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ECONOMIC VALUATION OF URBAN HEAT ISLAND IMPACTS: A STATE-OF-THE-ART REVIEW°∻

VALORACIÓN ECONÓMICA DE LOS IMPACTOS DE LA ISLA DE CALOR URBANA: UNA REVISIÓN DEL ESTADO DEL ARTE

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Abstract

Based on a review of studies published between 1990 and 2024, this paper analyses the state of the art in the economic valuation of the Urban Heat Island (UHI). The results reveal a limited knowledge base in Latin America and the Southern Hemisphere. Globally, researchers tend to underestimate UHI impacts on social welfare because non-use values are rarely considered. Moreover, significant gaps remain in the valuation of UHI effects on tourism, urban agriculture, and innovative mitigation strategies. Addressing these gaps by estimating the total economic value of UHI impacts is essential to demonstrate their relevance for social welfare and to guide the design of sustainable urban strategies that reflect social preferences.

Keywords: urban heat island, economic valuation, total economic value, welfare impacts, state of the art
Jel Codes: Q59, R00, D69

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Resumen

A partir de una revisión de investigaciones publicadas entre 1990 y 2024, este estudio analiza el estado del arte de la valoración económica de la Isla de Calor Urbana (UHI). Los resultados revelan una base de conocimiento limitada en América Latina y el hemisferio sur. A nivel global, persiste la tendencia a subestimar sus impactos sobre el bienestar social, ya que los valores de no uso se consideran de manera marginal. Además, se identificaron vacíos relevantes en la valoración de sus impactos sobre el turismo, la agricultura urbana y las estrategias de mitigación innovadoras. Abordar estas brechas mediante la estimación del valor económico total de los impactos de la UHI resulta clave para visibilizar su incidencia en el bienestar social y para orientar el diseño de estrategias urbanas sostenibles que incorporen las preferencias sociales.

Palabras clave: isla de calor urbana, valoración económica, valor económico total, impactos sobre el bienestar, estado del arte

Código JEL: Q59, R00, D69

INTRODUCTION

The Urban Heat Island (UHI) is a characteristic phenomenon of urban environments, primarily driven by the expansion of the built environment. This transformation alters the natural landscape and modifies local microclimatic conditions, producing higher temperatures in urban areas than in adjacent rural zones (Zhao & He, 2017). The phenomenon has significant implications for the welfare of urban populations by affecting energy consumption, thermal comfort, outdoor space usability, air quality, and public health (Jain et al., 2022).

Urban planning plays a pivotal role in mitigating the UHI. Over recent decades, researchers have proposed sustainable urban strategies such as green roofs, permeable surfaces, and urban greening initiatives (Correa et al., 2012; Feng et al., 2025). These interventions reduce urban temperatures through shading, convective cooling, and radiative heat loss, while also providing benefits such as lower greenhouse gas emissions, enhanced thermal comfort, and higher quality of life (Jain et al., 2022).

Understanding social preferences regarding these strategies is useful in several respects. For instance, if society could intervene to mitigate the UHI, which strategies should be prioritised? Moreover, what is the maximum amount society would pay for their implementation? Economic valuation methods can answer these questions, which are essential for guiding sustainable urban planning that reflects social preferences.

Economic valuation is commonly applied to estimate the monetary value of changes in social welfare resulting from ecological transformations.[1] However, to the authors' knowledge, no prior study has provided a structured synthesis and critical analysis of the literature on the economic valuation of the UHI.

Based on a review of investigations published between 1990 and 2024, this study analyses the state of the art in the economic valuation of the UHI and contributes to the literature by identifying methodological trends, knowledge gaps, and emerging challenges.

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1 See Carson and Mitchell (1993) for an early review.

I. THEORETICAL AND CONCEPTUAL FOUNDATIONS

I.1 Urban Heat Island

The UHI phenomenon represents an increasingly urgent environmental challenge, driven by urban expansion and further intensified by climate change. It is characterised by higher temperatures in urban areas than in adjacent rural zones. This effect arises in part from the thermal storage capacity of construction materials, the reduction of vegetated surfaces, and anthropogenic heat emissions (Li & Zhao, 2012).

The UHI generates adverse environmental conditions, including diminished ventilation and intensified urban warming. It also contributes to public health problems (Varquez & Kanda, 2018), lower labour productivity (Costa et al., 2016; Jones et al., 2024), and significant impacts on ecosystem services (ES) (Akbari, 2005; Chau et al., 2010; Bianchini & Hewage, 2012; Perini & Rosasco, 2013).[2]

In urban settings, ES play a vital role in human welfare, for example, by regulating local climate and air quality. However, many of these services face increasing threats from the UHI. The expansion of the built environment at the expense of vegetated surfaces reduces the capacity of cities to mitigate heat through shading and evapotranspiration, thereby impairing thermal comfort. Vegetation loss heightens reliance on mechanical cooling systems and raises energy consumption. In addition, elevated temperatures undermine the maintenance of biodiversity, compromising the integrity of urban ecosystems (Restrepo Correa et al., 2020).

The cultural services provided by urban green spaces—such as aesthetic beauty, recreation, and mental and physical well-being—are also at risk. Elevated temperatures reduce the use of these spaces and diminish user experience, limiting opportunities for social interaction and contact with nature (Scholte et al., 2015). In

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2 The conceptual framework of *The Economics of Ecosystems and Biodiversity* (TEEB) defines ES as the direct and indirect contributions of ecosystems to human welfare. A key perspective for classifying ES is the extent to which society recognizes the benefits derived from ecosystems. This perspective underpins the TEEB classification system, which distinguishes four main categories: (i) provisioning services, such as food, materials, and energy; (ii) regulating services, including ecosystems functions that regulate environmental processes; (iii) cultural services, related to cultural and spiritual needs; and (iv) habitat services, encompassing species habitats and the maintenance of biodiversity (TEEB, 2012). TEEB is a global initiative established to promote recognition of the economic value of biodiversity and ES and to provide practical guidance for policymakers and practitioners.

the tourism sector, the loss of these services lowers economic benefits and undermines the reputation of cities as attractive and sustainable destinations.[3]

The UHI also affects provisioning services supplied by urban agroecosystems, particularly those linked to urban agriculture, which has become increasingly relevant in sustainable urban strategies.[4] Thermal stress from elevated temperatures reduces crop productivity and harms animal health. Extreme heat also accelerates evapotranspiration, thereby raising irrigation demands and placing additional pressure on scarce water resources (Thiery et al., 2020).

These impacts on welfare underscore the importance of implementing sustainable urban strategies to mitigate the UHI. Expanding urban green infrastructure—through tree planting, the creation of urban parks, and the adoption of green roofs and walls—enhances shading and improves thermal regulation (Johnson et al., 2021). The use of sustainable materials with high solar reflectance, such as cool pavements and light-coloured roofing, is also essential (Tong & Li, 2017). Furthermore, urban planning plays a key role by establishing ventilation corridors that channel fresh air from surrounding rural areas and by ensuring an equitable distribution of green spaces (Jensen & Birche, 2018). Finally, educational campaigns that promote sustainable urban practices are crucial for achieving lasting and transformative change (Fruth et al., 2019).

In this context, estimating the Total Economic Value (TEV) of UHI impacts on social welfare is crucial for guiding the design of sustainable urban strategies and supporting more informed public policy decisions.[5]

I.2 Total Economic Value and Valuation Methods

From the perspective of environmental economics, the TEV of an ES is defined as the sum of its use and non-use values (Pearce & Turner, 1995). Use values represent the welfare derived from the direct or indirect use of an ES. In urban contexts, examples of ES that directly contribute to welfare include thermal

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3 See Berghöfer, A., Mader, A. & Patrickson, S., Calcaterra, E. & Smit, J. & Blignaut, J. & de Wit, M. & Van Zyl, H. (2011). TEEB Manual for Cities: Ecosystem Services in Urban Management.

4 See Castellarini (2022) for a comprehensive review.

5 The difference between the TEV of ES estimated before and after the UHI—or before and after the implementation of a mitigation strategy—enables the monetary assessment of changes in human welfare associated with this phenomenon. This variation in welfare attributable to the UHI is hereafter referred to as the “TEV of UHI impacts on social welfare”.

comfort and access to green spaces for recreation and mental and physical health benefits. Beyond these direct contributions, ES also provide indirect benefits, such as habitats for species and the regulation of climate and air quality.

A particular type of use values is the option value, which reflects individuals' preferences regarding the possibility of enjoying an ES in the future. For instance, although a person may not currently visit a given metropolitan area, they may plan a leisure trip in the coming days. If a heatwave degrades the scenic quality of green spaces in that area, it would reduce the individual's welfare.

In contrast to use values, non-use values arise in the absence of both direct and indirect use of ES. The main types are existence value and bequest value. Existence value refers to the satisfaction derived simply from knowing that an ES, such as urban trees, continues to exist. Bequest value denotes the welfare associated with ensuring that an ES, such as an urban park, remains available for future generations.

The economic valuation of the UHI requires estimating the TEV of its impacts on welfare. A central challenge in this valuation is that many ES are non-market goods, which precludes direct price observation. For example, there are no dedicated markets for climate regulation or habitats for species.

In light of this limitation, economics has developed a set of methods to assign monetary values to ES that lack a market (Bateman et al., 2006; TEEB, 2012). These methods are commonly classified as follows:

- Indirect methods based on cost and production functions (hereinafter referred to as indirect methods) draw on technical, economic, and engineering information to estimate either the economic impacts of environmental degradation or the benefits of conservation. Among cost-based approaches, three are most prominent: (i) the Avoided Cost Method (ACM), which estimates the value of an ES from the costs that would have been incurred in its absence; (ii) the Replacement Cost Method (RCM), which calculates the costs of substituting the ES with artificial technological solutions; and (iii) the Mitigation and Restoration Cost Method (MRCM), which measures the costs required to reduce, compensate, or reverse the negative of ES loss (Garrod & Willis, 1999). Production Function (PF) methods, in turn, assess the contribution of ES to income generation or productivity gains. A typical application is the valuation of the impact of specific ES on labour productivity (Pattanayak & Kramer, 2001).

- Indirect methods based on revealed preferences (hereinafter referred to as revealed preference methods) rely on observing the individual behaviour in markets related to the ES being valued. In such contexts, people indirectly reveal their preferences for certain ES through their economic decisions in third-party markets. Within this category, two methods stand out: (i) the Travel Cost Method (TCM), which estimates the recreational value of a specific site—such as a park or nature reserve—in monetary terms (Kontoleon et al., 2007); and (ii) the Hedonic Pricing Method (HPM), which derives implicit prices from the attributes of market-traded goods. This approach assumes that goods such as housing consist of multiple attributes, including environmental ones, each contributing to the total price to varying degrees (Rosen, 1974). For example, a property with scenic views or located in a high-amenity natural setting may command a higher price, allowing the monetary value of these environmental attributes to be inferred from variations in real estate markets.

- Direct methods based on stated preferences (hereinafter referred to as stated preference methods) are grounded in the preferences that individuals express regarding the ES of interest. By means of questionnaires, a simulated market is constructed, typically involving a hypothetical change—usually policy-induced—in the provision of the ES. The two main approaches are: (i) the Contingent Valuation Method (CVM), which estimates the value of the ES based on either the maximum amount respondents would be willing to pay for an improvement in its quantity or quality, or the minimum amount they would accept as compensation for its deterioration (Hanemann, 1994); and (ii) Choice Experiment Models (CEM), in which respondents evaluate two or more alternatives that share certain attributes, including a payment vehicle, and are asked to select their preferred option (Hensher et al., 2005). The monetary value of a marginal change in each attribute is then inferred from these choices.[6]

In general, revealed preference methods have the advantage of relying on observed individual behaviour in markets related to the ES being valued. However, their main limitation—shared with indirect methods based on cost and production functions—is that they cannot capture non-use values (Kontoleon et al., 2007). By

[6] Stated preference methods have been widely debated due to limitations such as strategic behaviour, protest responses, response bias, and disregard for income constraints. However, the specialised literature largely agrees that many of these limitations can be mitigated through rigorous survey design and careful validation of hypothetical scenarios (Hanemann, 1994; Hensher et al., 2005).

contrast, stated preference methods encompass both use and non-use values, as they rely on hypothetical scenarios in which individuals are directly asked to state their willingness to pay for the ES of interest.

Alongside these approaches, the Benefit Transfer Method (BTM) provides an alternative by estimating the value of an ES through the transfer of economic values inferred from a site with similar characteristics (Johnston et al., 2021). This method also captures both use and non-use values. Its main advantage lies in delivering results more quickly and at lower cost than other valuation methods.

In general terms, economic valuation methods incorporate social preferences into decision-making, thereby supporting the design of more informed public policies.

II. METHODOLOGY

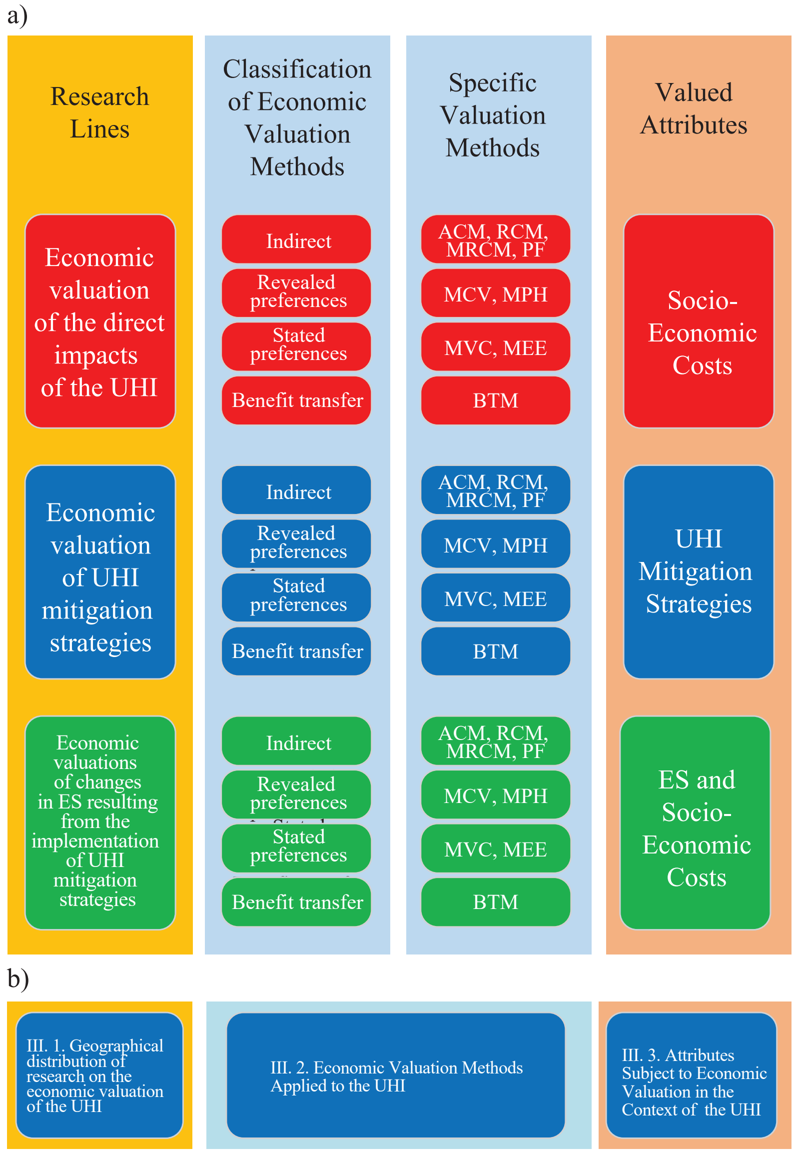
II.1 Data Collection

This study carried out a structured synthesis and critical analysis of the literature on the economic valuation of the UHI. Sources were retrieved through Google Scholar and covered publications from 1990 to March 2024.[7] The review included a wide range of documents reflecting the multidisciplinary nature of the topic, from peer-reviewed articles to policy-oriented and practice-based studies. The search strategy combined keywords and Boolean operators: "urban heat island" OR "heat waves" OR "urban heat island mitigation strategies" AND "economic valuation" OR "valuation methods". Keywords were applied in both English and Spanish.

The search yielded 52 publications, none of which specifically addressed the economic valuation of the UHI in urban areas of Argentina. The study by Akbari et al. (1990) marked an early contribution by assessing the impact of the UHI on welfare in monetary terms through the costs of electricity consumption and CO_2 emissions in Los Angeles, the United States. The literature shows a subsequent period of stagnation in this research field, which was revived only in the early 2000s with the works of Akbari et al. (2001) and Wong et al. (2003).

7 In this study, Google Scholar was selected over specialised databases such as Web of Science or Scopus due to its broad multidisciplinary coverage, which includes scientific, technical, and grey literature. This feature was considered particularly suitable for capturing the diverse range of documents addressing the economic valuation of UHI impacts on social welfare. Moreover, as an open-access platform, Google Scholar promotes methodological transparency and enables the replication of the search procedure by researchers without access to subscription-based databases.

Figure 1. Methodological framework for (a) analysing the state of the art in the economic valuation of the UHI and (b) organising the results



Source: Own elaboration.

II.2. Data Analysis

Based on the research question, “What was the subject of study through which the monetary valuation of changes in social welfare caused by the UHI was conducted?”, we identified three main lines of research: (a) economic valuation of the direct impacts of the UHI; (b) economic valuation of UHI mitigation strategies; and (c) economic valuation of changes in ES resulting from the implementation of UHI mitigation strategies.[8]

Within each research line, the studies were classified according to the family of economic valuation methods applied: indirect methods, revealed preference methods, stated preference methods, or the benefit transfer method. The specific method used in each case was then identified. Finally, the attributes subject to valuation were catalogued (Figure 1.a).

A complete list of the 52 publications reviewed is provided in the Appendix, organised by research line, author(s), country (study area), economic valuation method, and valued attributes.

III. RESULTS

The results are organised into three sections, as shown in Figure 1.b. Each section presents disaggregated findings by research line, followed by a cross-cutting analysis that considers all studies, irrespective of research line. This structure highlights methodological trends, knowledge gaps, and emerging challenges in the economic valuation of the UHI.

III.1. Geographical Distribution of Research on the Economic Valuation of the UHI

Of the 52 publications identified in the literature review, 50 were included in this analysis. Two studies—Estrada et al. (2017) and Huang et al. (2023)—were excluded, as both covered a large number of study areas, making a georeferenced analysis unfeasible. Estrada et al. (2017) assessed UHI-related impacts in 1,692 cities worldwide, while Huang et al. (2023) examined 85 European cities.

[8] The classification and labelling of ES used in this research were not explicitly employed in the reviewed documents. For the purposes of our analysis, ES were grouped and defined according to the classification system proposed by Pascual, U. & Muradian, R. (Coords.) (2012).

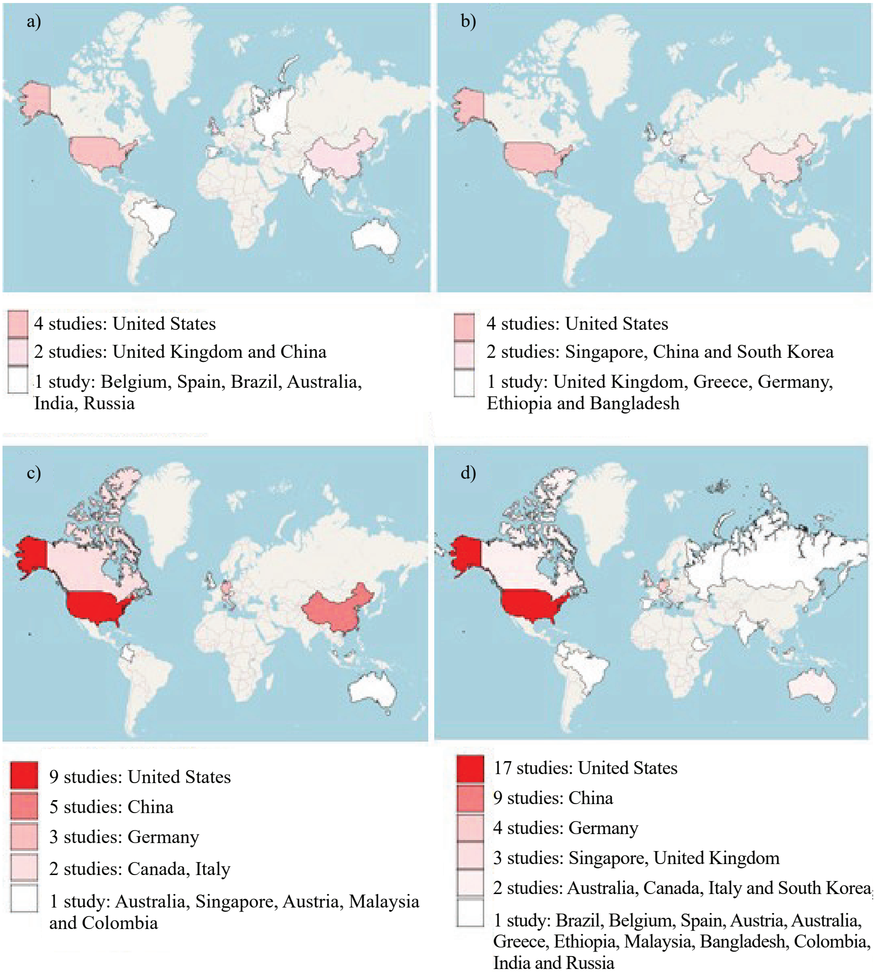
The 50 studies analysed encompassed 56 study areas (countries), as some publications addressed more than one case. The spatial analysis was conducted using study areas as the unit of analysis. Figure 2 illustrates the geographical distribution of the study areas by research line: 14 focused on the economic valuation of the direct impacts of the UHI, 16 on the economic valuation of UHI mitigation strategies, and 26 on the economic valuation of changes in ES resulting from the implementation of UHI mitigation strategies.

Our findings indicate that, within the first research line—economic valuation of the direct impacts of the UHI (Figure 2.a)—the United States accounted for the largest number of studies, with four publications (Monbouquette, 2012; Miner et al., 2016; Roxon et al., 2020; Estrada et al., 2024). The United Kingdom (Costa et al., 2016; Jones et al., 2024) and China (Lin et al., 2022; Estrada et al., 2024) each contributed two studies. The investigation by Costa et al. (2016) also covered Belgium and Spain, representing the only publication identified for those countries. A single study was reported for Brazil (Souza et al., 2009), Australia (Van Raalte et al., 2012), and India and Russia (Estrada et al., 2024).

Under the second research line—economic valuation of UHI mitigation strategies (Figure 2.b)—the United States again led, with four publications (Donovan & Butry, 2010; William et al., 2016; Shickman & Rogers, 2020; Atherton et al., 2021). Singapore (Wong et al., 2003; Tong & Li, 2017), China (Chan & Chow, 2013; Zhang et al., 2019), and South Korea (Kim et al., 2016; Ji et al., 2022) followed, each with two studies. Only one investigation was found for the United Kingdom (Mell et al., 2013), Greece (Latinopoulos et al., 2016), Germany (Fruth et al., 2019), Ethiopia (Bizuneh, 2021), and Bangladesh (Hasan et al., 2023).

The third research line—economic valuation of changes in ES resulting from the implementation of UHI mitigation strategies (Figure 2.c)—again showed the United States leading, with nine publications (Akbari et al., 1990, 2001; Akbari, 2005; Carter & Keeler, 2008; Clark et al., 2008; Bianchini & Hewage, 2012; Pomerantz, 2018; Sinha et al., 2021; Netusil et al., 2022). China followed with five studies (Chau et al., 2010; Lo & Jim, 2010; Peng & Jim, 2015; Hui et al., 2022; Jim et al., 2022), while Germany contributed three (Veisten et al., 2012; Johnson & Geisendorf, 2022; Van Oijstaeijen et al., 2022). Canada (Bianchini & Hewage, 2012; Feng, 2018) and Italy (Perini & Rosasco, 2013; Capotorti et al., 2019) each accounted for two publications. Finally, Australia (Whiteoak & Saigar, 2019), Singapore (Borzino et al., 2020), Austria (Johnson et al., 2021), Malaysia (Azis & Zulkifli, 2021), and Colombia (Arce Correa, 2023), each contributed a single study.

Figure 2. Geographical distribution of studies on the economic valuation of the UHI



Note: (a) Direct impacts of the UHI, (b) UHI mitigation strategies, (c) changes in ES resulting from the implementation of UHI mitigation strategies, and (d) cross-cutting analysis.
Source: Own elaboration using QGIS 3.34 for georeferencing purposes.

The cross-cutting analysis (Figure 2.d) shows that most studies on the economic valuation of the UHI were concentrated in the United States and China, which together accounted for 52% of all publications. The United States led with 17 studies, followed by China with nine. Other significant contributions came from Germany, the United Kingdom, and South Korea.

By contrast, research on the UHI in Latin America and the Southern Hemisphere remains limited, although these regions are more vulnerable to its effects due to lower adaptive capacity. This gap partly reflects disparities in the quantity and quality of urban green spaces between cities in the Global North and Global South, shaped by socioeconomic and environmental conditions (Li et al., 2024; Yuan et al., 2025). Furthermore, cities in the Southern Hemisphere, often constrained by scarce financial resources, face serious obstacles in developing urban green infrastructure and adopting cooling technologies, which restricts their capacity to mitigate UHI effects. This problem is particularly acute in cities with low vegetation cover or suboptimal urban planning (Roth, 2007; Li & Liao, 2017).

In this context, generating scientific knowledge on the economic valuation of the UHI in Latin America and the Global South is crucial to inform the design of sustainable urban strategies based on local evidence and to strengthen adaptive capacity.

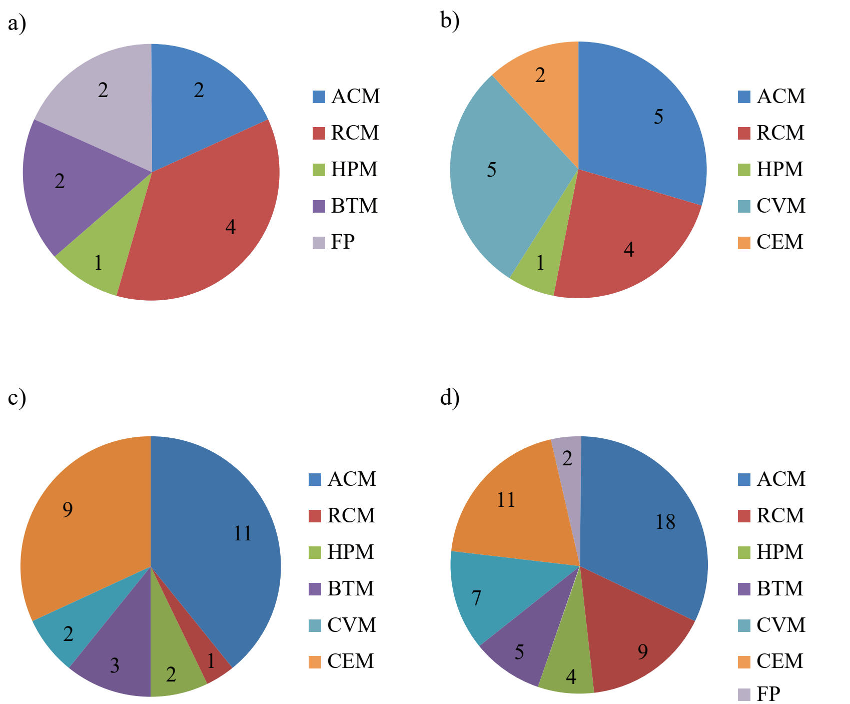
III.2. Economic Valuation Methods Applied to the UHI

Figure 3. presents the number of publications by economic valuation method applied to the UHI, disaggregated by research line.

Our findings indicate that, within the first research line—economic valuation of the direct impacts of the UHI (Figure 3.a)—the RCM was the most frequently applied method, used in four studies (Souza et al., 2009; Monbouquette, 2012; Van Raalte et al., 2012; Miner et al., 2016). Both the FP (Costa et al., 2016; Jones et al., 2024) and the ACM (Roxon et al., 2020; Estrada et al., 2024) were applied in two studies each, as was the BTM (Huang et al., 2023; Estrada et al., 2024). Finally, the HPM was used in one study (Lin et al., 2022).

Under the second research line—economic valuation of UHI mitigation strategies (Figure 3.b)—the ACM (Wong et al., 2003; Estrada et al., 2017; Shickman & Rogers, 2020; Atherton et al., 2021; Hasan et al., 2023) and the CVM (Mell et al., 2013; Latinopoulos et al., 2016; Zhang et al., 2019; Bizuneh, 2021; Ji et al., 2022) were the most frequently applied methods, each appearing in five studies. They were followed by the RCM, with four applications (Wong et al., 2003; Chan & Chow, 2013; William et al., 2016; Tong & Li, 2017), the CEM, with two applications (Kim et al., 2016; Fruth et al., 2019), and the HPM, which was used in one study (Donovan & Butry, 2010).

Figure 3. Economic valuation methods applied to the UHI



Note: (a) Direct impacts of the UHI, (b) UHI mitigation strategies, (c) changes in ES resulting from the implementation of UHI mitigation strategies, and (d) cross-cutting analysis. Numbers within each segment indicate the number of publications that applied the corresponding economic valuation method.
Source: Own elaboration.

The third research line—economic valuation of changes in ES resulting from the implementation of UHI mitigation strategies (Figure 3.c)—showed that the ACM was the most frequently applied method, used in 11 studies (Akbari et al., 1990, 2001; Akbari, 2005; Carter & Keeler, 2008; Clark et al., 2008; Perini & Rosasco, 2013; Peng & Jim, 2015; Pomerantz, 2018; Capotorti et al., 2019; Azis & Zulkifli, 2021; Johnson et al., 2021). This was followed by the CEM, applied in nine studies (Chau et al., 2010; Collins et al., 2017; Sinha et al., 2021; Hui et al., 2022; Jim & Hui, 2022; Johnson & Geisendorf, 2022; Van Oijstaeijen et al., 2022; Netusil et al., 2022; Arce Correa, 2023). The BTM was used in three studies (Bianchini & Hewage, 2012; Feng, 2018; Whiteoak & Saigar, 2019). The CVM (Lo & Jim, 2010; Borzino et al., 2020), and the HPM (Veisten et al., 2012; Sinha et al., 2021) appeared in two studies each. Finally, the RCM was applied in one study (Peng & Jim, 2015).

The cross-cutting analysis (Figure 3.d) revealed that only 32% of the applied valuation methods—namely the CEM, CVM, and BTM—captured both use and non-use values of UHI impacts on welfare. The predominance of approaches focused solely on use values leads to an underestimation of the TEV of UHI impacts and risks overlooking significant welfare losses. This methodological trend presents a major challenge for future research, which must adopt economic valuation approaches integrating both use and non-use values to provide a more comprehensive understanding of UHI-related welfare impacts. Advancing in this direction is essential, since estimates based solely on use values fail to reflect social preferences, ultimately weakening the formulation of sustainable urban strategies aligned with societal priorities.

In this context, the BTM has seen relatively limited application, despite its utility in settings with constrained institutional and financial resources. This approach enables the generation of economic estimates more rapidly and at lower cost than other methods, making it a strategic option for supporting the design of sustainable urban strategies in regions where primary research is not always feasible.

III.3. Attributes Subject to Economic Valuation in the Context of the UHI

Figure 4 presents the attributes subject to economic valuation, categorising studies according to their respective research lines.

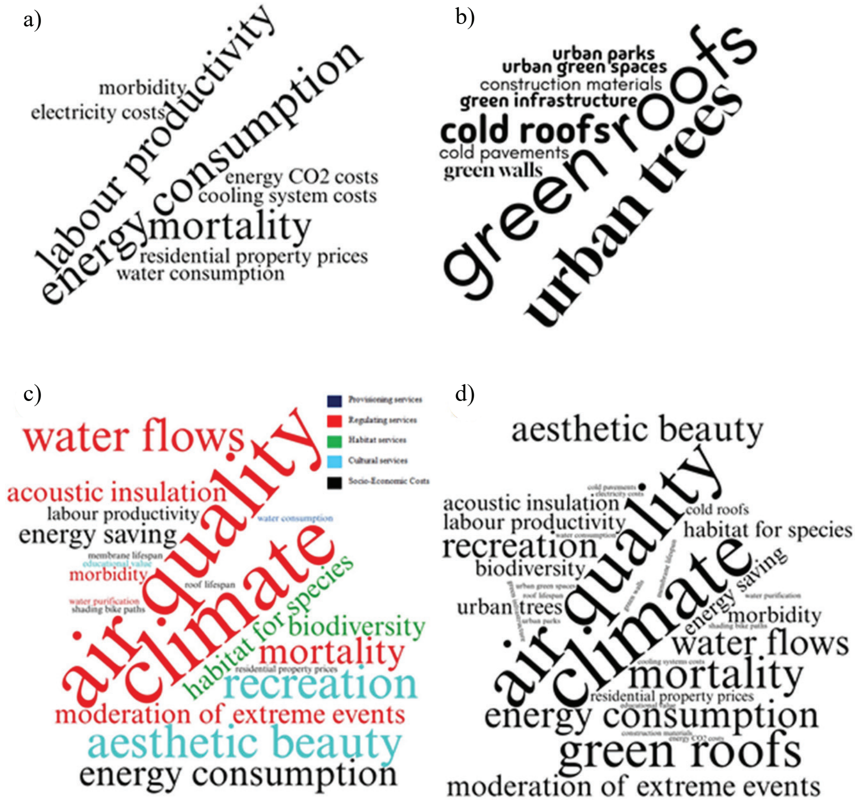
Under the first research line—economic valuation of the direct impacts of the UHI—the main areas of focus were health and energy consumption (Figure 4.a). Within the health domain, studies analysed UHI impacts on mortality (Huang et al., 2023; Van Raalte et al., 2012) and morbidity (Van Raalte et al., 2012). In the energy domain, researchers valued increases in energy consumption (Souza et al., 2009; Monbouquette, 2012; Van Raalte et al., 2012), electricity costs (Roxon et al., 2020), cooling system costs (Miner et al., 2016), and CO_2-related energy costs (Estrada et al., 2024). Lin et al. (2022) assessed the influence of the UHI on residential property prices, Costa et al. (2016) and Jones et al. (2024) estimated the economic value of lost labour productivity, and Van Raalte et al. (2012) examined water consumption.

Under the second research line—economic valuation of UHI mitigation strategies (Figure 4.b)—numerous studies assessed different components of urban green infrastructure. Some articles focused on urban green infrastructure in general (Mell et al., 2013), while others valued urban green spaces (Bizuneh, 2021) and urban parks (Latinopoulos et al., 2016). Additional research examined urban trees (Donovan & Butry, 2010; Kim et al., 2016; Shickman & Rogers, 2020), green roofs (Wong et al., 2003; Chan & Chow, 2013; Tong & Li, 2017; Zhang et al., 2019; Shickman & Rogers, 2020; Atherton et al., 2021; Ji et al., 2022), and green walls (Fruth et al., 2019). Other investigations valued construction materials more broadly (Hasan et al., 2023), as well as cold roofs (William et al., 2016; Estrada et al., 2017) and cold pavements (Estrada et al., 2017).

The third research line—economic valuation of changes in ES resulting from the implementation of UHI mitigation strategies (Figure 4.c)—has primarily focused on regulating services, with the greatest emphasis on climate regulation (Akbari et al., 1990, 2001; Bianchini & Hewage, 2012; Perini & Rosasco, 2013; Peng & Jim, 2015; Pomerantz, 2018; Borzino et al., 2020; Johnson et al., 2021; Sinha et al., 2021; Hui et al., 2022; Jim & Hui, 2022; Netusil et al., 2022; Van Oijstaeijen et al., 2022; Arce Correa, 2023), air quality regulation (Akbari et al., 2001; Carter & Keeler, 2008; Clark et al., 2008; Chau et al., 2010; Bianchini & Hewage, 2012; Perini & Rosasco, 2013; Feng, 2018; Capotorti et al., 2019; Sinha et al., 2021; Jim & Hui, 2022), and water flow regulation (Clark et al., 2008; Feng, 2018; Johnson et al., 2021; Hui et al., 2022; Jim & Hui, 2022). Other studies valued the moderation of extreme events (Carter & Keeler, 2008; Bianchini & Hewage, 2012; Azis & Zulkifli, 2021; Netusil et al., 2022) and acoustic insulation (Chau et al., 2010; Veisten et al., 2012; Feng, 2018).

Cultural services have also been analysed, particularly aesthetic beauty (Chau et al., 2010; Bianchini & Hewage, 2012; Perini & Rosasco, 2013; Feng, 2018; Johnson & Geisendorf, 2022), recreation (Lo & Jim, 2010; Bianchini & Hewage, 2012; Hui et al., 2022; Jim & Hui, 2022), and educational values (Van Oijstaeijen et al., 2022). Habitat services have been economically valued with emphasis on habitats for species (Bianchini & Hewage, 2012; Johnson & Geisendorf, 2022; Perini & Rosasco, 2013) and biodiversity (Collins et al., 2017; Johnson & Geisendorf, 2022; Netusil et al., 2022). By contrast, provisioning services have received limited attention, with only Chau et al. (2010) assessing the effects on water consumption.

Figure 4. Attributes subject to economic valuation in the context of the UHI



Note: (a) Direct impacts of the UHI, (b) UHI mitigation strategies, (c) changes in ES resulting from the implementation of UHI mitigation strategies, and (d) cross-cutting analysis. Each panel presents an independent analysis by research line, and the results are therefore not directly comparable across panels. Word size reflects the relative frequency within each research line. Panel (d) offers a cross-cutting synthesis that integrates all studies irrespective of research line, thereby providing an overarching view of the attributes valued in the context of the UHI.
Source: Own elaboration using the word cloud tool available at https://www.nubedepalabras.es

In addition to ES, several studies have examined broader socio-economic costs related to UHI mitigation strategies. Most research has focused on effects on energy use, with energy savings estimated by Akbari (2005), Clark et al. (2008), and Jim and Hui (2022), and energy consumption valued by Chau et al. (2010), Feng (2018), and Whiteoak and Saigar (2019). Health-related impacts have also received significant attention, particularly morbidity (Whiteoak & Saigar, 2019; Johnson et al., 2021) and mortality (Whiteoak & Saigar, 2019; Johnson et al., 2021; Hui et al., 2022; Jim & Hui, 2022).

By contrast, evidence concerning other socio-economic costs remains limited. Johnson et al. (2021) and Whiteoak and Saigar (2019) economically valued changes in labour productivity, while Johnson et al. (2021) also assessed impacts on residential property prices. Durability aspects have been economically quantified in only a few cases, notably Feng (2018), who analysed membrane lifespan, and Johnson et al. (2021), who valued increased roof lifespan. Additionally, Arce Correa (2023) estimated willingness to pay for shaded bike paths.

Finally, the cross-cutting analysis (Figure 4.d) showed that climate regulation is the most frequently valued attribute, followed by air quality regulation. This pattern underscores the growing prominence of ES in the economic valuation of the UHI, while also revealing the limited attention devoted to provisioning and habitat services, despite their recognised importance for human welfare.

Significant gaps also remain in the economic valuation of the UHI, particularly concerning its effects on key sectors such as tourism and urban agriculture. Furthermore, little valuation has been conducted for innovative mitigation strategies, including urban morphology and architectural planning, the creation of ventilation corridors to channel fresh air from surrounding rural areas, and the incorporation of water bodies into urban landscapes.

In light of these gaps, it is essential to expand the scope of economic valuation of the UHI to encompass a broader range of strategies, socio-economic costs, and ES. Promoting interdisciplinary research is crucial to capture the full spectrum of UHI impacts on social welfare.

CONCLUSIONS

This study represents one of the first efforts to systematise and critically analyse the state of the art in the economic valuation of the UHI. Drawing on a review of literature published between 1990 and 2024, it identified 52 relevant works. Although research in this field has grown in recent years, significant gaps persist—particularly in Latin America and the Southern Hemisphere—where scholarly output remains scarce. In countries such as Argentina, no specific studies on this topic were found. This scarcity limits the development of knowledge adapted to the distinctive characteristics of these regions.

At the global level, the narrow application of methodologies that capture both use and non-use values risks underestimating UHI impacts on social welfare. In this context, the BTM offers particular value for regions with institutional and financial constraints.

The findings also confirm the central role of ES in the economic valuation of the UHI, with particular emphasis on benefits such as climate and air quality regulation, while also highlighting the limited attention given to provisioning and habitat services, despite their recognised importance for human welfare. Significant gaps also remain in the valuation of UHI impacts, especially in sectors such as tourism, urban agriculture, and innovative mitigation strategies. Together, these gaps underscore the need to advance the estimation of the TEV of UHI impacts, in order to capture their effects on social welfare more comprehensively and to support the design of sustainable urban strategies that reflect social preferences.

Finally, the Appendix provides detailed information on the reviewed publications, offering readers the necessary data to cross-reference and conduct further analyses on the economic valuation of the UHI, according to their specific interests or research objectives.

APPENDIX

Table 1. Geographical distribution of studies on economic valuation of the UHI

References	Country (study area)	Economic valuation method	Valued attributes*
Souza et al. (2009)	Brazil	RCM	Energy consumption
Monbouquette (2012)	United States	RCM	Energy consumption
Van Raalte et al. (2012)	Australia	RCM	Mortality, morbidity, energy consumption, water consumption
Costa et al. (2016)	Spain, Belgium, United Kingdom	FP	Labour productivity

Miner et al. (2016)	United States	RCM	Cooling systems costs
Roxon et al. (2020)	United States	ACM	Electricity costs
Lin et al. (2022)	China	HPM	Residential property prices
Huang et al. (2023)	Global coverage	TBM	Mortality
Estrada et al. (2024)	United States, China, India, Russia	ACM, TBM	Social cost of energy-related CO_2 emissions (hereinafter referred to as energy CO_2 costs)
Jones et al. (2024)	United Kingdom	FP	Labour productivity

* Social and economic costs used to value the impacts of the UHI on social welfare.

Table 2. Economic valuation methods applied to the UHI

References	Country (study area)	Economic valuation method	Valued attributes*
Wong et al. (2003)	Singapore	ACM, RCM	Green roofs
Donovan & Butry (2010)	United States	HPM	Urban trees
Chan & Chow (2013)	China	RCM	Green roofs
Mell et al. (2013)	United Kingdom	CVM	Green infrastructure
Kim et al. (2016)	South Korea	CEM	Urban trees
Latinopoulos et al. (2016)	Greece	CVM	Urban parks
William et al. (2016)	United States	RCM	Cold roofs

Estrada et al (2017)	Global coverage	ACM	Cold roofs, cold pavements
Tong & Li (2017)	Singapore	RCM	Green roofs
Fruth et al. (2019)	Germany	CEM	Green walls
Zhang et al. (2019)	China	CVM	Green roofs
Shickman & Rogers (2020)	United States	ACM	Urban trees, green roofs
Atherton et al. (2021)	United States	ACM	Green roofs
Bizuneh (2021)	Ethiopia	CVM	Urban green spaces
Ji et al. (2022)	South Korea	CVM	Green roofs
Hasan et al. (2023)	Bangladesh	ACM	Construction materials

* UHI mitigation strategies for which the impacts on social welfare are valued.

Table 3. Attributes subject to economic valuation in the context of the UHI

References	Country (study area)	Economic valuation method	Valued attributes*
Akbari et al. (1990)	United States	ACM	Regulating services: climate regulation
Akbari et al. (2001)	United States	ACM	Regulating services: air quality regulation
Akbari (2005)	United States	ACM	Regulating services: climate regulation
			Socio-economic costs: energy saving
Carter & Keeler (2008)	United States	ACM	Regulating services: moderation of extreme events, air quality regulation

Clark et al. (2008)	United States	ACM	Regulating services: air quality regulation, water flows regulation
			Socio-economic costs: energy saving
Chau et al. (2010)	China	CEM	Provisioning services: water consumption
			Regulating services: air quality regulation, acoustic insulation
			Cultural services: aesthetic beauty
			Socio-economic costs: energy consumption
Lo & Jim (2010)	China	CVM	Cultural services: recreation
Bianchini & Hewage (2012)	Canada	BTM	Regulating services: climate regulation, air quality regulation, moderation of extreme events
			Cultural services: recreation, aesthetic beauty
			Habitat services: habitats for species
Veisten et al. (2012)	Germany	HPM	Regulating services: acoustic insulation
Perini & Rosasco (2013)	Italy	ACM	Regulating services: climate regulation, air quality regulation
			Cultural services: aesthetic beauty
			Habitat services: habitats for species
Peng & Jim (2015)	China	RCM	Regulating services: climate regulation
Collins et al. (2017)	United Kingdom	CEM	Habitat services: biodiversity

Pomerantz (2018)	United States	ACM	Regulating services: climate regulation
Feng (2018)	Canada	BTM	Regulating services: water flows regulation, acoustic insulation, air quality regulation
			Cultural services: aesthetic beauty
Feng (2018)	Canada	BTM	Socio-economic costs: energy consumption, membrane lifespan
Capotorti et al. (2019)	Italy	ACM	Regulating services: air quality regulation
Whiteoak & Saigar (2019)	Australia	BTM	Regulating services: mortality, morbidity
			Socio-economic costs: labour productivity, energy consumption
Borzino et al. (2020)	Singapore	CVM	Regulating services: climate regulation
Azis & Zulkifli (2021)	Malaysia	ACM	Regulating services: moderation of extreme events
Johnson et al. (2021)	Austria	ACM	Habitat services: habitats for species Regulating services: climate regulation, water flow regulation, mortality, morbidity Socio-economic costs: labour productivity, residential property prices, roof lifespan
Sinha et al. (2021)	United States	HPM, CEM	Regulating services: climate regulation, air quality regulation
Hui et al. (2022)	China	CEM	Regulating services: climate regulation, water flow regulation, mortality

			Cultural services: recreation
Jim & Hui (2022)	China	CEM	Regulating services: climate regulation, water flow regulation, mortality, air quality regulation
			Cultural services: recreation
			Socio-economic costs: energy saving
Johnson & Geisendorf (2022)	Germany	CEM	Habitat services: biodiversity
			Regulating services: climate regulation, water purification
			Cultural services: aesthetic beauty
Van Oijstaeijen et al. (2022)	Germany	CEM	Regulating services: climate regulation
			Cultural services: educational values
Netusil et al. (2022)	United States	CEM	Regulating services: climate regulation, moderation of extreme events
Netusil et al. (2022)	United States	CEM	Habitat services: biodiversity
Arce Correa (2023)	Colombia	CEM	Socio-economic costs: shaded bike paths

* Changes in the quantity and/or quality of ES used to value the UHI impacts on social welfare

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