environmental requirements - adoption of reward measures for the circulation of accredited vehicles - use of logistics platforms and vehicles meeting the minimum requirements required for accreditation to the urban goods distribution service;	p.81	-	not directly	NO	YES	**NO**	**NO**	
29	Reduction of the Environmental Impact of the Public Vehicle Fleet	FL 1: Purchase of new electric buses	The action aims to improve the emission profile of the fleet of urban buses circulating in GTT, through the purchase of 120 new electric buses which will be added to the 50 already entered service in 2021, to replace the most obsolete diesel vehicles (Euro 3 and Euro 4) and a part of the methane vehicles more than 5 years old.	p.82	City of Turin	YES	YES	YES	**YES**	-	GTT (The Turin Transport Group) plan to 2023/2024
30		FL 2: Shift to rail for public transportation (TPL)	The action aims to increase the % of rail travel of urban LPT vehicles using electrified vehicles, through interventions of: - purchase of 70 new electric trams; - 23% increase in the tram network, going from 78.33 to 96.19 km.	p.83	City of Turin	YES	YES	YES	**YES**	-	GTT (The Turin Transport Group) plan to 2023/2024
31		FL 3: Purchase of new methane-powered and Euro 6 buses	The action aims to improve the emission profile of the fleet of urban buses circulating within GTT, through the purchase of 122 new methane buses to replace the most obsolete diesel vehicles (Euro 3 and Euro 4) and a part of the methane vehicles more than 5 years old	p.84	City of Turin	YES	YES	YES	**YES**	-	GTT (The Turin Transport Group) plan to 2023/2024
32		FL 4 : Improvement of the emission profile of municipal vehicles	The action aims to improve the emission profile of the fleet of 863 vehicles forming part of the City of Turin's vehicle fleet, increasing the share of low-emission vehicles powered by LPG (liquefied petroleum gas), methane or electricity. The "Green to share" project includes in particular: - the purchase of 87 new electric vehicles, replacing internal combustion vehicles with an average age of more than 12 years - the acquisition of an integrated technological platform, aimed at introducing a shared mobility service (corporate car sharing), consisting of: - a front end system via web and app aimed at users - a software application and on-board unit for the management of vehicle fleets and transport services - a network of charging points for electric vehicles (wall boxes) located in parking areas identified within at least 20 municipal offices For the evaluation of the environmental benefits, it was considered that electric vehicles replace petrol and diesel vehicles in a proportional way to the number of vehicles present in the municipal fleet in 2019.	p.85	City of Turin	YES	YES	YES	**YES**	-	Project "Green to Share"
33	Urban Afforestation Initiatives	FU 1: Participatory reforestation campaigns	The action includes the "1000 trees for Turin" initiative, which includes the involvement of residents, environmental associations, political representatives and municipal technicians. Based on historical data (2000 trees planted between 2016 and 2018), the planting of 500 trees/year is estimated for a total of 5000 trees by 2030.	p.86	City of Turin	YES	YES	YES	**YES**	-	"1000 trees for Turin" campaign
34		FU 2: In-house reforestation interventions	The action involves the planting of approximately 40,000 trees in extensive city parks and another 20,000 trees through participation in the "forestation" tender (Climate decree) with the "Corona Verde - Turin metropolitan area" project. This latest project involves the use of native species, among which the most represented will be oaks (oak and oak), hornbeam, field maple, ash, black alder, white, black and aspen poplars, the wild cherry, the elm, the mountain ash with the addition of shrub species such as hawthorn, hazel, laburnum, viburnum, dogwood and dogwood. In addition to the reforestation work, the maintenance and survival of the young plants must be guaranteed for the first seven years of planting. Finally, the planting of 1200 new trees is planned through the funds of the Integrated Urban Plan (measure M5C2 of the PNRR) and further planting interventions in the river parks of Colletta and Confluence, Meisino, Pellerina, Stura Nord and Nizza Millefonti (project REACT).	p.87	City of Turin	YES	YES	YES	**YES**	-	Climate decree / PNRR (National Recovery and Resilience Plan), the "Corona Verde – the Turin Metropolitan Area" project, REACT project

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

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35	Green Maintenance and Management Aimed at Preserving Absorption Capacity	FU 3: Reforestation campaigns with sponsors and institutional partners	The City of Turin intends to stipulate a series of memoranda of understanding with specialized organizations, responsible for intercepting the interest of private companies in carrying out forestation interventions as part of carbon offset policies. In particular, collaboration protocols have been activated with 3 non-profit organizations (AzzeroCO2 - Rete Clima - Arbolia/SNAM) in order to encourage the financing of urban forestry interventions in the Turin area by private entities who want to engage in the environmental field both for the improvement of the quality of urban territory and to combat climate change.	p.88	-	not directly	NO	YES	**NO**	**NO**	
36		MGV 1: Interventions for increasing the resilience of public green spaces – REACT Project	The action involves: · protect the forests of the hilly area owned by the Municipality; · redevelop the urban front of the river parks, with urban forestry interventions and pruning and planting of shrubs on the banks of the Po · improve the tree-lined avenues, in particular Corso Umbria and Corso Belgio.	p.89	Banks of the Po river, corso Umbria and corso Belgio	YES	YES	YES	**YES**	-	Strategic Plan for Green Infrastructure (GREENPRINT) and Proposal of REACT Project
37		MGV 2: Maximization of Ecosystem Services in Hillside Forests	The Administration has decided to start the development of a specific management plan for the hilly forests owned by the municipality. The Corporate Forestry Plan (PFA) of the Municipality of Turin 2020-2035 aims to enable the City of Turin to manage its forestry assets in a sustainable, innovative and effective way, with the aim of strengthening the environmental support services offered from the forest, the so-called ecosystem services (ES), i.e. the benefits that the forest ecosystem can offer to the citizens of Turin, through a planning of silvicultural interventions over a fifteen-year period, including the capacity for carbon sequestration and storage.	p.90	Hillside forests of Turin	not directly	YES	YES	**NO**	**YES**	Strategic Plan for Green Infrastructure (GREENPRINT) and 2020 Corporate Forestry Plan (PFA)
				ADAPTATION actions							
38	Biodiversity	A1: Strategic Green Infrastructure Plan	With the City Council Resolution of 22 March 2021, the Strategic Green Infrastructure Plan was approved, an analysis and programming tool to direct investments and management policies of the Turin public urban green system in the coming decades, integrating the tools of urban planning. The Plan analyzes and delves into Turin's urban green system, defining medium-long term strategies for its valorisation and development. This is a planning document to direct investments in new works and maintenance interventions, define management priorities of the urban public green infrastructure system, starting from an overall analysis of the public green system, identifying the strengths and weaknesses, evaluating opportunities and defining strategies, objectives and actions. A part is reserved for the role of public green spaces for the management of emergencies in the context of civil protection activities; Furthermore, the different methods of caring for greenery and managing public greenery are analysed, as well as the different forms of public-private partnership and active involvement of citizens for the care and development of public greenery, to be considered as one of the main "assets of urban municipalities".	p.145	-	YES	NO	YES	**NO**	**YES**	Strategic Plan for Green Infrastructure [GREENPRINT]
39		A2: Increase in urban greenery	The action consists of increasing urban greenery and included in the Climate Resilience Plan, which envisages increasing the number of trees and trees in the city, bringing benefits to ecosystems, human health and cities, compared to extreme events, such as heat, flooding and floods.	p.146	-	YES	NO	YES	**NO**	**YES**	Reference to Climate Resilience Plan and Strategic Plan for Green Infrastructure [GREENPRINT]

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
40		A3: Tree management	The action, also included in the Climate Resilience Plan, consists in the management of the tree heritage through updated arboricultural techniques and pruning techniques, with the aim of having healthier, safer trees capable of maintaining shading capacity and providing ecosystem services. The intervention envisaged by the extraordinary maintenance project "Urban Forestry (Lot 3)," included in the REACT-EU PON METRO, is part of this context. Specifically, this action outlines the planned intervention for "Lot 3 - Reconstitution of urban avenues," which entails the revitalization of the tree-lined areas of Corso Belgio. This involves replacing existing trees that belong to invasive species, listed in the 'black list' of the Piedmont Region, with trees of species suitable for the current urban context, promoting biodiversity conservation. The intervention will also include the reorganization of spaces and uses, incorporating nature-based solutions (NBS) to enhance soil permeability, facilitating improved rainwater management.	p.147	Corso Belgio	YES	YES	YES	**YES**	-	Reference to Climate Resilience Plan, Strategic Plan for Green Infrastructure [GREENPRINT] and Urban Sustainable Water Management Plan
41		A4: Most Resilient Tree Species	This action, therefore, included in the Climate Resilience Plan, consists in updating the green regulations with the preparation of an abacus of tree species that are more resistant and more suitable for the new climatic conditions	p.148	-	YES	NO	YES	**NO**	**YES**	Reference to Climate Resilience Plan and Strategic Plan for Green Infrastructure [GREENPRINT]
42		A5: Private tree census extension	The action, already incorporated into the Climate Resilience Plan, involves conducting a census of trees within the private green heritage. This initiative aims to diversify and catalog the functions associated with these trees, thereby creating a comprehensive overview of urban greenery and the ecosystem services they provide.	p.149	-	YES	NO	YES	**NO**	**YES**	Reference to Climate Resilience Plan and Strategic Plan for Green Infrastructure [GREENPRINT]
43		A6: River parks	The action, included in the Climate Resilience Plan, involves the recovery of riverbanks through the creation of river parks (Torino Città d'Acque project), progressively transforming the 73 kilometers of riverbanks along the 4 rivers that run through Turin into a system of linear parks with cycling paths. The action aims to support the city's adaptation to climate impacts, particularly concerning flooding. Within this context, the intervention planned by the extraordinary maintenance project "Urban Forestry" (Lot 2) included in the REACT-EU PON METRO is introduced. Specifically, this sheet outlines the intervention for Lot 2: Plain river parks, which involves enhancing ecological corridors within Turin's river parks: Pellerina Park, Meisino Park, Colletta and Confluence Park, Stura Nord Park, Millefonti Park. This intervention aligns with the action plan for the sustainable management of water in urban areas.	p.150	Turin river parks: Parco Pellerina, Parco del Meisino, Parco della Colletta and della Confluenza, Parco Stura Nord, Parco Millefonti.	YES	YES	YES	**YES**	-	Reference to Climate Resilience Plan, Strategic Plan for Green Infrastructure [GREENPRINT] and Urban Sustainable Water Management Plan
44	Human Health	A7: Heat Emergency Plan	The current action, included in the Climate Resilience Plan, involves the activation of the Annual Heat Emergency Plan targeted at vulnerable elderly individuals to address the difficulties caused by heatwaves and high temperatures from July 1st to September 30th. The plan, implemented by the Municipality in collaboration with the ASL (Local Health Authority) City of Turin and family doctors, establishes a network of services available to frail elderly individuals who, during the summer months, face challenges not only due to high temperatures but also due to health issues and loneliness.	p.151	-	YES	NO	YES	**NO**	**YES**	Reference to Civil Protection Plan and Climate Resilience Plan. Proposal of Heat Emergency Plan
45		A8: Support for Public Events	The action, already present in the Climate Resilience Plan, provides for the identification of Civil Protection interventions to be activated during events that concentrate a large number of people in a limited area, ensuring their well-being, for example with the supply of water or through extemporaneous refrigeration systems.	p.152	-	YES	NO	YES	**NO**	**YES**	Climate Resilience Plan, Municipal Civil Protection Plan, SGSE (Electrical Safety Management System) Procedures
46		A9: Dissemination of Heat Alert Bulletins	The action, also included in the Climate Resilience Plan of the City of Turin, involves sending alerts in the event of high heat anomalies to support functions and structures, and publishing the bulletin on the institutional website for the public. The action aims to enhance and increase the adaptability of the Administration and the community.	p.153	-	YES	NO	YES	**NO**	**YES**	Reference to Civil Protection Plan and Climate Resilience Plan

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test					
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*	PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
47		A10: Increasing the Adaptive Capacity of the Population	The action, also included in the Climate Resilience Plan, encompasses a series of activities aimed at increasing the adaptive capacity of the population: · Citizen awareness activities regarding the correct behaviors to adopt during the hottest days and intense precipitation events. · Development of social support strategies for the most vulnerable groups, aiming to raise awareness within local communities to protect the most fragile population from extreme events. This involves stimulating an active role, including the identification and involvement of recognized local network points (pharmacies, elderly spaces, etc.). · Definition of a structured communication and behavioral procedure (during or following an event) to provide citizens with information about events that have occurred in the city (e.g., tree falls, park closures due to inaccessibility) and sensitize them to the adoption of behavioral practices to reduce risk.	p.154	-	YES	NO	YES	**NO**	**YES**	Reference to Civil Protection Plan and Climate Resilience Plan
48		A11: Identification of Shelter Zones for Extreme Events	The action, also included in the Climate Resilience Plan, aims to identify refuge zones from heatwaves. It includes two actions: The hillside of the city as a refuge zone, involving designated resting areas, assessing access routes, and enhancing services. Horizontal signage for refuge areas, which means defining a map of green areas to be disseminated throughout the municipal territory, including placement at public transportation stops. Additionally, horizontal signage guides people to reach climate refuges.	p.155	-	YES	NO	YES	**NO**	**YES**	Reference to Civil Protection Plan and Climate Resilience Plan

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Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	Potentially Affect Heat Risk?	Place-specific?	Specific tool or intervention with objectives and outcomes?			
49	Biodiversity	A12: Interventions on urban layout to counteract heatwaves and promote stormwater management	The action, also part of the Climate Resilience Plan, comprises interventions aimed at modifying the city layout to counteract heat island effects and promote sustainable water management. These solutions reduce solar radiation absorbed by urban surfaces by using high-albedo materials and increasing shaded spaces, including: Cool pavements using innovative materials (drainage materials, colored asphalt, etc.). Implementation of water features in squares or streets (e.g., waterfalls, basins, fountains). Relocation of trees, considering placement near stops or areas with higher vulnerability. Transformation of disused tracks into green tracks and, where possible, tram tracks into green pathways. Temporary coverings for summer periods in squares or other resting areas. Within this context, the project under the National Operational Program, PON METRO REACT-EU, involves diverse adaptation interventions: Green public transportation stops, requalifying 15 stops with green-covered shelters and replacing existing pavements with high-albedo materials. Green tracks, transforming a section of tram tracks into a green track within a protected area currently characterized by asphalt. Railway coverings in Torino Ceres and Piazzale Scuola Allievo, involving de-impermeabilization, replacement of existing pavements with more draining materials, creation of green areas, and planting trees and shrubs in public parking spaces. Communication and awareness activities to inform the population about local climate change effects and the benefits of experimental solutions to counter climate vulnerabilities. In the context of the National Operational Program "Metropolitan Cities 2014-2020 PON METRO REACT-EU," the project TO6.1.4.B - VALDOCCO VIVIBILE 2 aims to redefine urban space use, creating more pedestrian areas and qualitative spaces. The project focuses on de-impermeabilizing soil by reorganizing roads, constructing new sidewalks, creating permeable green areas to manage rainwater, and planting new trees, positively impacting heat island reduction and soil permeability. Finally, the "Resilient Neighborhoods" project (LOTTO 1 SAN DONATO-LOTTO 2 SAN SECONDO) within the framework of PON METRO REACT-EU TORINO PROGETTO TO6.1.4.C introduces traffic moderation interventions, promotes pedestrian-friendly spaces, and includes the creation of green areas. These interventions align with actions outlined in the Plan for Sustainable Water Management in Urban Areas.	p.156	Trainline ferroviaria Torino Ceres, Piazzale Scuola Allievo, quarters Valdocco, San Donato, San Secondo.	YES	YES	YES	**YES**	-	Reference to Climate Resilience Plan, Urban Sustainable Water Management Plan and Project Valdocco Vivibile
50		A13: Improved Use of LPT in Case of Extreme Heat	The current action groups interventions aimed at ensuring comfort in various moments of daily life, especially during heatwaves, with a focus on mobility to maintain suitable conditions when using public transportation. These actions, outlined in the Climate Resilience Plan, include: Conditioning of public transportation (TPL); Covered or shaded TPL stops; Comfort enhancements at TPL stops, integrating solutions that involve ventilation and/or misting; Shaded bike paths, involving the construction of shaded cycling lanes.	p.158	-	YES	-	YES	**NO**	**YES**	Reference to Climate Resilience Plan

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
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50		A13: Improved Use of LPT in Case of Extreme Heat	The current action groups interventions aimed at ensuring comfort in various moments of daily life, especially during heatwaves, with a focus on mobility to maintain suitable conditions when using public transportation. These actions, outlined in the Climate Resilience Plan, include: Conditioning of public transportation (TPL); Covered or shaded TPL stops; Comfort enhancements at TPL stops, integrating solutions that involve ventilation and/or misting; Shaded bike paths, involving the construction of shaded cycling lanes.	p.158	-	YES	-	YES	**NO**	**YES**	Reference to Climate Resilience Plan

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
54	Infrastructures	A17: Reduction of River Flooding Risk	The current action encompasses measures already included in the Climate Resilience Plan, all aimed at reducing the risk of river overflow: Removal of hazardous and disruptive elements from riverbanks, such as unregulated gardens, business activities, unauthorized settlements. Inspections of piped sections in hillside streams. Implementation of structural prevention measures, including bank defenses, embankments, and raising levees to reduce the risk of overflow. Construction of a levee on the left bank of the Po River. Evaluation of potential unblocking of sections of piped watercourses to reduce critical points due to reduced channel width. Possible extraordinary maintenance on the white network with the creation of protective structures. Data collection implementation and coordination to enact targeted planning and emergency operational measures. River cleaning for infrastructure safety: the removal of debris/branches/wood that could be carried downstream, creating blockages and increasing the impact on infrastructure. This action can bring overall benefits to the city, including buildings, infrastructure, cultural heritage, and the health of both residents and visiting tourists.	p.162	-	NO	NO	YES	**NO**	**NO**	Climate Resilience Plan, Municipal Civil Protection Plan
55		A18: Sustainable Rainwater Management	This policy groups a series of actions already outlined in the Climate Resilience Plan and the Urban Sustainable Water Management Plan for the management of rainwater: - Regulation for rainwater drainage, identifying solutions for rainwater drainage to be approved through a regulation. - Rainwater drainage areas along roads, with surface arrangements featuring green spaces. - Rain gardens, i.e., green areas for collecting rainwater and subsequent drainage. - Collection of rainwater on roofs to allow for reuse, including the creation of green roofs. - Communication activities regarding new solutions aimed at rainwater disposal.	p.164	Mennea Park and in the parking lots Martini Mauri south, Braccini west, and Braccini east (an area of about 20,000 m2); Altiero Spinelli Primary School buildings (total affected area of 1,550 m2); Municipal buildings on via Bologna; Municipal buildings on corso Peschiera at the corner of corso Racconigi; Road section between via Nietzsche and the dam bridge Del Pascolo; Road section of corso Regina Margherita, between via Pietro Cossa and corso Svizzera; Road section of via Ippolito Nievo Road section of corso Trattati di Roma; Former riding track area	NO	YES	YES	**NO**	**NO**	Climate Resilience Plan, Urban Sustainable Water Management Plan
56		A19: Greywater Management	This policy groups a series of actions already outlined in the Action Plan for Sustainable Urban Water Management, specifically for the management of greywater: - Revision of the Technical Implementation Standards (NTA) of the General Master Plan (PRG). -Revision of the Building Regulation and the Energetic-Environmental Appendix. - Regulation for the design and implementation of urbanization works. - Analysis of specifications for public works.	p.166	-	NO	NO	YES	**NO**	**NO**	Climate Resilience Plan, Urban Sustainable Water Management Plan
57		A20: Management of Storm Drains	This policy includes two actions already outlined in the Climate Resilience Plan: - Monitoring the condition of drains to proceed with regular cleaning, reducing malfunctioning due to leaf accumulation or during heavy rainfall. - Regular cleaning and, where possible, replacement of drains with simple grates with wolf-mouth grates to reduce the risk of clogging from leaves. The action will contribute to the climate adaptation of urban infrastructure, minimizing urban inconveniences that may occur during extreme events.	p.167	-	NO	NO	YES	**NO**	**NO**	Climate Resilience Plan, Municipal Civil Protection Plan
58		A21: Reduction of Soil Consumption	This policy groups two actions outlined in the Climate Resilience Plan, with the objective of reducing the load on the white water disposal network through soil de-impermeabilization: - Removal of impermeable spaces to increase soil permeability. - Use of drainage materials in transforming areas.	p.168	-	YES	NO	YES	**NO**	**YES**	Climate Resilience Plan, Urban Sustainable Water Management Plan, Strategic Plan for Green Infrastructure
59		A22: Forms of facilitation/incentives for water management	In order to reduce the load of rainwater on the disposal network, the following action is envisaged, already present in the Climate Resilience Plan: defining forms of facilitation/incentives (e.g., savings on the water bill) for those who do not discharge white water into the disposal infrastructure	p.169	-	NO	NO	YES	**NO**	**NO**	Climate Resilience Plan, Urban Sustainable Water Management Plan

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Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	Notes*
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
60		A23: Natural Siltation Solutions in Areas Away from Urbanized Regions	This action aims to identify suitable areas upstream for natural attenuation solutions. Furthermore, it will be necessary to coordinate with AIPO (Po River Basin Authority) and encourage interventions for the Po River, also using the River Contract instrument.	p.170	-	NO	NO	YES	**NO**	**NO**	Climate Resilience Plan, Municipal Civil Protection Plan and PRG (Municipal General Plan of Turin)
61	Transversal	A24: General Preparedness for Climate Change	Under this policy are grouped some actions already included in the Climate Resilience Plan with this objective: - Public preparedness, involving widespread information activities on various risks, targeting both the general public and the Administration's Services. - Implementation of an extensive preventive communication campaign for citizens, aiming to inform them about climate risks near their homes, workplaces, and commonly frequented routes, and advising on protective measures. It also aims to provide information about events in the city, sensitizing them to adopt behavioral practices to reduce risks. - Dissemination of meteorological and hydrological alert bulletins to the municipal Civil Protection Division and subsequent transmission to contacts identified by the Authority, as well as dissemination targeted at citizens.	p.171	-	YES	NO	YES	**NO**	**YES**	Climate Resilience Plan, Urban Sustainable Water Management Plan, Strategic Plan for Green Infrastructure,Municipal Civil Protection Plan
62	Transversal	A25: Emergency Management	For the improvement of local management of climate emergencies, a series of actions are planned, already included in the Climate Resilience Plan: - Update of the Municipal Emergency Plan, considering interaction with other city services (e.g., green space management in emergencies) and integrating heatwaves as a climate risk to manage. - Civil protection exercises, involving the planning and management of periodic civil protection exercises for flood events or sudden and rapid rainfall events. - Definition of an internal operational procedure for managing specific emergency events, ensuring immediate response to rapid events, specifying how to interact with other involved entities (Civil Protection, Municipal Police Operations Center, Fire Department, Bridges and Waterways Service, etc.), and outlining roles and responsibilities. - Activation of an alert system capable of sending communications according to predefined alert thresholds to various institutional entities and, finally, based on severity, to people in the vicinity of at-risk areas. These actions are considered cross-cutting as they aim to influence all sectors.	p.172	-	YES	NO	YES	**NO**	**YES**	Climate Resilience Plan, Municipal Civil Protection Plan
63	Transversal	A26: Training and Research for Innovative Solutions	As envisaged in the Climate Resilience Plan, a series of actions within this policy are planned: - Professional updating, involving the activation of a specific technical training program on public and private construction. - Internal training and sharing of solutions already adopted by the city, including experimental ones. - Specific internal technical training on the design, implementation, and maintenance of Nature-Based Solutions (NBS) to mitigate the urban heat island effect, increase soil permeability, and slow down the runoff of rainwater into sewers through the creation of sustainable urban drainage areas for white water management as an alternative or in addition to the rainwater disposal network. - Technical construction manuals, providing specific technical specifications and examples of solutions already implemented, to be made available. - Catalog of possible solutions for designers, defining a catalog of actions to support the design, including for private entities, to address the increase in heavy rainfall.	p.173	-	not directly	NO	YES	**NO**	**YES**	Climate Resilience Plan, Urban Sustainable Water Management Plan
64	Transversal	A27: Economic reporting related to extreme events with damage to public green spaces and municipal buildings	The policy includes an action outlined in the Climate Resilience Plan aimed at assessing the cost incurred due to extreme weather events and the potential cost related to increased frequency and intensity of events. This will allow the internal working group coordinating the Climate Resilience Plan to understand the costs of non-adaptation, gaining greater awareness and guidance on how and where to take action. Therefore, assessment of the economic impact of events on the city and the cost of non-adaptation.	p.174	-	NO	-	YES	**NO**	**YES**	Climate Resilience Plan

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan Actions and Policies						*Three-Point Test*			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category	Name of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
65	Human Health	A28: Requalification of green areas with innovative methods	The City of Turin is the recipient of funds from the National Operational Programme, "Metropolitan Cities 2014-2020 PON Metro," within which the extraordinary maintenance project "Requalification with Innovative Methods of Green Areas in 2 Lots" is included. The redevelopment project includes various interventions, such as increasing the tree heritage, green areas, and de-paving surfaces, contributing to the objectives of adaptation and resilience to climate change. This project aligns with actions outlined in the Resilience Plan, as framed earlier; therefore, the monitored results may contribute to the assessment of the following actions: - A2: Increase in urban greenery - A20: Reduction of soil consumption	p.175	Giardini reali inferiori; Parco della Pellerina; Giardino don Gnocchi; Giardino Peppino Impastato; Parco Dora – area Valdocco; Giardino Nuova Delhi; Giardino San Paolo; Giardino Madre Teresa di Calcutta; Parco di Vittorio	YES	YES	YES	**YES**	**YES**	Climate Resilience Plan
66	Transversal	A29: Small and Medium-sized Enterprises (SMEs) and Similar - Business Action Plans for Adaptation to Climate Change (Cram Tool Life DERRIS)	As part of the Derris project, initiated in the city of Turin in 2016, a Self-Assessment Tool for Risks (CRAM tool) has been developed. This tool provides SMEs with the ability to: - Understand the risks they face in the event of extreme weather events (floods, rain, wind, lightning, hail, temperatures, and landslides). - Identify solutions to prevent damage to their businesses. - Receive concrete responses, bridging the gap between the insurance industry, public administration, and businesses. The goal is to provide SMEs with the necessary tools to reduce risks. This document introduces the action related to promoting this tool, encouraging SMEs to develop Climate Change Adaptation Plans.	p.176	-	NO	NO	YES	**NO**	**YES**	Derris project
67		A30: OTC(Municipal Technical Body) activities in the issuance of competency opinions in Strategic Environmental Assessment (SEA) procedures	The process of Strategic Environmental Assessment (SEA) involves preparing a report on the environmental impact resulting from the implementation of a specific plan or program to be adopted or approved. This includes conducting consultations, evaluating the environmental report, and considering the results of consultations in the decision-making process for approving a plan or program. The information is then made available to the public. This dpolicy aims to introduce the action related to the activities of the Municipal Technical Body concerning issuing opinions within SEA procedures. These opinions may also take into account adaptation measures.	p.177	-	NO	NO	YES	**NO**	**NO**	

***Notes related to the connection between action or policy to another city plan or project**
'-' - missing or not enough information provided in plan for evaluation

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan Actions and Policies (for the city of Turin and within PRG scenario only)							Three-Point Test			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category		Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
1	APPLICATION	Private traffic regulation	R01.01	Expansion of the ZTL (Limited Traffic Zone)(Open Center)	Annex K, p.9	-	YES	NO	YES	**NO**	**YES**	
2		Shared and electric mobility	G01.01	Bikesharing	Annex K, p.9	-	YES	NO	NO	**NO**	**YES**	
3			G01.02	Electric micro-mobility promotion	Annex K, p.9	-	not directly	NO	NO	**NO**	**NO**	
4			G01.03	Development of car pooling / car sharing	Annex K, p.9	-	YES	NO	NO	**NO**	**NO**	
5			G01.04	Car sharing system extension (Collegno, Grugliasco...)	Annex K, p.9	-	not direcly	NO	YES	**NO**	**NO**	
6		Passengers demand policies	D00.01a	Mobility management	Annex K, p.11	-	not direcly	NO	NO	**NO**	**NO**	
7			D00.01b	Development of mobility manager role	Annex K, p.11	-	not direcly	NO	NO	**NO**	**NO**	
8			D00.04	Horizon 2020 project - TinnGO: development of shared gender neutral ways	Annex K, p.11	-	NO	NO	-	**NO**	**NO**	Refer to Horizon 2020 - TinnGO Project
9			D00.05a	Horizon 2020 project -Harmony: co-creation labs	Annex K, p.11	-	NO	NO	-	**NO**	**NO**	Refer to Horizon 2020 - Harmony Project
10			D00.05a	Horizon 2020 project - Harmony: implementation of MaaS systems	Annex K, p.11	-	not directly	NO	-	**NO**	**NO**	Refer to Horizon 2020 - Harmony Project
11			D00.07	Rationalization of CMTO (Metropolitan City of Turin) school premises	Annex K, p.11	-	-	NO	-	**NO**	**NO**	
12			D00.08	The 1/4 hour city	Annex K, p.11	-	YES	NO	NO	**NO**	**YES**	
13		-	C00.02a	Line 2 - Torino P.ta Susa - Beinasco - Orbassano	Annex K, p.12	Line 2 - Torino P.ta Susa - Beinasco - Orbassano	YES	YES	YES	**YES**	-	
14			C00.02b	Line 2 - Torino P.ta Susa - Baldissera	Annex K, p.12	Line 2 - Torino P.ta Susa - Baldissera	YES	YES	YES	**YES**	-	
15			C00.02c	Line 2 - Via Lanzo	Annex K, p.12	Line 2 - Via Lanzo	YES	YES	YES	**YES**	-	
16			C00.03a	Line 3 - Baldissera - Falchera	Annex K, p.12	Line 3 - Baldissera - Falchera	YES	YES	YES	**YES**	-	
17			C00.04a	Line 4 - Corso Vercelli - corso Romania - via Torino	Annex K, p.12	Line 4 - Corso Vercelli - corso Romania - via Torino	YES	YES	YES	**YES**	-	
18			C00.04b	Line 4 - Torino piazza della Repubblica - Settimo Torinese	Annex K, p.12	Line 4 - Torino piazza della Repubblica - Settimo Torinese	YES	YES	YES	**YES**	-	
19			C00.05a	Line 5 - Lingotto - via Pio VII	Annex K, p.12	Line 5 - Lingotto - via Pio VII	YES	YES	YES	**YES**	-	
20			C00.05b	Line 5 - Via Artom on Comune di Torino till Stazione Nichelino	Annex K, p.12	Line 5 - Via Artom on Comune di Torino till Stazione Nichelino	YES	YES	YES	**YES**	-	
21			C00.06	Line 6 - completion between ponte Amedeo VIII in Turin and Gassino Torinese	Annex K, p.12	Line 6 - completion between ponte Amedeo VIII in Turin and Gassino Torinese	YES	YES	YES	**YES**	-	
22			C00.07a	Line 7 - da P.ta Nuova - a piazza Bengasi	Annex K, p.12	Line 7 - da P.ta Nuova - a piazza Bengasi	YES	YES	YES	**YES**	-	
23			C00.08	Complementary network	Annex K, p.13	-	YES	-	-	**NO**	**YES**	
24			C00.09a	Internal circular network	Annex K, p.13	-	YES	-	-	**NO**	**YES**	
25			C00.09b	External circular network	Annex K, p.13	-	YES	-	-	**NO**	**YES**	
26			C00.09c	Metropolitan circular network	Annex K, p.13	-	YES	-	-	**NO**	**YES**	
27			C00.10	Cycle signaling plan (primary network of metropolitan interest)	Annex K, p.13	-	NO	NO	NO	**NO**	**NO**	
28			C01.01a	Via Nizza	Annex K, p.14	Via Nizza	YES	YES	YES	**YES**	-	
29			C01.01b	Piazza Bengasi	Annex K, p.14	Piazza Bengasi	YES	YES	YES	**YES**	-	

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan Actions and Policies (for the city of Turin and within PRG scenario only)						*Three-Point Test*			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category	Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
30		C01.02	Completion of the cycle path via Vigliani	Annex K, p.14	Completion of the cycle path via Vigliani	YES	YES	YES	**YES**	-	
31		C01.03	Completion of c.so Bramante, c.so Lepanto	Annex K, p.14	Completion of c.so Bramante, c.so Lepanto	YES	YES	YES	**YES**	-	
32		C01.04	C.so Stati Uniti cycle path, from C.so Sacchi to C.so Umberto	Annex K, p.14	C.so Stati Uniti cycle path, from C.so Sacchi to C.so Umberto	YES	YES	YES	**YES**	-	
33		C01.05a	C.so Galileo Ferraris cycle path	Annex K, p.14	C.so Galileo Ferraris cycle path	YES	YES	YES	**YES**	-	
34		C01.05b	Cycle path c.so Galileo Ferraris and c.so Unione Sovietica	Annex K, p.14	Cycle path c.so Galileo Ferraris and c.so Unione Sovietica	YES	YES	YES	**YES**	-	
35		C01.06	Completion of the cycle path via Giordano Bruno	Annex K, p.14	Completion of the cycle path via Giordano Bruno	YES	YES	YES	**YES**	-	
36		C01.07	Completion of the cycle path in C.so Cosenza facing north between C.so Agnelli and Via Tripoli	Annex K, p.14	Completion of the cycle path in C.so Cosenza facing north between C.so Agnelli and Via Tripoli	YES	YES	YES	**YES**	-	
37		C01.08	Cycle path along c.so MonteLungo, via Gessi, via c. so Racconigi	Annex K, p.14	Cycle path along c.so MonteLungo, via Gessi, via c. so Racconigi	YES	YES	YES	**YES**	-	
38		C01.09	Cycle path in c.so Orbassano between via Tirreno and c.so Cosenza	Annex K, p.14	Cycle path in c.so Orbassano between via Tirreno and c.so Cosenza	YES	YES	YES	**YES**	-	
39		C01.10	Cycle path via Lussipiccolo, via Gorizia	Annex K, p.14	Cycle path via Lussipiccolo, via Gorizia	YES	YES	YES	**YES**	-	
40		C01.11	Piazza Pitagora cycle loop	Annex K, p.14	Piazza Pitagora cycle loop	YES	YES	YES	**YES**	-	
41		C01.12	Cycle path via Tirreno	Annex K, p.14	Cycle path via Tirreno	YES	YES	YES	**YES**	-	
42		C01.13	Cycle path c.so Siracusa	Annex K, p.14	Cycle path c.so Siracusa	YES	YES	YES	**YES**	-	
43		C01.14	Via Braccini, Lancia, D'Albertis (eliminating roadside parking)	Annex K, p.14	Via Braccini, Lancia, D'Albertis (eliminating roadside parking)	YES	YES	YES	**YES**	-	
44		C01.15	Cycle path c.so Racconigi between Piazza Robilant and c.so Peschiera	Annex K, p.14	Cycle path c.so Racconigi between Piazza Robilant and c.so Peschiera	YES	YES	YES	**YES**	-	
45		C01.16	Cycle path c.so Trapani	Annex K, p.14	Cycle path c.so Trapani	YES	YES	YES	**YES**	-	
46		C01.17	Cycle path c.so Tassoni, c.so Svizzera	Annex K, p.14	Cycle path c.so Tassoni, c.so Svizzera	YES	YES	YES	**YES**	-	
47		C01.18	Cycle path c.so Principe Eugenio	Annex K, p.14	Cycle path c.so Principe Eugenio	YES	YES	YES	**YES**	-	
48	Bike Lanes	C01.19	Completion of the cycle path in Corso Regina Margherita	Annex K, p.14	Completion of the cycle path in Corso Regina Margherita	YES	YES	YES	**YES**	-	
49		C01.20	Completion of the cycle path in via Nole	Annex K, p.14	Completion of the cycle path in via Nole	YES	YES	YES	**YES**	-	
50		C01.21	Cycle paths on via Chambery, via Vandalino, via Rieti	Annex K, p.14	Cycle paths on via Chambery, via Vandalino, via Rieti	YES	YES	YES	**YES**	-	
51		C01.22	Direct connection in the park ThyssenKrupp	Annex K, p.14	Direct connection in the park ThyssenKrupp	YES	YES	YES	**YES**	-	
52		C01.23	Connection c.so Venezia - c.so Grosseto on the new Rebaudengo junction	Annex K, p.14	Connection c.so Venezia - c. so Grosseto on the new Rebaudengo junction	YES	YES	YES	**YES**	-	

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan Actions and Policies (for the city of Turin and within PRG scenario only)						*Three-Point Test*			PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
N	Category	Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
53		C01.24	Cycle path c.so Vercelli, via Renato Martorelli, c.so Palermo	Annex K, p.14	Cycle path c.so Vercelli, via Renato Martorelli, c.so Palermo	YES	YES	YES	**YES**	-	
54		C01.25	Cycle path c.so Verona	Annex K, p.15	Cycle path c.so Verona	YES	YES	YES	**YES**	-	
55		C01.26	Cycle path c.so Novara	Annex K, p.15	Cycle path c.so Novara	YES	YES	YES	**YES**	-	
56		C01.27	Cycle path c.so Tortona	Annex K, p.15	Cycle path c.so Tortona	YES	YES	YES	**YES**	-	
57		C01.28	Cycle path via Corelli, via Cruto	Annex K, p.15	Cycle path via Corelli, via Cruto	YES	YES	YES	**YES**	-	
58		C01.29	Cycle path via Pietracqua, via Petrella	Annex K, p.15	Cycle path via Pietracqua, via Petrella	YES	YES	YES	**YES**	-	
59		C01.30	Cycle path via Botticelli between Strada Bassa di Stura and piazza Derna	Annex K, p.15	Cycle path via Botticelli between Strada Bassa di Stura and piazza Derna	YES	YES	YES	**YES**	-	
60		C01.31a	Cycle path corso Vercelli from Piazza Rebaudengo to Strada Courgnè	Annex K, p.15	Cycle path corso Vercelli from Piazza Rebaudengo to Strada Courgnè	YES	YES	YES	**YES**	-	
61		C01.31b	Completion of Corso Vercelli cycle path	Annex K, p.15	Completion of Corso Vercelli cycle path	YES	YES	YES	**YES**	-	
62		C01.31c	Completion of corso Romania cycle path	Annex K, p.15	Completion of corso Romania cycle path	YES	YES	YES	**YES**	-	
63		C01.32	Strada Cuorgnè and internal connection to Falchera for the C.so Romania cycle path	Annex K, p.15	Strada Cuorgnè and internal connection to Falchera for the C.so Romania cycle path	YES	YES	YES	**YES**	-	
64		C01.33	Turin-Ceres construction site: superficial redevelopment of Corso Grosseto with construction of cycle paths	Annex K, p.15	Turin-Ceres construction site: superficial redevelopment of Corso Grosseto with construction of cycle paths	YES	YES	YES	**YES**	-	
65		C01.37	Strada del Meisino walkway	Annex K, p.15	Strada del Meisino walkway	YES	YES	YES	**YES**	-	
66		C01.38	Cycle path of strada del Drosso	Annex K, p.15	Cycle path of strada del Drosso	YES	YES	YES	**YES**	-	
67		C01.39	Cycle path of via Lanzo	Annex K, p.15	Cycle path of via Lanzo	YES	YES	YES	**YES**	-	
68	Cycle routes	C02.01	Cycle routes: Eurovelo corridors and national itineraries	Annex K, p.16	-	YES	-	-	**NO**	**YES**	
69		C02.02	Cycle routes: Vento cycle route	Annex K, p.16	-	YES	-	-	**NO**	**YES**	
70		C02.03	Cycle routes: Regional Cycling Mobility Program	Annex K, p.16	-	YES	-	-	**NO**	**YES**	
71		C02.04	Cycling accessibility program at SFM (Metropolitan Railway Service)/metro stations (bike to rail)	Annex K, p.16	-	YES	NO	-	**NO**	**YES**	
72		C02.05	Bicycle interchange parking (bike to rail)	Annex K, p.16	-	YES	NO	-	**NO**	**YES**	
73		Q00.01	Street design guidelines	Annex K, p.17	-	NO	NO	-	**NO**	**NO**	
74		Q01.01	Car-free school accessibility / school roads	Annex K, p.17	-	YES	NO	-	**NO**	**YES**	
75		Q01.02	Turin city 30' - main avenues	Annex K, p.17	-	-	NO	-	**NO**	**NO**	
76		Q01.03	Service Roads 20km/h - Corso Francia	Annex K, p.17	Service Roads 20km/h - Corso Francia	YES	YES	YES	**YES**	-	
77		Q01.04	Service Roads 20km/h - Corso Vittorio Emanuele II	Annex K, p.17	Service Roads 20km/h - Corso Vittorio Emanuele II	YES	YES	YES	**YES**	-	
78		Q01.05	Service Roads 20km/h - Corso Giambone	Annex K, p.17	Service Roads 20km/h - Corso Giambone	YES	YES	YES	**YES**	-	
79		Q01.06	Service Roads 20km/h - Corso Peschiera/Einaudi	Annex K, p.17	Service Roads 20km/h - Corso Peschiera/Einaudi	YES	YES	YES	**YES**	-	

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan Actions and Policies (for the city of Turin and within PRG scenario only)							*Three-Point Test*					
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80		Traffic moderation	Q01.07	Service Roads 20km/h - Corso Lecce	Annex K, p.17	Service Roads 20km/h - Corso Lecce	YES	YES	YES	**YES**	-	
81			Q01.08	Service Roads 20km/h - Corso Ferrucci	Annex K, p.17	Service Roads 20km/h - Corso Ferrucci	YES	YES	YES	**YES**	-	
82			Q01.09	Service Roads 20km/h - Corso Regina Margherita	Annex K, p.17	Service Roads 20km/h - Corso Regina Margherita	YES	YES	YES	**YES**	-	
83			Q01.10	Service Roads 20 km/h - Completion of the corso Regina Margherita	Annex K, p.17	Service Roads 20 km/h - Completion of the corso Regina Margherita	YES	YES	YES	**YES**	-	
84			Q01.11	Service Roads 20km/h - Corso Potenza	Annex K, p.17	Service Roads 20km/h - Corso Potenza	YES	YES	YES	**YES**	-	
85			Q01.12	Service Roads 20km/h - Corso Vercelli between Lungo Dora Napoli and Corso Emilia	Annex K, p.17	Service Roads 20km/h - Corso Vercelli between Lungo Dora Napoli and Corso Emilia	YES	YES	YES	**YES**	-	
86			Q01.13	Service Roads 20km/h - Corso San Maurizio	Annex K, p.17	Service Roads 20km/h - Corso San Maurizio	YES	YES	YES	**YES**	-	
87		River navigation	N01.01	Strengthening / promotion of river navigation	Annex K, p.18	-	NO	NO	-	**NO**	**NO**	
88		Maintenance	A01.01	Maintenance of via Paolo Sacchi	Annex K, p.18	Maintenance of via Paolo Sacchi	NO	YES	-	**NO**	**NO**	
89			A01.02	Maintenance of c.so Abruzzi, c.so Agnelli, corso IV Novembre, corso Unione Sovietica - from C.so Stati Uniti to border of Stupinigi	Annex K, p.18	Maintenance of c.so Abruzzi, c.so Agnelli, corso IV Novembre, corso Unione Sovietica - from C.so Stati Uniti to border of Stupinigi	NO	YES	-	**NO**	**NO**	
90			A01.03	Maintenance of c.so Castelfidardo	Annex K, p.18	Maintenance of c.so Castelfidardo	NO	YES	-	**NO**	**NO**	
91			A01.04	Maintenance of c.so Mediterraneo	Annex K, p.18	Maintenance of c.so Mediterraneo	NO	YES	-	**NO**	**NO**	
92			A01.05	Maintenance of c.so Brunelleschi	Annex K, p.18	Maintenance of c.so Brunelleschi	NO	YES	-	**NO**	**NO**	
93			A01.06	Maintenance of via Sandro Botticelli	Annex K, p.18	Maintenance of via Sandro Botticelli	NO	YES	-	**NO**	**NO**	
94			A01.07	Maintenance of c.so Regio Parco	Annex K, p.18	Maintenance of c.so Regio Parco	NO	YES	-	**NO**	**NO**	
95			A01.08	Maintenance of c.so Matteotti	Annex K, p.18	Maintenance of c.so Matteotti	NO	YES	-	**NO**	**NO**	
96			A01.09	Maintenance of via dell'Arcivescovado	Annex K, p.18	Maintenance of via dell'Arcivescovado	NO	YES	-	**NO**	**NO**	
97			A01.10	Maintenance of via Principe Amedeo	Annex K, p.18	Maintenance of via Principe Amedeo	NO	YES	-	**NO**	**NO**	
98			A01.11	Maintenance of via Giuseppe Verdi	Annex K, p.18	Maintenance of via Giuseppe Verdi	NO	YES	-	**NO**	**NO**	
99			A01.12	Maintenance of c.so Giulio Cesare and c.so Romania	Annex K, p.18	Maintenance of c.so Giulio Cesare and c.so Romania	NO	YES	-	**NO**	**NO**	
100			A01.13	Maintenance of Lungo Stura Lazio	Annex K, p.18	Maintenance of Lungo Stura Lazio	NO	YES	-	**NO**	**NO**	
101	INDIVIDUAL MOTORIZED MOBILITY		V00.06	SATT (Turin Highway) - speed limit review	Annex K, p.19	-	NO	NO	-	**NO**	**NO**	
102			V00.07	SATT (Turin Highway) - traffic management system	Annex K, p.19	-	NO	NO	-	**NO**	**NO**	
103			V00.08	SATT (Turin Highway) - revision of the tariff system	Annex K, p.19	-	NO	NO	-	**NO**	**NO**	
104			V01.01a	Construction of C.so Marche - North-South highway tunnel connection	Annex K, p.19	Construction of C.so Marche - North-South highway tunnel connection	YES	YES	YES	**YES**	-	

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan Actions and Policies (for the city of Turin and within PRG scenario only)						Three-Point Test					
N	Category	Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*	PASSED Three-Point Test	DIDN'T PASS Three-Point Test, but RELEVANT	*Notes**
105		V01.01b	Construction of C.so Marche - connections with Str. del Portone - corsoTazzoli - Cimitero Sud	Annex K, p.19	Construction of C.so Marche - connections with Str. del Portone - corsoTazzoli - Cimitero Sud	YES	YES	YES	**YES**	-	
106		V01.03	Highway connection - C.so Regina Margherita - SS24	Annex K, p.19	Highway connection - C.so Regina Margherita - SS24	YES	YES	YES	**YES**	-	
107		V01.06	Completion of Spina centrale	Annex K, p.19	Completion of Spina centrale	YES	-	YES	**NO**	**NO**	
108	-	V01.07a	Continuation of the Corso Spezia underpass: road solution	Annex K, p.19	Continuation of the Corso Spezia underpass: road solution	YES	YES	YES	**YES**	-	
109		V01.09	Resolution of the Maroncelli rotonda (underpass)	Annex K, p.20	Resolution of the Maroncelli rotonda (underpass)	NO	YES	YES	**NO**	**NO**	
110		V01.11	Resolution of the Baldissera node (at-grade traffic light intersection)	Annex K, p.20	Resolution of the Baldissera node (at-grade traffic light intersection)	NO	YES	YES	**NO**	**NO**	
111		V01.13	Construction of the Derna underpass	Annex K, p.20	Construction of the Derna underpass	NO	YES	YES	**NO**	**NO**	
112		V01.15	Reorganization of the c.so Orbassano road platform following the M2 (Metro Line 2)	Annex K, p.20	Reorganization of the c.so Orbassano road platform following the M2 (Metro Line 2)	YES	YES	YES	**YES**	-	
113		Q01.14	Road Diet - Corso Francia	Annex K, p.26	Road Diet - Corso Francia	YES	YES	YES	**YES**	-	
114		Q01.15	Road Diet - Corso Orbassano	Annex K, p.26	Road Diet - Corso Orbassano	YES	YES	YES	**YES**	-	
115		F02.02	Completion of the railway link: Dora station	Annex K, p.27	Completion of the railway link: Dora station	YES	YES	YES	**YES**	-	
116		F02.03	Completion of the railway link: Zappata station	Annex K, p.27	Completion of the railway link: Zappata station	YES	YES	YES	**YES**	-	
117	-	F03.01	Completion of the railway link: Turin - Ceres Line	Annex K, p.27	Completion of the railway link: Turin - Ceres Line	YES	YES	YES	**YES**	-	
118		F06.01	New stop for line SFM5 - San Paolo	Annex K, p.27	New stop for line SFM5 - San Paolo	YES	YES	YES	**YES**	-	
119		F06.02	New stop for line SFM5 - Quaglia Le Gru	Annex K, p.27	New stop for line SFM5 - Quaglia Le Gru	YES	YES	YES	**YES**	-	
120	Metro network	M01.01	Extension of the M1 line to Piazza Bengasi	Annex K, p.28	Extension of the M1 line to Piazza Bengasi	YES	YES	YES	**YES**	-	
121		M01.02	Underground interchange parking for M1 line in Piazza Bengasi	Annex K, p.28	Underground interchange parking for M1 line in Piazza Bengasi	NO	YES	YES	**NO**	**NO**	
122		M02.01	New line M2 Rebaudengo - Corso Novara	Annex K, p.28	New line M2 Rebaudengo - Corso Novara	YES	YES	YES	**YES**	-	
123		M02.02	New line M2 Novara - Porta Nuova	Annex K, p.28	New line M2 Novara - Porta Nuova	YES	YES	YES	**YES**	-	
124		M02.03	New line M2 extension to Anselmetti-Orbassano	Annex K, p.28	New line M2 extension to Anselmetti-Orbassano	YES	YES	YES	**YES**	-	
125		M02.05	New line M2 extension to S.Mauro/Pescarito	Annex K, p.28	New line M2 extension to S. Mauro/Pescarito	YES	YES	YES	**YES**	-	
126		M02.06	Underground interchange parking for M2 line Drosso	Annex K, p.28	Underground interchange parking for M2 line Drosso	NO	YES	YES	**NO**	**NO**	
127		M02.07	Underground interchange parking for M2 line Pescarito	Annex K, p.28	Underground interchange parking for M2 line Pescarito	NO	YES	YES	**NO**	**NO**	
128		T00.01	Speeding up the tram network	Annex K, p.29	-	NO	NO	-	**NO**	**NO**	
129	-	T03.01	Extension of T3 line to Piazza Hermada - Toselli	Annex K, p.29	Extension of T3 line to Piazza Hermada - Toselli	YES	YES	YES	**YES**	-	

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Urban Sustainable Mobility Plan [PUMS]

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N	Category		Code of Action or Policy	Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*			
130		Tram Network	T10.01	Reactivation of T10 line to the North (up to via Massari)	Annex K, p.29	Reactivation of T10 line to the North (up to via Massari)	YES	YES	YES	**YES**	-	
131		Tram Network	T10.03	Extension of T10 line to Drosso M2 stop	Annex K, p.29	Extension of T10 line to Drosso M2 stop	YES	YES	YES	**YES**	-	
132		Tram Network	T12.01	Construction of new T12 line from Stadium to c.so G. Cesare	Annex K, p.29	Construction of new T12 line from Stadium to c.so G. Cesare	YES	YES	YES	**YES**	-	
133		Tram Network	T12.02	Parcheggio interscambio T12 Stadium	Annex K, p.29	Parcheggio interscambio T12 Stadium	YES	YES	YES	**YES**	-	
134		Tram Network	T12.03	Construction of new T12 line from c.so G.Cesare to c. so Lepanto	Annex K, p.29	Construction of new T12 line from c.so G.Cesare to c.so Lepanto	YES	YES	YES	**YES**	-	
135		Tram Network	T15.02a	Setback of the terminal stop of T15 line - Ospedale Martini	Annex K, p.29	Setback of the terminal stop of T15 line - Ospedale Martini	NO	YES	YES	**NO**	**NO**	
136		Tram Network	T15.03	T15 line protection (strength tram line)	Annex K, p.29	T15 line protection (strength tram line)	-	YES	-	**NO**	**NO**	
137		Tram Network	T15.04	Transit of T15 line from Porta Susa	Annex K, p.29	Transit of T15 line from Porta Susa	YES	YES	YES	**YES**	-	
138		Electric Busways	B02.01b	Electric bus route 2 - Via A. Ponchielli - Lingotto - via C. Corradino	Annex K, p.30	Electric bus route 2 - Via A. Ponchielli - Lingotto - via C. Corradino	YES	YES	YES	**YES**	-	
139		Electric Busways	B08.02	Electric bus route 8 - Campus Einaudi - Lingotto (without Spezia underpass)	Annex K, p.30	Electric bus route 8 - Campus Einaudi - Lingotto (without Spezia underpass)	YES	YES	YES	**YES**	-	
140		Electric Busways	B55.01	Electric bus route 55 - Via Orbassano - Piazza Bengasi	Annex K, p.30	Electric bus route 55 - Via Orbassano - Piazza Bengasi	YES	YES	YES	**YES**	-	
141		Electric Busways	B62.02	Transit of 62 line from S.Paolo	Annex K, p.30	Transit of 62 line from S. Paolo	YES	YES	YES	**YES**	-	
142	TECHNOLOGICAL INTERVENTIONS	-	X01.01	Renewal/electrification of the urban bus park	Annex K, p.32	-	not directly	NO	-	**NO**	**NO**	
143	TECHNOLOGICAL INTERVENTIONS	-	X02.01	Powering the urban bus park of extra-urban methane/LNG buses	Annex K, p.32	-	not directly	NO	-	**NO**	**NO**	
144	TECHNOLOGICAL INTERVENTIONS	-	X03.01	Expansion of charging stations	Annex K, p.32	-	NO	NO	-	**NO**	**NO**	
145	TECHNOLOGICAL INTERVENTIONS	-	X04.01	Incentives for the spread of electric cars (European projects in the e-smart region, Emoticon)	Annex K, p.32	-	YES	NO	-	**NO**	**NO**	
146	TECHNOLOGICAL INTERVENTIONS	-	X05.01	Development of automatic driving (private transport)	Annex K, p.32	-	NO	NO	-	**NO**	**NO**	
147	TECHNOLOGICAL INTERVENTIONS	-	X05.02	Development of automatic driving (public transport)	Annex K, p.32	-	NO	NO	-	**NO**	**NO**	
148	URBAN INTERVENTIONS	-	U01.01	Palazzo della Regione	Annex K, p.32	Palazzo della Regione	-	YES	-	**NO**	**YES**	
149	URBAN INTERVENTIONS	-	U01.21	Parco della Salute della ricerca e innovazione	Annex K, p.32	Parco della Salute della ricerca e innovazione	YES	YES	YES	**YES**	-	

***Notes related to the connection between action or policy to another city plan or project**

'-' - missing or not enough information provided in plan for evaluation

ANNEX II: THE SCORECARD OF ACTIONS AND POLICIES WITHIN TURIN'S PLANNING FRAMEWORK (BASED ON THE PIRS™ FOR HEAT WORKSHEET)

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

Plan's Actions and/or Policies passed Three-Point Test

Plan Actions and Policies (for the city of Turin and within PRG scenario only)						*Three-Point Test*				
N	POLICY **ID**	Code of Action or Policy	Describtion	Location	Reference (in the plan)	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*	PASSED Three-Point Test	**The PIRS™ for Heat Score**
4	**E1**	TLR 1: Extension of the district heating network	This action involves expanding the current district heating network to the San Salvario neighborhoods and the North-East area of Turin. Overall, the action includes the construction of over 70 km of new network from 2021-2027, connecting a volume of 73,235,351 m³ to 87,440,000 m³ and generating an additional 200 GWh/year of energy.	San Salvario, Torino Nord-Est	p.56	YES	YES	YES	**YES**	**1**
5	**E2**	TLR 2: Construction of a storage power plant in progress Salvemini	The action involves creating a new Iren heat storage and solar thermal system in Mirafiori Nord, at the corner of Corso Salvemini and Via Guido Reni, previously occupied by the old thermoelectric power plant. The site includes integrated systems: a heat storage system with three tanks totaling approximately 2500 m³, a pumping station with three electric pumps for heat distribution, a solar thermal system with a nominal power of 411 kW connected to the district heating system of Mirafiori Nord, and a 45 kWp photovoltaic system on the building's roof.	Corso Selvemini corner via Guido Reni (Mirafiori Nord)	p.57	YES	YES	YES	**YES**	**1**
7	**E3**	EP 2: Energy requalification of libraries and buildings of historical and cultural interest	Energy efficiency improvements are planned for 25 historically and culturally significant buildings or buildings used as libraries, using funds obtained from projects and funding competitions.	Buildings leased at Via Foligno, Via Abeti, Via Le Chiuse, Via Verolengo; Offices and multipurpose hall at Centro Rete; Libraries at the mausoleum of Bela Rosin, Villa Tesoriera, Villa Amoretti, Calvino, Geisser; Cultural building at Via Viterbo; Former Superga factory; CPG on Strada delle Cacce, Via Rubino, Corso Siracusa; Passerin d'Entreves, Marchesa, Bonhoeffer, Ginzburg libraries; Spazio 4 Neighborhood House and Marchesa Auditorium; Murazzi del Po (Student Zone / Arcades).	p.59	YES	YES	YES	**YES**	**1**
8	**E4**	EP 3: Energy requalification of school buildings	Energy efficiency measures are planned for 8 municipal school buildings.	Corso Vercelli 157, Via Cecchi 16/18, Via Beinasco 34; Via Vallauri 24, Via Lussimpiccolo 36/A, Via Randaccio 60, Via San Sebastiano Po 6, Via Ada Negri 21 – 23.	p.60	YES	YES	YES	**YES**	**1**
10	**E5**	EP5: Energy requalification of municipal office buildings	Energy efficiency improvements are planned for 2 significant municipal buildings.	Municipal building at Piazza San Giovanni and Municipal Police, the Department of Environment and Ecological Transition offices at Via Padova 29/Via Bologna	p.62	YES	YES	YES	**YES**	**1**
11	**E6**	EP 6: Energy requalification of barracks and police stations	It involves the energy redevelopment of the Provincial Fire Department Command Headquarters on Corso Regina Margherita, with the replacement of existing 800 kW condensing boilers and connection to the city's district heating network.	Headquarters of the Provincial Fire Department, Corso Regina Margherita	p.63	YES	YES	YES	**YES**	**1**
19	**E7**	TPL 4: Implementation of Metro Line 2 – Lot 1	Line 2, configured in a "Y" shape, will connect 32 stations along a total route of 27 km, divided into three main sections: a central 16 km section with 23 stations, starting from Rebaudengo to Anselmetti; a southward extension from Anselmetti to Orbassano, spanning 6 km and connecting 5 stations; a northward extension of the same length with 4 stops, reaching Pescarito/S. Mauro. Line 2 will integrate with existing public transportation through three interchange points. At Zappata and Rebaudengo stations, it will connect to the Metropolitan Railway System, while at Porta Nuova Station, it will intersect with Metro Line 1. Additionally, four interchange parking facilities for public and private vehicles are planned to enhance the intermodality of the transport system at Orbassano, Anselmetti, San Mauro, and Rebaudengo stations. Lot 1 covers the Rebaudengo–Politecnico section.	LOTTO 1 plan of Metro Line 2 between Rebaudengo – Politecnico stations, interchange parking in stations Orbassano, Anselmetti, San Mauro e Rebaudengo	p.71	YES	YES	YES	**YES**	**U**
27	**E8**	MA 7: Installation of bike stations	Construction of a bicycle parking lot (velostation) consisting of 100 stalls, in Via Nizza near Porta Nuova. The stations are made up of various double-height metal stalls, seven of which are equipped with electric charging stations to allow those in possession of an electric bike to recharge it. Inside this space there is an area intended for a cycle workshop for the repair or rental of bicycles.	Via Nizza near Porta Nuova station	p.79	YES	YES	YES	**YES**	**U**

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

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30	**E9**	FL 1: Purchase of new electric buses	The action aims to improve the emission profile of the fleet of urban buses circulating in GTT, through the purchase of 120 new electric buses which will be added to the 50 already entered service in 2021, to replace the most obsolete diesel vehicles (Euro 3 and Euro 4) and a part of the methane vehicles more than 5 years old.	City of Turin	p.82	YES	YES	YES	**YES**	**1**
31	**E10**	FL 2: Shift to rail for public transportation (TPL)	The action aims to increase the % of rail travel of urban LPT vehicles using electrified vehicles, through interventions of: - purchase of 70 new electric trams; - 23% increase in the tram network, going from 78.33 to 96.19 km.	City of Turin	p.83	YES	YES	YES	**YES**	**1**
32	**E11**	FL 3: Purchase of new methane-powered and Euro 6 buses	The action aims to improve the emission profile of the fleet of urban buses circulating within GTT, through the purchase of 122 new methane buses to replace the most obsolete diesel vehicles (Euro 3 and Euro 4) and a part of the methane vehicles more than 5 years old	City of Turin	p.84	YES	YES	YES	**YES**	**1**
33	**E12**	FL 4 : Improvement of the emission profile of municipal vehicles	The action aims to improve the emission profile of the fleet of 863 vehicles forming part of the City of Turin's vehicle fleet, increasing the share of low-emission vehicles powered by LPG (liquefied petroleum gas), methane or electricity. The "Green to share" project includes in particular: - the purchase of 87 new electric vehicles, replacing internal combustion vehicles with an average age of more than 12 years - the acquisition of an integrated technological platform, aimed at introducing a shared mobility service (corporate car sharing), consisting of: - a front end system via web and app aimed at users - a software application and on-board unit for the management of vehicle fleets and transport services - a network of charging points for electric vehicles (wall boxes) located in parking areas identified within at least 20 municipal offices For the evaluation of the environmental benefits, it was considered that electric vehicles replace petrol and diesel vehicles in a proportional way to the number of vehicles present in the municipal fleet in 2019.	City of Turin	p.85	YES	YES	YES	**YES**	**1**
34	**E13**	FU 1: Participatory reforestation campaigns	The action includes the "1000 trees for Turin" initiative, which includes the involvement of residents, environmental associations, political representatives and municipal technicians. Based on historical data (2000 trees planted between 2016 and 2018), the planting of 500 trees/year is estimated for a total of 5000 trees by 2030.	City of Turin	p.86	YES	YES	YES	**YES**	**1**
35	**E14**	FU 2: In-house reforestation interventions	The action involves the planting of approximately 40,000 trees in extensive city parks and another 20,000 trees through participation in the "forestation" tender (Climate decree) with the "Corona Verde - Turin metropolitan area" project. This latest project involves the use of native species, among which the most represented will be oaks (oak and oak), hornbeam, field maple, ash, black alder, white, black and aspen poplars, the wild cherry, the elm, the mountain ash with the addition of shrub species such as hawthorn, hazel, laburnum, viburnum, dogwood and dogwood. In addition to the reforestation work, the maintenance and survival of the young plants must be guaranteed for the first seven years of planting. Finally, the planting of 1200 new trees is planned through the funds of the Integrated Urban Plan (measure M5C2 of the PNRR) and further planting interventions in the river parks of Colletta and Confluence, Meisino, Pellerina, Stura Nord and Nizza Millefonti (project REACT).	City of Turin	p.87	YES	YES	YES	**YES**	**1**
37	**E15**	MGV 1: Interventions for increasing the resilience of public green spaces – REACT Project	The action involves: · protect the forests of the hilly area owned by the Municipality; · redevelop the urban front of the river parks, with urban forestry interventions and pruning and planting of shrubs on the banks of the Po · improve the tree-lined avenues, in particular Corso Umbria and Corso Belgio.	Banks of the Po river, corso Umbria and corso Belgio	p.89	YES	YES	YES	**YES**	**1**

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41	**E16**	A3: Tree management	The action, also included in the Climate Resilience Plan, consists in the management of the tree heritage through updated arboricultural techniques and pruning techniques, with the aim of having healthier, safer trees capable of maintaining shading capacity and providing ecosystem services. The intervention envisaged by the extraordinary maintenance project "Urban Forestry (Lot 3)," included in the REACT-EU PON METRO, is part of this context. Specifically, this action outlines the planned intervention for "Lot 3 - Reconstitution of urban avenues," which entails the revitalization of the tree-lined areas of Corso Belgio. This involves replacing existing trees that belong to invasive species, listed in the 'black list' of the Piedmont Region, with trees of species suitable for the current urban context, promoting biodiversity conservation. The intervention will also include the reorganization of spaces and uses, incorporating nature-based solutions (NBS) to enhance soil permeability, facilitating improved rainwater management.	Corso Belgio	p.147	YES	YES	YES	**YES**	**1**
44	**E17**	A6: River parks	The action, included in the Climate Resilience Plan, involves the recovery of riverbanks through the creation of river parks (Torino Città d'Acque project), progressively transforming the 73 kilometers of riverbanks along the 4 rivers that run through Turin into a system of linear parks with cycling paths. The action aims to support the city's adaptation to climate impacts, particularly concerning flooding. Within this context, the intervention planned by the extraordinary maintenance project "Urban Forestry" (Lot 2) included in the REACT-EU PON METRO is introduced. Specifically, this sheet outlines the intervention for Lot 2: Plain river parks, which involves enhancing ecological corridors within Turin's river parks: Pellerina Park, Meisino Park, Colletta and Confluence Park, Stura Nord Park, Millefonti Park. This intervention aligns with the action plan for the sustainable management of water in urban areas.	Turin river parks: Parco Pellerina, Parco del Meisino, Parco della Colletta and della Confluenza, Parco Stura Nord, Parco Millefonti.	p.150	YES	YES	YES	**YES**	**1**

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50	**E18**	A12: Interventions on urban layout to counteract heatwaves and promote stormwater management	The action, also part of the Climate Resilience Plan, comprises interventions aimed at modifying the city layout to counteract heat island effects and promote sustainable water management. These solutions reduce solar radiation absorbed by urban surfaces by using high-albedo materials and increasing shaded spaces, including: Cool pavements using innovative materials (drainage materials, colored asphalt, etc.). Implementation of water features in squares or streets (e.g., waterfalls, basins, fountains). Relocation of trees, considering placement near stops or areas with higher vulnerability. Transformation of disused tracks into green tracks and, where possible, tram tracks into green pathways. Temporary coverings for summer periods in squares or other resting areas. Within this context, the project under the National Operational Program, PON METRO REACT-EU, involves diverse adaptation interventions: Green public transportation stops, requalifying 15 stops with green-covered shelters and replacing existing pavements with high-albedo materials. Green tracks, transforming a section of tram tracks into a green track within a protected area currently characterized by asphalt. Railway coverings in Torino Ceres and Piazzale Scuola Allievo, involving de-impermeabilization, replacement of existing pavements with more draining materials, creation of green areas, and planting trees and shrubs in public parking spaces. Communication and awareness activities to inform the population about local climate change effects and the benefits of experimental solutions to counter climate vulnerabilities. In the context of the National Operational Program "Metropolitan Cities 2014-2020 PON METRO REACT-EU," the project TO6.1.4.B - VALDOCCO VIVIBILE 2 aims to redefine urban space use, creating more pedestrian areas and qualitative spaces. The project focuses on de-impermeabilizing soil by reorganizing roads, constructing new sidewalks, creating permeable green areas to manage rainwater, and planting new trees, positively impacting heat island reduction and soil permeability. Finally, the "Resilient Neighborhoods" project (LOTTO 1 SAN DONATO-LOTTO 2 SAN SECONDO) within the framework of PON METRO REACT-EU TORINO PROGETTO TO6.1.4.C introduces traffic moderation interventions, promotes pedestrian-friendly spaces, and includes the creation of green areas. These interventions align with actions outlined in the Plan for Sustainable Water Management in Urban Areas.	Trainline ferroviaria Torino Ceres, Piazzale Scuola Allievo, quarters Valdocco, San Donato, San Secondo.	p.156	YES	YES	YES	**YES**	**1**
52	**E19**	A14: Preventive Measures in Hilly Areas	The action, also included in the Climate Resilience Plan, involves monitoring and visual inspection activities in hilly areas, especially around residential zones, to assess potential issues such as landslides and collapses. The goal is to reduce risks for residents in hilly areas, promoting both human health and the well-being of buildings, monuments, and infrastructure. Within this context, the intervention planned by the extraordinary maintenance project "Urban Forestry (Lot 1)" included in the REACT-EU PON METRO is introduced. Specifically, this document outlines the intervention for Lot 1: Hillside Parks and Woods, which focuses on enhancing hillside woods and parks by addressing hydro-geological instability, maximizing ecosystem services, and ensuring citizen enjoyment in locations such as Parco Maddalena, Strada dei Boschi, connection to Parco San Vito, Panoramic Superga and areas Val della Torre, Path 29 from Strada Catalinette to Parco Meisino, and Path 26 Beria; Parco Europa, Parco Leopardi, Villa Genero, Villa Abegg, Villa Rey. These interventions are also included as actions in the plan for sustainable water management in urban areas.	Parco Maddalena, Strada dei Boschi, connection to Parco San Vito, panoramic point Superga and areas Val della Torre, Sentiero 29 from Strada Catalinette to Parco Meisino and Sentiero 26 Beria; Parco Europa, Parco Leopardi, Villa Genero, Villa Abegg, Villa Rey	p.159	YES	YES	YES	**YES**	**1**

II. Hazard mitigation plan

Action Plan for Sustainable Energy and Climate [PAESC]

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66	**E20**	A28: Requalification of green areas with innovative methods	The City of Turin is the recipient of funds from the National Operational Programme, "Metropolitan Cities 2014-2020 PON Metro," within which the extraordinary maintenance project "Requalification with Innovative Methods of Green Areas in 2 Lots" is included. The redevelopment project includes various interventions, such as increasing the tree heritage, green areas, and de-paving surfaces, contributing to the objectives of adaptation and resilience to climate change. This project aligns with actions outlined in the Resilience Plan, as framed earlier; therefore, the monitored results may contribute to the assessment of the following actions: - A2: Increase in urban greenery - A20: Reduction of soil consumption	Giardini reali inferiori; Parco della Pellerina; Giardino don Gnocchi; Giardino Peppino Impastato; Parco Dora – area Valdocco; Giardino Nuova Delhi; Giardino San Paolo; Giardino Madre Teresa di Calcutta; Parco di Vittorio	p.175	YES	YES	YES	**YES**	**1**

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

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1	**M1**	C00.02a	Bike service	Line 2 - Torino P.ta Susa - Beinasco - Orbassano	Annex K, p.12	Line 2 - Torino P.ta Susa - Beinasco - Orbassano	YES	YES	YES	**YES**	**1**
2	**M2**	C00.02b		Line 2 - Torino P.ta Susa - Baldissera	Annex K, p.12	Line 2 - Torino P.ta Susa - Baldissera	YES	YES	YES	**YES**	**1**
3	**M3**	C00.02c		Line 2 - Via Lanzo	Annex K, p.12	Line 2 - Via Lanzo	YES	YES	YES	**YES**	**1**
4	**M4**	C00.03a		Line 3 - Baldissera - Falchera	Annex K, p.12	Line 3 - Baldissera - Falchera	YES	YES	YES	**YES**	**1**
5	**M5**	C00.04a		Line 4 - Corso Vercelli - corso Romania - via Torino	Annex K, p.12	Line 4 - Corso Vercelli - corso Romania - via Torino	YES	YES	YES	**YES**	**1**
6	**M6**	C00.04b		Line 4 - Torino piazza della Repubblica - Settimo Torinese	Annex K, p.12	Line 4 - Torino piazza della Repubblica - Settimo Torinese	YES	YES	YES	**YES**	**1**
7	**M7**	C00.05a		Line 5 - Lingotto - via Pio VII	Annex K, p.12	Line 5 - Lingotto - via Pio VII	YES	YES	YES	**YES**	**1**
8	**M8**	C00.05b		Line 5 - Via Artom on Comune di Torino till Stazione Nichelino	Annex K, p.12	Line 5 - Via Artom on Comune di Torino till Stazione Nichelino	YES	YES	YES	**YES**	**1**
9	**M9**	C00.06		Line 6 - completion between ponte Amedeo VIII in Turin and Gassino Torinese	Annex K, p.12	Line 6 - completion between ponte Amedeo VIII in Turin and Gassino Torinese	YES	YES	YES	**YES**	**1**
10	**M10**	C00.07a		Line 7 - da P.ta Nuova - a piazza Bengasi	Annex K, p.12	Line 7 - da P.ta Nuova - a piazza Bengasi	YES	YES	YES	**YES**	**1**
11	**M11**	C01.01a		Via Nizza	Annex K, p.14	Via Nizza	YES	YES	YES	**YES**	**1**
12	**M12**	C01.01b		Piazza Bengasi	Annex K, p.14	Piazza Bengasi	YES	YES	YES	**YES**	**1**
13	**M13**	C01.02		Completion of the cycle path via Vigliani	Annex K, p.14	Completion of the cycle path via Vigliani	YES	YES	YES	**YES**	**1**
14	**M14**	C01.03		Completion of c.so Bramante, c.so Lepanto	Annex K, p.14	Completion of c.so Bramante, c.so Lepanto	YES	YES	YES	**YES**	**1**
15	**M15**	C01.04		C.so Stati Uniti cycle path, from C.so Sacchi to C.so Umberto	Annex K, p.14	C.so Stati Uniti cycle path, from C.so Sacchi to C.so Umberto	YES	YES	YES	**YES**	**1**
16	**M16**	C01.05a		C.so Galileo Ferraris cycle path	Annex K, p.14	C.so Galileo Ferraris cycle path	YES	YES	YES	**YES**	**1**
17	**M17**	C01.05b		Cycle path c.so Galileo Ferraris and c.so Unione Sovietica	Annex K, p.14	Cycle path c.so Galileo Ferraris and c.so Unione Sovietica	YES	YES	YES	**YES**	**1**
18	**M18**	C01.06		Completion of the cycle path via Giordano Bruno	Annex K, p.14	Completion of the cycle path via Giordano Bruno	YES	YES	YES	**YES**	**1**
19	**M19**	C01.07		Completion of the cycle path in C.so Cosenza facing north between C.so Agnelli and Via Tripoli	Annex K, p.14	Completion of the cycle path in C.so Cosenza facing north between C.so Agnelli and Via Tripoli	YES	YES	YES	**YES**	**1**
20	**M20**	C01.08		Cycle path along c.so MonteLungo, via Gessi, via c. so Racconigi	Annex K, p.14	Cycle path along c.so MonteLungo, via Gessi, via c. so Racconigi	YES	YES	YES	**YES**	**1**

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

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21	**M21**	C01.09	Bike Lanes	Cycle path in c.so Orbassano between via Tirreno and c.so Cosenza	Annex K, p.14	Cycle path in c.so Orbassano between via Tirreno and c.so Cosenza	YES	YES	YES	**YES**	**1**
22	**M22**	C01.10		Cycle path via Lussipiccolo, via Gorizia	Annex K, p.14	Cycle path via Lussipiccolo, via Gorizia	YES	YES	YES	**YES**	**1**
23	**M23**	C01.11		Piazza Pitagora cycle loop	Annex K, p.14	Piazza Pitagora cycle loop	YES	YES	YES	**YES**	**1**
24	**M24**	C01.12		Cycle path via Tirreno	Annex K, p.14	Cycle path via Tirreno	YES	YES	YES	**YES**	**1**
25	**M25**	C01.13		Cycle path c.so Siracusa	Annex K, p.14	Cycle path c.so Siracusa	YES	YES	YES	**YES**	**1**
26	**M26**	C01.14		Via Braccini, Lancia, D'Albertis (eliminating roadside parking)	Annex K, p.14	Via Braccini, Lancia, D'Albertis (eliminating roadside parking)	YES	YES	YES	**YES**	**1**
27	**M27**	C01.15		Cycle path c.so Racconigi between Piazza Robilant and c.so Peschiera	Annex K, p.14	Cycle path c.so Racconigi between Piazza Robilant and c.so Peschiera	YES	YES	YES	**YES**	**1**
28	**M28**	C01.16		Cycle path c.so Trapani	Annex K, p.14	Cycle path c.so Trapani	YES	YES	YES	**YES**	**1**
29	**M29**	C01.17		Cycle path c.so Tassoni, c.so Svizzera	Annex K, p.14	Cycle path c.so Tassoni, c.so Svizzera	YES	YES	YES	**YES**	**1**
30	**M30**	C01.18		Cycle path c.so Principe Eugenio	Annex K, p.14	Cycle path c.so Principe Eugenio	YES	YES	YES	**YES**	**1**
31	**M31**	C01.19		Completion of the cycle path in Corso Regina Margherita	Annex K, p.14	Completion of the cycle path in Corso Regina Margherita	YES	YES	YES	**YES**	**1**
32	**M32**	C01.20		Completion of the cycle path in via Nole	Annex K, p.14	Completion of the cycle path in via Nole	YES	YES	YES	**YES**	**1**
33	**M33**	C01.21		Cycle paths on via Chambery, via Vandalino, via Rieti	Annex K, p.14	Cycle paths on via Chambery, via Vandalino, via Rieti	YES	YES	YES	**YES**	**1**
34	**M34**	C01.22		Direct connection in the park ThyssenKrupp	Annex K, p.14	Direct connection in the park ThyssenKrupp	YES	YES	YES	**YES**	**1**
35	**M35**	C01.23		Connection c.so Venezia - c.so Grosseto on the new Rebaudengo junction	Annex K, p.14	Connection c.so Venezia - c. so Grosseto on the new Rebaudengo junction	YES	YES	YES	**YES**	**1**
36	**M36**	C01.24		Cycle path c.so Vercelli, via Renato Martorelli, c.so Palermo	Annex K, p.14	Cycle path c.so Vercelli, via Renato Martorelli, c.so Palermo	YES	YES	YES	**YES**	**1**
37	**M37**	C01.25		Cycle path c.so Verona	Annex K, p.15	Cycle path c.so Verona	YES	YES	YES	**YES**	**1**
38	**M38**	C01.26		Cycle path c.so Novara	Annex K, p.15	Cycle path c.so Novara	YES	YES	YES	**YES**	**1**
39	**M39**	C01.27		Cycle path c.so Tortona	Annex K, p.15	Cycle path c.so Tortona	YES	YES	YES	**YES**	**1**
40	**M40**	C01.28		Cycle path via Corelli, via Cruto	Annex K, p.15	Cycle path via Corelli, via Cruto	YES	YES	YES	**YES**	**1**
41	**M41**	C01.29		Cycle path via Pietracqua, via Petrella	Annex K, p.15	Cycle path via Pietracqua, via Petrella	YES	YES	YES	**YES**	**1**

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

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42	**M42**	C01.30		Cycle path via Botticelli between Strada Bassa di Stura and piazza Derna	Annex K, p.15	Cycle path via Botticelli between Strada Bassa di Stura and piazza Derna	YES	YES	YES	**YES**	**1**
43	**M43**	C01.31a		Cycle path corso Vercelli from Piazza Rebaudengo to Strada Courgnè	Annex K, p.15	Cycle path corso Vercelli from Piazza Rebaudengo to Strada Courgnè	YES	YES	YES	**YES**	**1**
44	**M44**	C01.31b		Completion of Corso Vercelli cycle path	Annex K, p.15	Completion of Corso Vercelli cycle path	YES	YES	YES	**YES**	**1**
45	**M45**	C01.31c		Completion of corso Romania cycle path	Annex K, p.15	Completion of corso Romania cycle path	YES	YES	YES	**YES**	**1**
46	**M46**	C01.32		Strada Cuorgnè and internal connection to Falchera for the C.so Romania cycle path	Annex K, p.15	Strada Cuorgnè and internal connection to Falchera for the C.so Romania cycle path	YES	YES	YES	**YES**	**1**
47	**M47**	C01.33		Turin-Ceres construction site: superficial redevelopment of Corso Grosseto with construction of cycle paths	Annex K, p.15	Turin-Ceres construction site: superficial redevelopment of Corso Grosseto with construction of cycle paths	YES	YES	YES	**YES**	**1**
48	**M48**	C01.37		Strada del Meisino walkway	Annex K, p.15	Strada del Meisino walkway	YES	YES	YES	**YES**	**1**
49	**M49**	C01.38		Cycle path of strada del Drosso	Annex K, p.15	Cycle path of strada del Drosso	YES	YES	YES	**YES**	**1**
50	**M50**	C01.39		Cycle path of via Lanzo	Annex K, p.15	Cycle path of via Lanzo	YES	YES	YES	**YES**	**1**
51	**M51**	Q01.03		Service Roads 20km/h - Corso Francia	Annex K, p.17	Service Roads 20km/h - Corso Francia	YES	YES	YES	**YES**	**U**
52	**M52**	Q01.04		Service Roads 20km/h - Corso Vittorio Emanuele II	Annex K, p.17	Service Roads 20km/h - Corso Vittorio Emanuele II	YES	YES	YES	**YES**	**U**
53	**M53**	Q01.05		Service Roads 20km/h - Corso Giambone	Annex K, p.17	Service Roads 20km/h - Corso Giambone	YES	YES	YES	**YES**	**U**
54	**M54**	Q01.06		Service Roads 20km/h - Corso Peschiera/Einaudi	Annex K, p.17	Service Roads 20km/h - Corso Peschiera/Einaudi	YES	YES	YES	**YES**	**U**
55	**M55**	Q01.07		Service Roads 20km/h - Corso Lecce	Annex K, p.17	Service Roads 20km/h - Corso Lecce	YES	YES	YES	**YES**	**U**
56	**M56**	Q01.08		Service Roads 20km/h - Corso Ferrucci	Annex K, p.17	Service Roads 20km/h - Corso Ferrucci	YES	YES	YES	**YES**	**U**
57	**M57**	Q01.09	Traffic moderation	Service Roads 20km/h - Corso Regina Margherita	Annex K, p.17	Service Roads 20km/h - Corso Regina Margherita	YES	YES	YES	**YES**	**U**
58	**M58**	Q01.10		Service Roads 20 km/h - Completion of the corso Regina Margherita	Annex K, p.17	Service Roads 20 km/h - Completion of the corso Regina Margherita	YES	YES	YES	**YES**	**U**
59	**M59**	Q01.11		Service Roads 20km/h - Corso Potenza	Annex K, p.17	Service Roads 20km/h - Corso Potenza	YES	YES	YES	**YES**	**U**
60	**M60**	Q01.12		Service Roads 20km/h - Corso Vercelli between Lungo Dora Napoli and Corso Emilia	Annex K, p.17	Service Roads 20km/h - Corso Vercelli between Lungo Dora Napoli and Corso Emilia	YES	YES	YES	**YES**	**U**

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan's Actions and/or Policies passed Three-Point Test

Plan Actions and Policies (for the city of Turin and within PRG scenario only)							*Three-Point Test*			PASSED Three-Point Test	The PIRS™ for Heat Score
N	POLICY ID	Code of Action or Policy		Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*		
61	**M61**	Q01.13	-	Service Roads 20km/h - Corso San Maurizio	Annex K, p.17	Service Roads 20km/h - Corso San Maurizio	YES	YES	YES	**YES**	**U**
62	**M62**	V01.01a		Construction of C.so Marche - North-South highway tunnel connection	Annex K, p.19	Construction of C.so Marche - North-South highway tunnel connection	YES	YES	YES	**YES**	**-1**
63	**M63**	V01.01b		Construction of C.so Marche - connections with Str. del Portone - corso Tazzoli - Cimitero Sud	Annex K, p.19	Construction of C.so Marche - connections with Str. del Portone - corso Tazzoli - Cimitero Sud	YES	YES	YES	**YES**	**-1**
64	**M64**	V01.03		Highway connection - C.so Regina Margherita - SS24	Annex K, p.19	Highway connection - C.so Regina Margherita - SS24	YES	YES	YES	**YES**	**-1**
65	**M65**	V01.07a		Continuation of the Corso Spezia underpass: road solution	Annex K, p.19	Continuation of the Corso Spezia underpass: road solution	YES	YES	YES	**YES**	**-1**
66	**M66**	V01.15		Reorganization of the c.so Orbassano road platform following the M2 (Metro Line 2)	Annex K, p.20	Reorganization of the c.so Orbassano road platform following the M2 (Metro Line 2)	YES	YES	YES	**YES**	**U**
67	**M67**	Q01.14		Road Diet - Corso Francia	Annex K, p.26	Road Diet - Corso Francia	YES	YES	YES	**YES**	**1**
68	**M68**	Q01.15		Road Diet - Corso Orbassano	Annex K, p.26	Road Diet - Corso Orbassano	YES	YES	YES	**YES**	**1**
69	**M69**	F02.02	Railway network	Completion of the railway link: Dora station	Annex K, p.27	Completion of the railway link: Dora station	YES	YES	YES	**YES**	**1**
70	**M70**	F02.03		Completion of the railway link: Turin - Ceres Line	Annex K, p.27	Completion of the railway link: Turin - Ceres Line	YES	YES	YES	**YES**	**1**
71	**M71**	F06.01		New stop for line SFM5 - San Paolo	Annex K, p.27	New stop for line SFM5 - San Paolo	YES	YES	YES	**YES**	**U**
72	**M72**	F06.02		New stop for line SFM5 - Quaglia Le Gru	Annex K, p.27	New stop for line SFM5 - Quaglia Le Gru	YES	YES	YES	**YES**	**U**
73	**M73**	M01.01	Metro network	Extension of the M1 line to Piazza Bengasi	Annex K, p.28	Extension of the M1 line to Piazza Bengasi	YES	YES	YES	**YES**	**1**
74	**M74**	M02.01		New line M2 Rebaudengo - Corso Novara	Annex K, p.28	New line M2 Rebaudengo - Corso Novara	YES	YES	YES	**YES**	**1**
75	**M75**	M02.02		New line M2 Novara - Porta Nuova	Annex K, p.28	New line M2 Novara - Porta Nuova	YES	YES	YES	**YES**	**1**
76	**M76**	M02.03		New line M2 extension to Anselmetti-Orbassano	Annex K, p.28	New line M2 extension to Anselmetti-Orbassano	YES	YES	YES	**YES**	**1**
77	**M77**	M02.05		New line M2 extension to S.Mauro/Pescarito	Annex K, p.28	New line M2 extension to S. Mauro/Pescarito	YES	YES	YES	**YES**	**1**
78	**M78**	T03.01		Extension of T3 line to Piazza Hermada - Toselli	Annex K, p.29	Extension of T3 line to Piazza Hermada - Toselli	YES	YES	YES	**YES**	**1**
79	**M79**	T10.01		Reactivation of T10 line to the North (up to via Massari)	Annex K, p.29	Reactivation of T10 line to the North (up to via Massari)	YES	YES	YES	**YES**	**1**
80	**M80**	T10.03		Extension of T10 line to Drosso M2 stop	Annex K, p.29	Extension of T10 line to Drosso M2 stop	YES	YES	YES	**YES**	**1**

V. Functional plan (e.g., parks and recreation, transportation, green infrastructure)

Urban Sustainable Mobility Plan [PUMS]

Plan's Actions and/or Policies passed Three-Point Test

Plan Actions and Policies (for the city of Turin and within PRG scenario only)							Three-Point Test			PASSED Three-Point Test	The PIRS™ for Heat Score
N	POLICY ID	Code of Action or Policy		Describtion	Reference (in the plan)	Location	*Potentially Affect Heat Risk?*	*Place-specific?*	*Specific tool or intervention with objectives and outcomes?*		
81	**M81**	T12.01	Tram Network	Construction of new T12 line from Stadium to c.so G. Cesare	Annex K, p.29	Construction of new T12 line from Stadium to c.so G. Cesare	YES	YES	YES	**YES**	**1**
82	**M82**	T12.02		Parcheggio interscambio T12 Stadium	Annex K, p.29	Parcheggio interscambio T12 Stadium	YES	YES	YES	**YES**	**U**
83	**M83**	T12.03		Construction of new T12 line from c.so G.Cesare to c. so Lepanto	Annex K, p.29	Construction of new T12 line from c.so G.Cesare to c.so Lepanto	YES	YES	YES	**YES**	**1**
84	**M84**	T15.04		Transit of T15 line from Porta Susa	Annex K, p.29	Transit of T15 line from Porta Susa	YES	YES	YES	**YES**	**1**
85	**M85**	B02.01b	Electric Busways	Electric bus route 2 - Via A. Ponchielli - Lingotto - via C. Corradino	Annex K, p.30	Electric bus route 2 - Via A. Ponchielli - Lingotto - via C. Corradino	YES	YES	YES	**YES**	**1**
86	**M86**	B08.02		Electric bus route 8 - Campus Einaudi - Lingotto (without Spezia underpass)	Annex K, p.30	Electric bus route 8 - Campus Einaudi - Lingotto (without Spezia underpass)	YES	YES	YES	**YES**	**1**
87	**M87**	B55.01		Electric bus route 55 - Via Orbassano - Piazza Bengasi	Annex K, p.30	Electric bus route 55 - Via Orbassano - Piazza Bengasi	YES	YES	YES	**YES**	**1**
88	**M88**	B62.02		Transit of 62 line from S.Paolo	Annex K, p.30	Transit of 62 line from S. Paolo	YES	YES	YES	**YES**	**1**
89	**M89**	U01.21	Uban Interventions	Parco della Salute della ricerca e innovazione	Annex K, p.32	Parco della Salute della ricerca e innovazione	YES	YES	YES	**YES**	**1**
90	**M90**	F02.03	Railway network	Completion of the railway link: Zappata station	Annex K, p.27	Completion of the railway link: Zappata station	YES	YES	YES	**YES**	**1**

ANNEX III:
THE INTERVIEW REPORT

REPORT

OF THE INTERVIEW CONDUCTED WITH A REPRESENTATIVE OF THE MUNICIPALITY OF TURIN

The interview aimed to acquire valuable insights for the methodological application of the PIRS for Heat in Turin. Aligned with the 'Minimizing community's time requirement' approach for PIRS for Heat implementation, the interview occurred on 27.11.2023 at 16:00 CET via the Zoom platform.

Interviewee: Arch. Donato Gugliotta, technical manager in urban planning information systems in the urban planning and private building department, represents the 'Comune di Torino'- the city's public municipal organization.

Key Questions. Key questions were focused on the interviewee's viewpoint on Turin plans and policy tools that could be incorporated into the PIRS for Heat approach, as well as relevant updates on current strategic plans.

Key Findings. The interview delved into current plans and projects addressing climate change and sustainability in Turin. A confirmative list of plans suitable for PIRS for Heat was established. Additionally, because of its dated and advisory nature, the General Regulatory Plan (PRG) was considered no longer relevant and implied to be excluded. Furthermore, the discussion expanded to explore the hypothesis of analyzing the municipality's already implemented policies and actions.

In conclusion. Arch. Gugliotta's expertise helped solidify the list of city plans, resolving uncertainties about the inclusion of PRG. The conversation extended beyond the methodology to Turin's focus on heat hazard mitigation, addressing general planning issues and local characteristics of the city's planning system.

It's important to highlight that while this study did not include the implementation of policies and actions in the final analysis, this topic could be extended to the following studies in evaluating heat planning in cities.

In summary, the interview provided a holistic view of Turin's urban planning, emphasizing the need for continuous evaluation and adaptation to address evolving challenges such as heat hazards. Arch. Gugliotta's insights contributed significantly to the research aim and helped define the final list of suitable plans upon which the methodology was developed.