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Review

A Systematic Review on the Existing Research, Practices, and Prospects Regarding Urban Green Infrastructure for Thermal Comfort in a High-Density Urban Context

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Abstract: Urban green infrastructures (UGI) have been suggested as a natural solution to tackle the problem of human thermal comfort as well as to reduce energy consumption in buildings under the pressures of rapid urbanization and global warming. However, the acceptance of UGI to mitigate the urban heat effect is not yet universal. The development of such an infrastructure is also not consistent across the regions, emphasizing the different objective parameters and methodologies. A systematic review has been conducted to analyze the published research work on UGI, targeting thermal comfort, in the past decade to identify the trends of UGI development around the world. The result shows that most of the studied locations were situated around the Mediterranean Sea region in a temperate climate, and most of the studied cities are within countries with a high gross domestic product, large urban area and urban population, primary energy consumption, and high greenhouse gas and carbon dioxide emissions. Extensive green roofs are the most popular type of UGI and mostly use *Sedum* plants. In the published studies, experimental setups are the most common methods by which to collect data. EnergyPlus is the most popular software used to conduct energy analysis for buildings, whereas ENVI-met is more commonly used for microclimate analysis. These results indicated that the direction of UGI studies is driven by climate characteristics and the socioeconomic factors of geographical location, which favor low construction cost and maintenance needs, with a minimal irrigation requirement for small-scale UGI projects. Understanding the trend of UGI approaches for thermal comfort allows researchers to standardize practices that help the decision-making process for future researchers while recognizing the limitations and potential of current UGI practices. It is recommended that future studies should include arid and equatorial climate regions, with more focus on large-scale projects including high-rise building environments to comprehensively evaluate the effectiveness of UGIs.

Keywords: urban green infrastructure; urbanization; thermal comfort; energy consumption; climate change; urban heat

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1. Introduction

Driven by population growth, rapid urbanization has become a common phenomenon in cities around the world. According to the United Nations World Population Prospects [1,2], the projected global population will reach above 8.2 billion by 2030, while over 5 billion people will be living in urban areas. The urban sprawl has irreversible effects on the existing environment and society that cause negative impacts on human health and wellbeing [3]. The high-rise, high-density architecture of the inner city often leads to urban heat island (UHI) effects, which eventually decreases human life expectancy by causing heat-related illness and diseases [4].

To counter the UHI scenario or extreme heat events, urban dwellers tend to pursue thermal comfort through the extensive use of heating ventilation and air conditioning

(HVAC) systems, which triggers a general increase in the city's energy consumption. In Australia, the HVAC system accounts for 40% of the total building energy consumption of a typical office building [5]. Worldwide, as estimated by the International Energy Agency (2018), air conditioning accounts for 10% of all global electricity consumption and is expected to be the second-largest source of global electricity demand by 2050 [6]. The use of an HVAC system is also one of the main contributors to greenhouse gas (GHG) emissions, especially hydrofluorocarbons (HFCs), which have depleted the ozone layer [7]. According to Climate Watch data (2021), the "electricity and heat" sector was the largest producer of global GHG emissions, contributing around 32% in 2018 [8].

GHG emissions are the main driver of global warming, escalating the negative impacts of climate change and will present additional challenges to maintaining human wellbeing [9]. The World Meteorological Organization (2021) predicts that there is an increasing likelihood that the annual average global temperature will rise by 1.5 °C in the next 5 years. This prediction is in line with the estimations made by the Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [10], who has forecast that Australia will experience more frequent and more severe weather events with a warmer and drier climate in the future. The expected higher temperatures will lead to more frequent heatwaves and bushfires [11,12]. The situation may worsen far more profoundly than it appears at present. The bushfires drastically raise the levels of pollutants and toxic fumes in the air, which are extremely harmful to both humans and animals [13]. The situation is even worse in urban areas, as high-rise buildings create barriers that constrain the airflow, meaning that air pollutants will be trapped and recirculate in urban areas for a longer duration in comparison with rural areas [14]. Under such circumstances, people are advised to stay indoors to avoid the toxic smoke and to rely on mechanical ventilation to maintain indoor air quality [15].

The combined threats of urbanization and climate change create pressures on maintaining human wellbeing and energy demands. Although the current technology using an HVAC system is capable of providing thermal comfort for an urban population, it is inevitable that users will generate GHG from this approach; this considerable amount of GHG contributes to climate change, which further speeds up global warming and creates the vicious cycle illustrated in Figure 1. An alternative sustainable solution is urgently needed for a safe and resilient living environment.

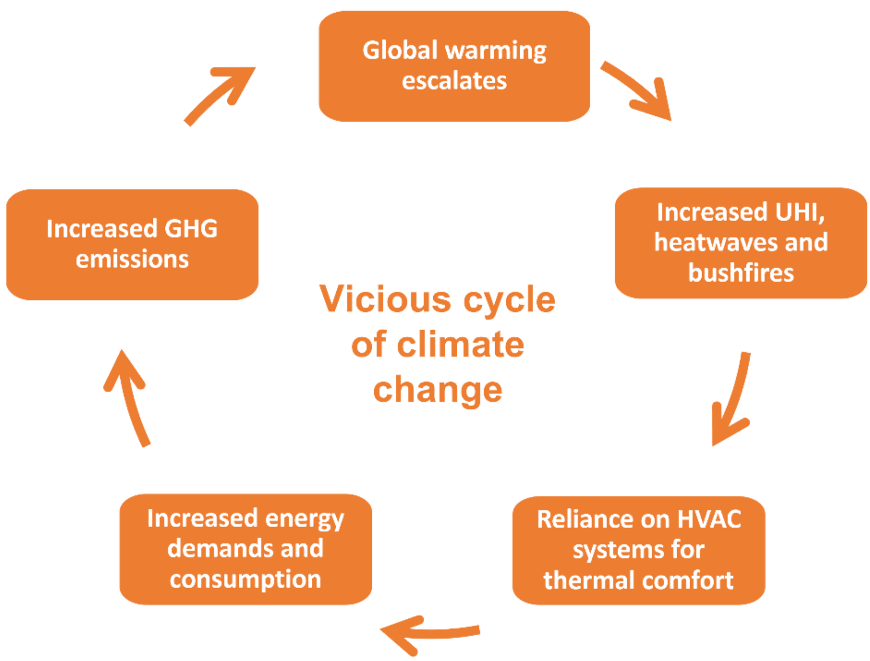


Figure 1. The vicious cycle of climate change.

1.1. The Role of Urban Green Infrastructure (UGI)

The elements of urban green infrastructure (UGI), such as green roofs, green walls, and green facades, represent a natural base solution to break the vicious cycle shown in Figure 1 by providing thermal comfort to urban residents without placing an additional burden in terms of urbanization and global warming. Integrating UGI into urban design can improve the urban microclimate, achieve energy-demand savings, and create temperate outdoor spaces [16,17]. Studies show that UGI is effective for controlling UHI and improving air quality; it leads to positive health effects by reducing asthma, cardiovascular and respiratory disease, obesity, and circulatory disease [18–20]. The indirect positive health impacts associated with socio-economic factors include child cognitive development, elderly longevity, and strengthened immunity [21]. The incorporation of UGI in urban design can help cities to tackle the challenges of limited access to resources and a lack of green space due to urban development, but the success of UGI implantation requires input from the city authorities, businesses, and other institutions, working together to investigate different options to adapt a variety of urban spaces [22].

Although some cities have adapted their UGI as part of urban planning to mitigate urban heat effects, progress is variable and depends on region. As mentioned by the European Commission, the core European cities have an average of 40% surface area that is given over to UGI, yielding around 18 m^2 of publicly accessible green space per inhabitant, with 44% of the urban population living within 300 m of a public park [23]. However, when considering individual cities, the cities around the Mediterranean Sea offer less than 9 m^2 per person of green space on average, while central and northern European cities have more than 20 m^2 per person on average [24]. Similarly, in the United States, San Francisco was the first US city that required new residential and commercial buildings to have at least 15% of the roof area covered by green roofs or solar panels [25]. Despite the fact that the city's urban policy was in favor of UGI development, San Francisco has allocated only around 20 m^2 of green space per inhabitant, whereas Atlanta has allocated more than 100 m^2 of green space per person, which is seven times more than in New York City, which has just 13 m^2 per person [26]. There are several factors that stop people from installing a green roof on an existing building. As the rooftops are usually used for the HVAC system equipment, and the installation of a green roof requires retrofitting to ensure that the roof load-bearing capacity is satisfied, the property owner must also have the option to choose between a green roof, cool roof, or solar panels [27]. Therefore, it is necessary to understand the trends of UGI practice worldwide to mitigate thermal comfort in an urban environment.

1.2. Research Objectives

Although there are examples around the world of successfully integrated UGI schemes for thermal comfort, the acceptance rate, adaptation, and popularity of UGI are still not up to the mark. There are more cities and countries still struggling to establish a clear agenda and consistent policy regarding the implementation of UGI. There is a clear consensus among the researchers that the reasons for the slow progress of UGI development are mainly because of the competition for space in cities, the difficulty of finding finance, uncertainty regarding the economic benefits of GI, the complexity of dealing with a living infrastructure, a lack of policy and standardized practices, slow adoption and a lack of awareness of new ideas [28–32]. It is necessary to further investigate the current practice of UGI for thermal comfort to provide more information related to UGI practices, to achieve a better understanding of UGI designs, the appropriate methods, performance evaluations, and the potential parameters that can be achieved.

This study aims to provide a review of the different types of UGI that are most applicable in an urban context to gain a greater understanding of the factors that might affect UGI effectiveness in regulating human thermal comfort and energy consumption.

The following questions define the scope of our research:

1. What are the main regions and geographical areas where the concept of UGI is more popular?

2. What are the main study parameters being investigated through the research?
3. What are the main approaches adopted for studying UGI around the world?

2. Materials and Methods

A systematic review approach was used for this study and was divided into two stages. The first stage is the initial screening, which aims to filter out those articles that are irrelevant to the UGI frameworks, using specified keywords that are applicable to the selected UGI categories. The second stage is the subsequent screening, which identifies the research focus of the filtered articles from the previous stage to make sure the articles align with the research objectives. Figure 2 illustrates the workflow of this systematic review. The review process was first conducted on 16 January 2022; the SCOPUS and the Web of Science (WoS) search engines were used to maximize the selection of potential articles with open access.

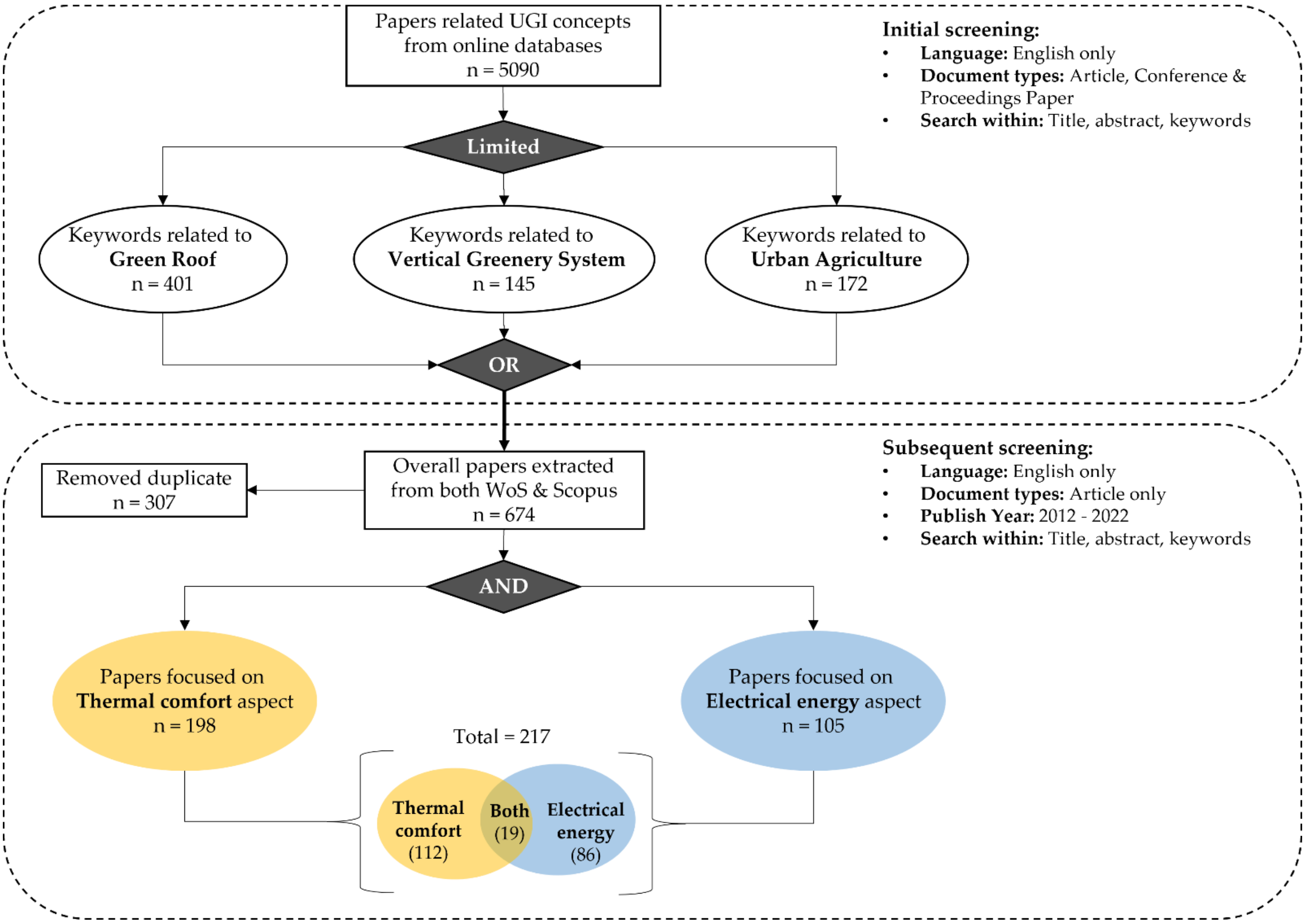


Figure 2. The workflow of the systematic review.

2.1. Types of UGI

Different countries might use different definitions and configurations to categorize UGIs, based on the existing practice and current building standards. For example, in Australia, there are only extensive green roofs and intensive green roofs; semi-intensive green roofs are not considered. The dimensions also vary between the design guidelines [33,34]. As mentioned by Koc et al., there is a lack of studies that concentrate on the classification of UGIs from a climatological perspective [35]. Table 1 provides a brief explanation of the features of each UGI category and subcategory:

Table 1. Abbreviation for and description of each UGI type investigated in this review [33–40].

Abbreviation	UGI Type	Description
GR	**Green Roof**	Artificial landscape on a roof surface with vegetated layers.
EGR	Extensive green roof	Lightweight structure, with a substrate thickness of less than 200 mm. Limited vegetation with shallow roots, such as sedums, herbs, and grasses.
IGR	Intensive green roof	Heavyweight structure, substrate thickness from 250 mm to more than 1 m. Suitable to grow lawns, perennials, shrubs, and small trees.
SemiGR	Semi-intensive green roof	The weight is between EGR and IGR, with a substrate between 120 mm and 250 mm to support grasses, herbs, and shrubs.
BR	Blue roof	Blue roofs involve the use of water-saturated slabs on the building rooftop to provide extra storage for rainwater under the rooftop surface or vegetation layer.
VGS	**Vertical Greenery System**	Vertical structures that allow vegetation to grow across the building's façade and walls.
GF	Green façade	The vegetation cover is formed by climbing plants or hanging plants that grow directly on the façade.
DSGF	Double skin green façade	Similar to the green façade, the vegetation cover is formed on a particular support system that is attached to the building's walls, so that the plant is growing indirectly on the façade.
GW	Green wall	A green wall is also known as a living wall, with supporting structures attached to the façade. With substrate-based plants growing in planter boxes or in pockets on the panels, the vegetation cover is formed by sedums, herbs, or moss instead of climbing plants.
UA	**Urban Agriculture**	The vegetation is edible, which provides a food source and offers other benefits within the urban environment.
RTGH	Rooftop greenhouse	A passive system designed and integrated on a building rooftop to improve the thermal performance.

2.2. Initial Screening of the Literature

The initial screening process focuses on those articles that are related to the framework of UGI concepts and filters out papers on irrelevant green infrastructure. This study only focuses on the UGI that is most suitable for a high-density urban context and is applicable to high-rise buildings. Only three main categories were considered: the green roof (GR), vertical greenery systems (VGS), and urban agriculture (UA). As there are corresponding subcategories extending from these three main categories, the detail of the specific keywords is provided in Appendix A. We applied a search filter that limited the selection to documents using the English language, and restricted the document types to only articles, conference papers, and proceedings papers. Eventually, there were 401 results based on GR keywords across two platforms, 145 results were based on VGS keywords, and 172 results were based on UA keywords.

2.3. Subsequent Screening of Filtered Literature

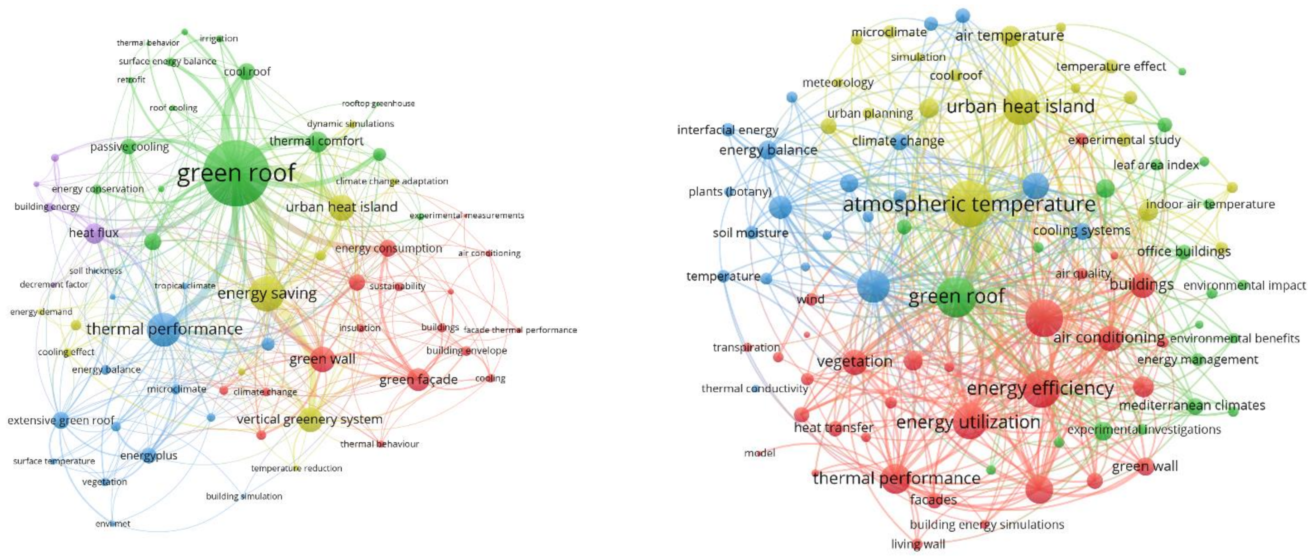
The subsequent screening specifies a research focus that is related to the thermal comfort or electricity energy aspects of the research; the typical keywords for each aspect and the exact searching codes used in Scopus and the WoS are provided in Appendix A. This screening stage was begun by narrowing down the three main UGI categories into two specified areas; a total number of 674 papers were extracted from Scopus and the WoS from the initial screening, while 307 duplicated papers across two platforms were removed. As a result, a total of 217 articles were reviewed (see Appendix B); of these, 112 articles focused on the thermal comfort aspect, 86 articles focused on electrical energy, and 19 articles investigated both aspects. Figure 2 illustrates the filtering and screening process of the articles.

Critical evaluation criteria for the screening process are as follows:

1. The study UGI type must correspond to this research scope.
2. A realistic study location can be identified.
3. The methodology has been validated and used practically in the research.
4. The study focuses on either thermal comfort or electricity energy consumption.

2.4. Establishment of a Bibliography Network Based on Keywords

After the screening, a bibliography network was used to demonstrate the relationship between keywords and the link between topics. The bibliography network used the co-word analysis method on the VOS viewer [41]. A bibliography network is a technique that helps to examine the content of publications by organizing the author's keywords, based on the frequency of the words that appear together, assuming that the words have a thematic relationship with each other [42]. Figure 3a on the left shows the strength of the link between keywords and was illustrated by the thickness. For example, the word "green roof" has the strongest link to "energy saving", after which "cool roof", "thermal performance", and "urban heat island" appear. The phrases "vertical greenery system", "green façade", and "green wall" occurred equally often, with a similar strength of link.



(**a**) (**b**)

Figure 3. (**a**) Bibliography network using the authors' keywords; (**b**) bibliography network using index keywords.

Note that the author keywords are chosen by the authors themselves as being most representative of the content of the publication, while indexed keywords are chosen by the publisher (in this case, Scopus and the WoS), which are standardized to vocabularies including synonyms, alternative spellings, and plurals derived from thesauri that are owned or licensed by the corresponding publisher/company [43]. While author keywords provide a clearer and simpler thematic relationship between the various keywords since authors are more likely to choose the words that more directly fit and best describe their research scope, the indexed keywords in the bibliography provide a wider perspective on the potential connections between topics that might involve the keywords.

3. Analysis and Discussions

The systematic review for this research provides an in-depth analysis of UGI for thermal comfort, covering the geographical distributions, design parameters, and the methodologies/approaches used to cover the study objectives.

3.1. Geographical Distribution of Study Sites

Many studies have been conducted in the last decade to investigate the impacts of UGI in terms of thermal comfort and energy consumption. A study in Turin, Italy showed that the use of green roofs has the potential to decrease the land surface temperature by 2.7 °C, with an energy saving of approximately 14 GWh/year [44]. In Toronto, the average reduction in peak temperatures at the pedestrian level ranged between 0.4 °C and 0.7 °C when using green roofs, resulting in an energy saving of 11.53 kWh/year per unit area [45]. The green roof offers distinct improvements in terms of both thermal comfort and energy consumption; however, the performance differences between two cities can be huge. It is important to investigate the characteristic of a geographic location to identify potential factors that might influence the performance of the UGI.

3.1.1. Regional Trends

The map in Figure 4 illustrated the locations and the corresponding climate zones of the studied cities. The results show that up to 89% of the studied sites are in the northern hemisphere, with 8% of the studies being located around the equatorial regions; only 3% of studies have been conducted in the southern hemisphere.

Figure 4 also illustrated the distribution according to climate zones, based on the Köppen–Geiger climate classification system [46]; the definition and color scheme of each climate zone are provided in Appendix C. The majority of the studies were conducted in a temperate climate (Type C), as mentioned in 107 articles, while equatorial (Type E), arid (Type A), and continental (Type D) climates shared a similar number of studies, with 21, 24, and 26 articles, respectively. There is as yet no study conducted for a polar climate, mainly because suitable vegetation will not survive in such conditions. Under each climate type, the subsequent climate zone can be defined by the figures for precipitation and temperature. Figure 5 provides the distribution of the studied sites according to the individual climate zone. The most frequently studied climate zone is Csa (a temperate climate with dry and hot summers), with 74 articles; these studies are concentrated around the Mediterranean Sea region, which has dry and hot summers. Both Cfa (a temperate climate with a fully humid and hot summer) and Cfb (a temperate climate with a fully humid and warm summer) have a similar number of studies, at 46 and 44, respectively. The studies on these climate zones are mainly conducted in Europe, the east coast of Asia, and a scattering around North America. In terms of the Type D climate, the climate zone Dfb (a humid continental climate with warm summers) is studied most frequently, with 23 articles scattered around North America and northeast Europe. In terms of the Type A climate, the climate zone BWh (a deserts climate with dry and hot weather all year) is examined in 21 studies that are mainly located in the Middle East and the west coast of North America.

Different climate zones require specific considerations that will greatly affect the UGI design parameters. For example, UGI presents a good passive cooling strategy in arid climate areas; however, the design requires more irrigation as the annual rainfall is limited. Cities around the equatorial region have less distinct or even have no seasonal changes compared to other climate zones; instead of having four seasons, the climate is usually divided into wet and dry seasons or the monsoon season. Therefore, extra considerations regarding the loading are required in the GR design, due to the excess rainfall. Unlike a GR, a VGS is more affected by the building's orientation; the vegetation in a different orientation might grow differently because of changes in the daily solar path. A change in location between the northern and southern hemispheres will have an opposite impact on VGS. Since most of the studied sites were in the northern hemisphere, most of the VGS studies were focused on investigating the south- (32%) and west-facing (24%) facades, only 11% of VGS studies have investigated all four orientations (north, east, south, and west), and only 1 paper simulated eight orientations.

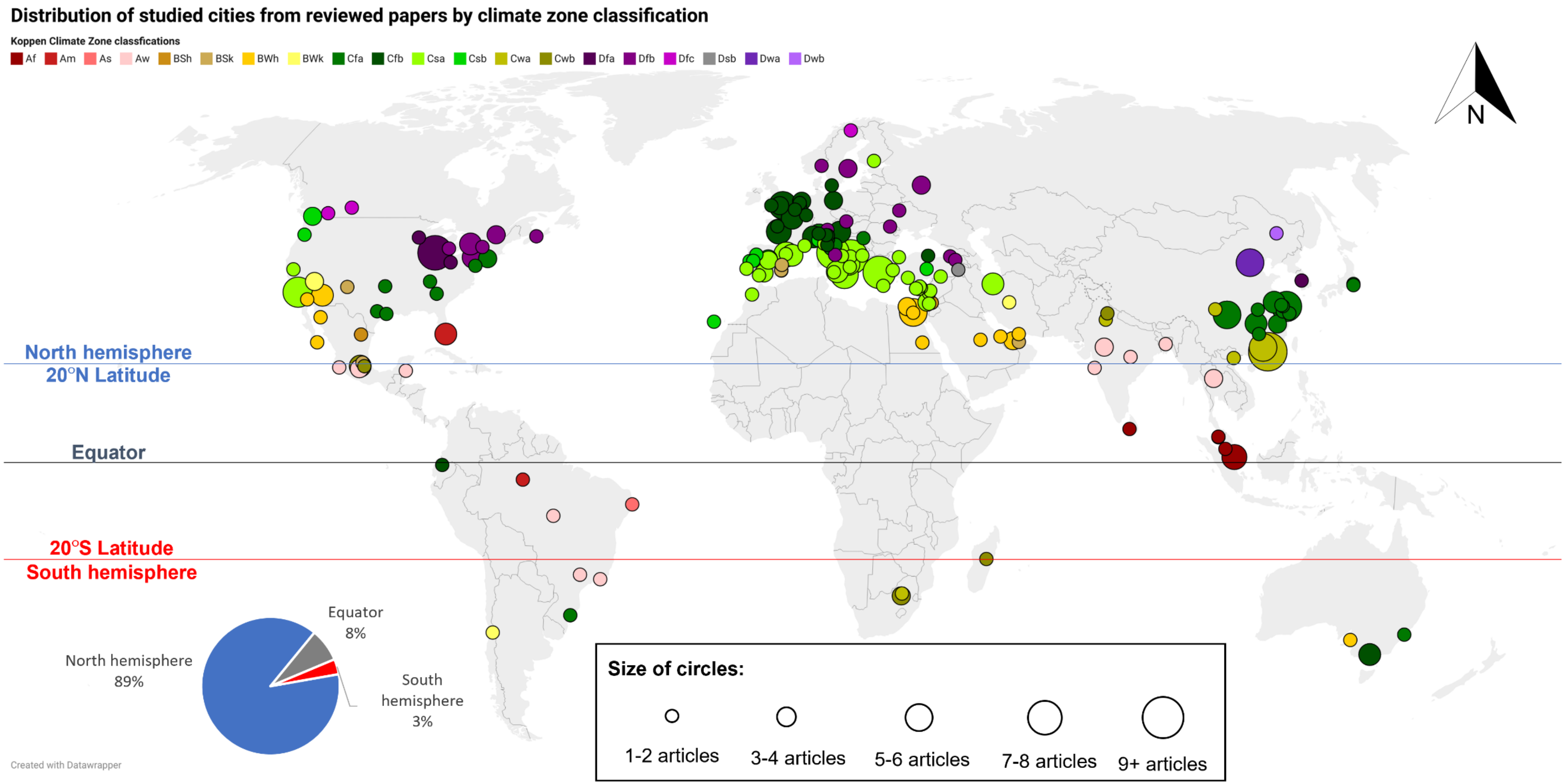


Figure 4. The world map illustrating the distribution of the studied cities in the reviewed papers, according to the updated Köppen-Geiger climate classification scheme in 2016 (see Appendix C for a detailed explanation of the Köppen-Geiger climate classification scheme) [46]. In this paper, the area above the 20° N latitude line is considered to be the northern hemisphere, while the area below the 20° S latitude line is considered to be the southern hemisphere; between the two is considered the equatorial region. Map edited using Datawrapper website. Available online: https://www.datawrapper.de/ (accessed on 7 May 2022).

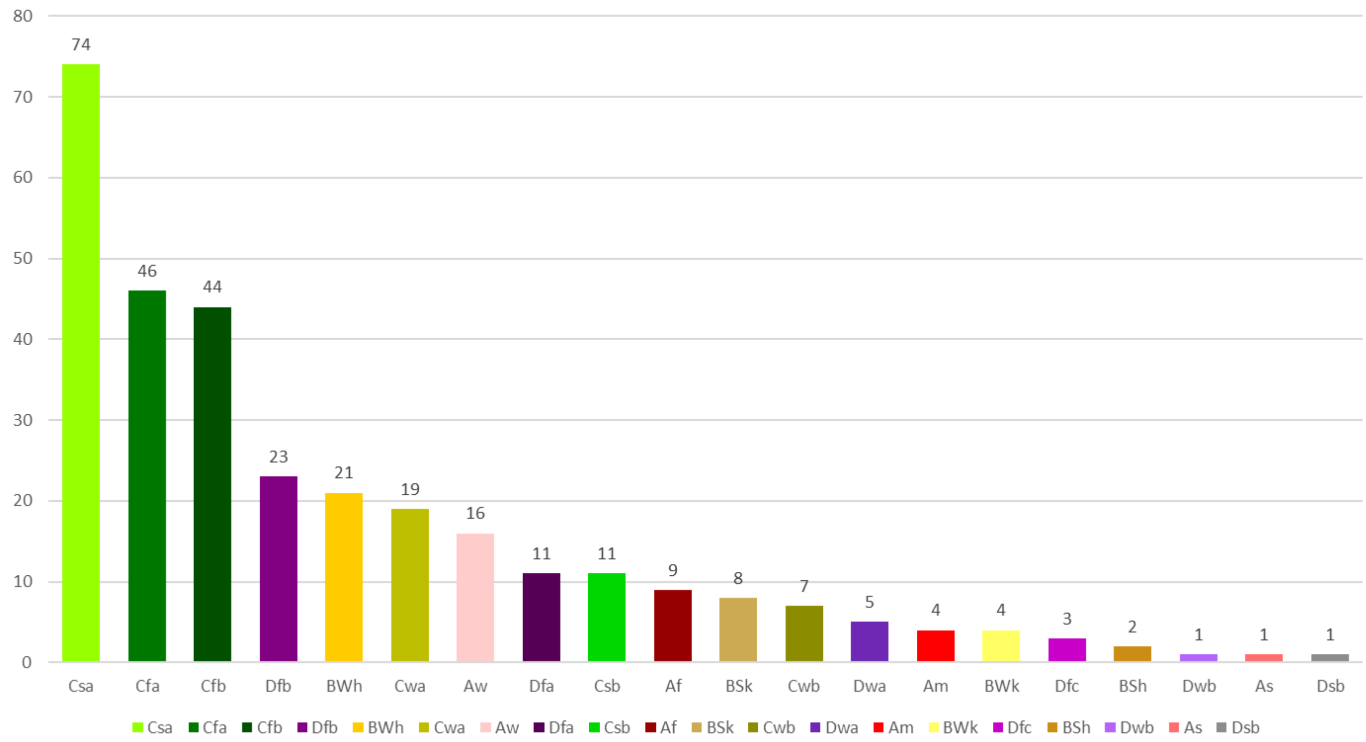


Figure 5. The distribution of Köppen-Geiger climate classification zones according to the studied locations. (See Appendix C for a detailed explanation of the Köppen-Geiger climate classification scheme).

3.1.2. Top-Performing Countries and Cities

Each country and city has a different level of progress in UGI development, depending on the corresponding socioeconomic factors and the level of government interest. The top ten countries with the highest numbers of UGI research publications are shown in Figure 6. From the systematic review, the results show that China has published the most studies in the last decade, with 41 articles; most of the studies in China were conducted in Hong Kong, Shanghai, and Guangzhou. Italy is the second most popular country in terms of UGI studies, with 40 articles; Bari, Rome, and Catania are the most popular Italian cities in terms of UGI research. The third country in terms of the most UGI publications is the United States of America (USA) with 26 articles; Chicago, Los Angeles, and Phoenix are the most frequently studied US cities.

Rank	1				2				3				4				5				6				7				8		9				10			
Country	China				Italy				USA				Spain				France				UK				Canada				Greece		Egypt				India			
Top 3 Cities	Hong Kong	Shanghai	Guangzhou	Others	Bari	Rome	Catania	Others	Chicago	Los Angeles	Phoenix	Others	Puigverd de Lleida	Barcelona	Mardrid	Others	La Rochelle	Paris	Nantes	Others	London	Reading	Cardiff	Others	Toronto	Montreal	Vancouver	Others	Athens	Crete	Cairo	Alexandria	Giza	Others	Ujjain	New Delhi	Mumbai	Others
no. of publications	10	6	5	20	9	7	5	19	8	6	3	9	4	3	2	8	4	3	1	2	5	2	1	1	3	2	1	2	7	1	5	2	1	1	2	1	1	3

Figure 6. The ranking of the top 10 countries with the most UGI research publications, published between 2010 and 2021, with additional information on the top 3 cities in each country.

In total, 177 separate cities across 50 countries around the world were identified; as there are some cities that have been studied more than once, a total of 310 counts in terms of the studied locations were recorded. The map in Figure 7 illustrates the distribution of the studied cities and the number of publications that are represented. It shows that most of the studies are conducted in European countries and those countries surrounding the Mediterranean Sea, typically, the United Kingdom (UK), France, Spain, Italy, Egypt, and Greece. Away from Europe, the majority of UGI studies are conducted in southeast Asian and northern American countries, such as China, India, Singapore, the US, and Canada. The rest of the world shows relatively fewer publications that are scattered around the globe; only Brazil, Mexico, and Australia exhibit slightly more UGI studies than the other countries.

To understand why these countries are more advanced in terms of UGI research compared to the others, the following factors have been considered:

- The overall number of publications, by country;
- The gross domestic product (GDP);
- Urban population;
- Urban land area;
- Primary energy consumption:
- Greenhouse gas and carbon dioxide emissions [47].

Based on the above factors, a normalized weight for each factor was generated to compare the patterns in the top 20 countries with the highest numbers of research publications. The normalizing factors are shown in Figure 8, with the trendlines identifying similar patterns. China, the US, Italy, India, Canada, and Brazil demonstrate stronger relationships with the above factors. It is worth mentioning that Germany and Japan were not on the top ten list of countries. With further investigation, it was found that although Germany and Japan do have a fair number of UGI studies, the study focus of this research is on the combined parameters of "electrical energy" and "thermal comfort" performance, in which areas Germany ranks below 20 and Japan ranks 14. As Germany and Japan are not among the top ten countries in the screening process of this research, this does not affect the primary conclusions of this study.

In the case of the Russian Federation, UGI is not the focus of research in the country because of various factors; it has a low urban land area percentage and UGIs do not provide many benefits in an area with an extremely cold climate.

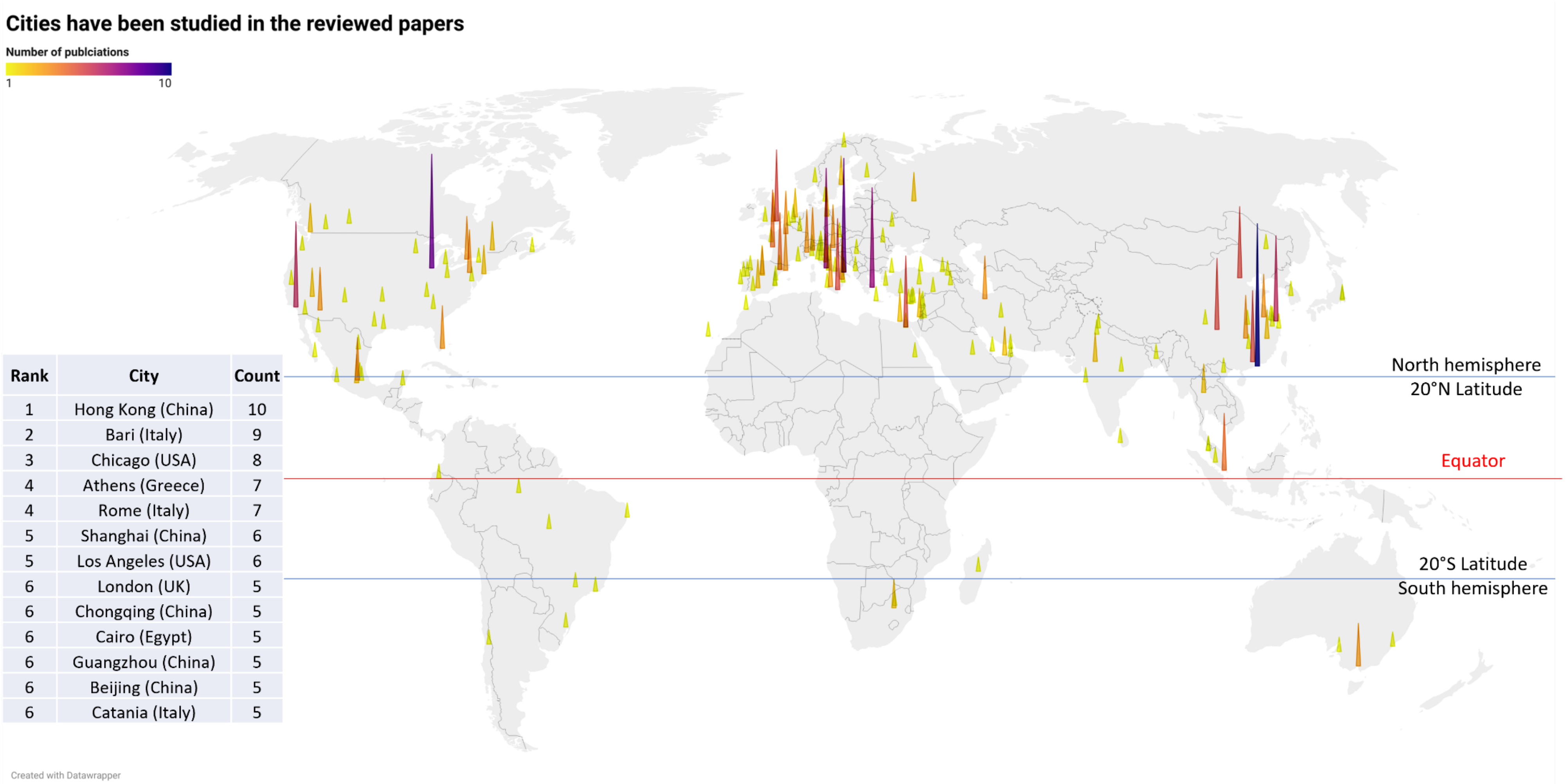


Figure 7. A world map illustrating the distribution of the studied cities in the reviewed papers. Map edited using Datawrapper website. Available online: https://www.datawrapper.de/ (accessed on 7 May 2022).

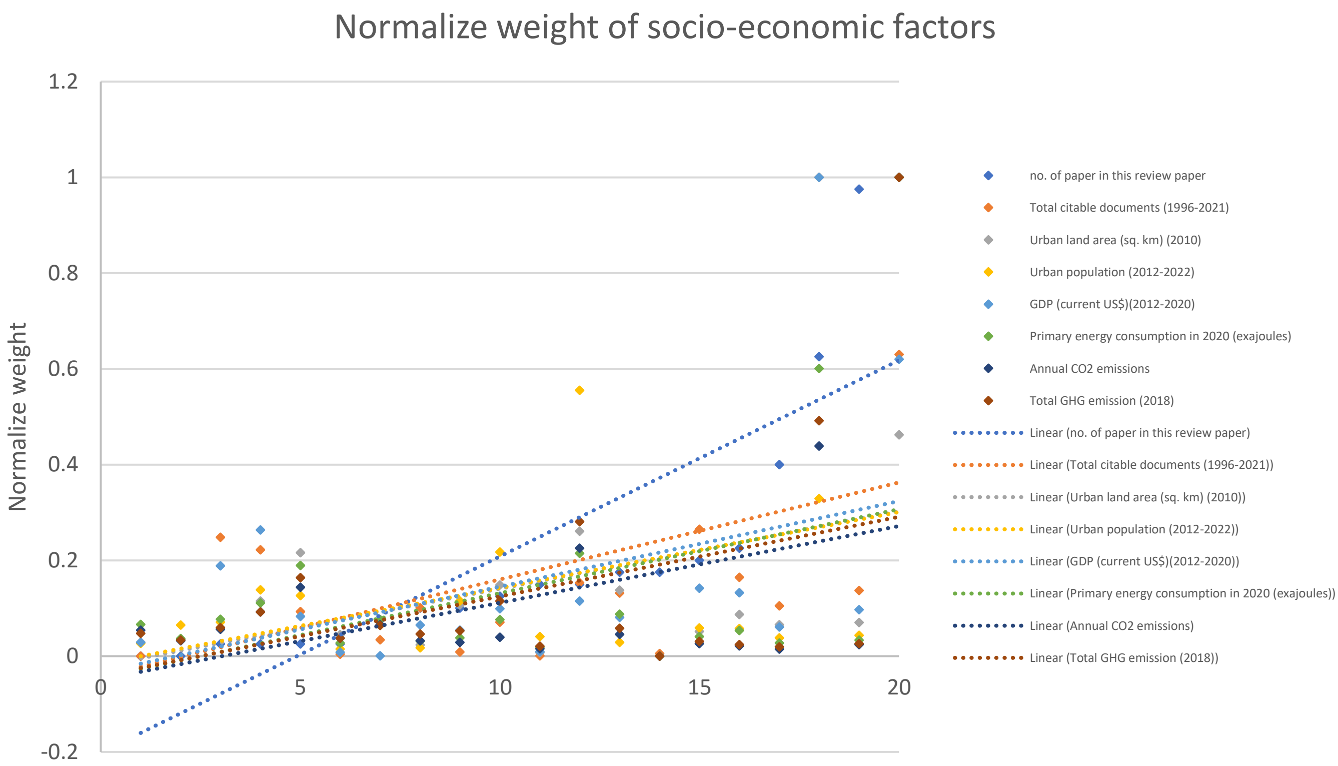


Figure 8. The normalized weight of the socioeconomic factors.

3.2. Study Parameters

Different types of UGI require different design parameters to achieve ideal effectiveness; understanding the current practices will help to standardize the design parameters in the future. Figure 9 shows the number of reviewed papers that have been published between 2012 and 2021, according to the individual UGI categories. Figure 9 shows a general increasing trend for all three UGI categories. There are far more publications studying the GR types, compared with the VGS and UA types.

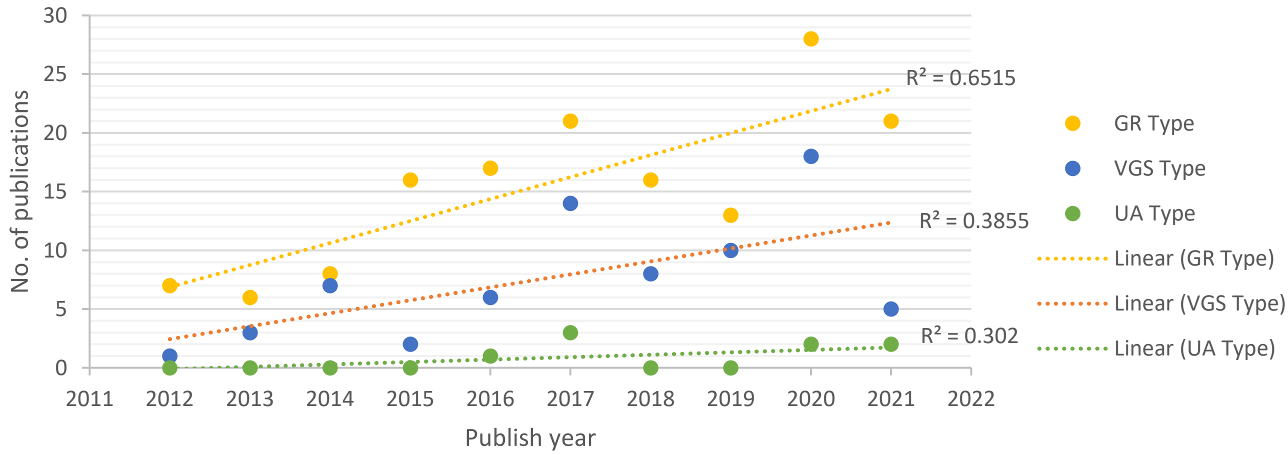
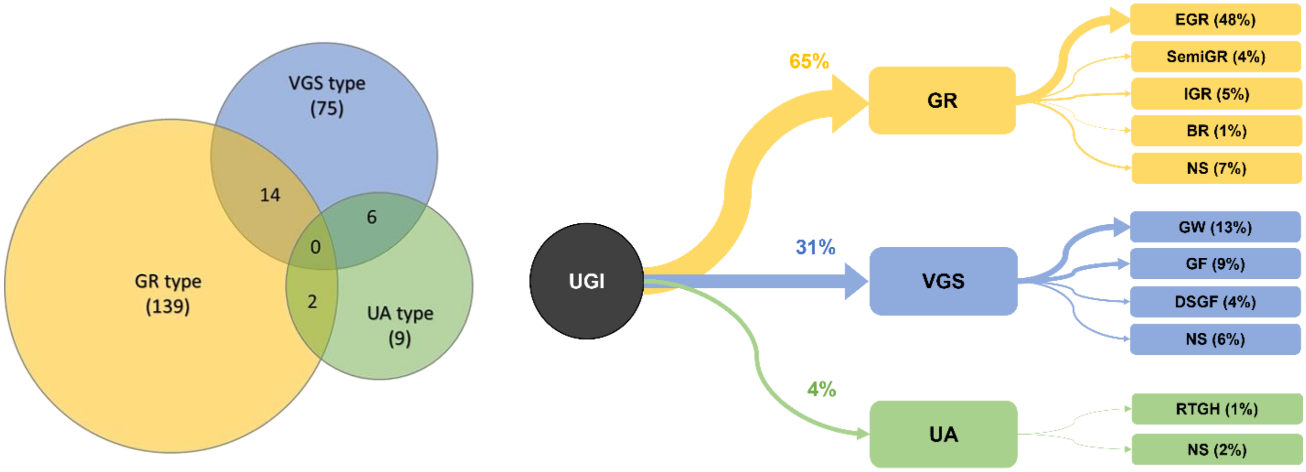


Figure 9. Distribution of the reviewed papers published between 2012 to 2021, according to their UGIB categories.

3.2.1. UGI Categories and Types

The Venn diagram in Figure 10a illustrates the proportions of the three different types of UGI from the 217 reviewed papers. The majority of papers focused only on GR, with 139 papers in total. In total, 75 papers focused only on VGS, and only 9 papers focused solely on UA. A small number of papers studied more than one UGI type, with 14 papers studying both GR and VGS and 2 papers studying both GR and UA, while 6 papers studied both VGS and UA; none have studied all three types of UGI.



(**a**) (**b**)

Figure 10. (**a**) Venn diagram of the number of studies, based on the three main UGI categories; (**b**) the distribution of UGI studies according to the categories and subcategories.

The subcategory distribution of UGI types is illustrated in Figure 10b. The most popular type of GR to be studied was the EGR (48%), while the SemiGR shared a similar number of studies as the IGR, which contributed 4% and 5%, respectively. BRs only appeared in 1% of overall studies, while the remainder are not specified (NS). Although this study showed that IGR can achieve a better performance in terms of improving thermal comfort and reducing building cooling energy demand, the construction and maintenance costs favor the use of an EGR [48]. articles studying VGS have a relatively balanced distribution across the different types of VGS; the most popular to the least popular are GF, GW, and DSGF, respectively, while the remainder are not specified. Only a small number of papers investigated the UA type, making it difficult to group them into a particular structure type of UA, as each of these papers used a different typology that is hard to classify (for example, edible green roofs, rooftop farms, etc.), although the RTGH has been used in more than one paper. Overall, 15% of the combined studies are not specified in terms of the subcategories of UGI types, and a few studies on VGS have not used the terminology of GW and GF. This finding further supports the need for a standardized classification scheme, as suggested by Koc et al. [35].

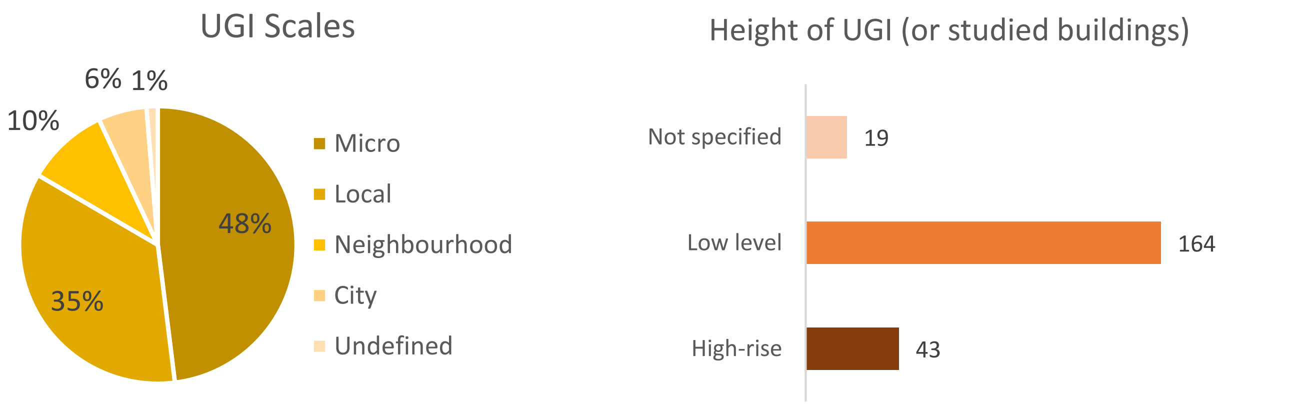
3.2.2. Scale and Height Parameters

Scale is important when planning and designing the UGI. In terms of city planning, the scale would determine the applicable UGI type and the suitable building types, as well as the level of impact on the surroundings [49]. Therefore, this paper investigates the scale and building types to understand the trends. Table 2 provides the range of each scale level of UGI, along with a brief description. Figure 11a shows the scales of UGI that have been studied; almost half of the UGI schemes are on a microscale (48%), while about one-third are at a local scale (35%), with 10% in the neighborhood scale, and 6% on the city scale. The trend shows a constant pattern, where smaller-scale structures were more common than a large-scale study. This result is also similar to that of another review study that focused only on GR [50]. A case study regarding GW in Hong Kong showed that a 100% increase in greenery coverage could potentially achieve an 88% saving on cooling load [51].

Table 2. The scale of the UGI compared with the size of the studied site.

UGI Scale	Features	Min. Range [1]		Max. Range [1]
Micro	A very small structure/model that is inhabitable.	0	to	<100
Local	Based on a single building, usually filled with occupants.	≥100	to	<10,000
Neighborhood	A group of buildings that are situated across a few streets or blocks.	≥10,000	to	<1,000,000
City	Clusters of building blocks or multiple precincts.	≥1,000,000		

Note: [1] The values are measured in m^2.



(**a**) (**b**)

Figure 11. (**a**) The scale of the studied UGI; (**b**) the height of the UGI (or studied buildings).

Similar to the scale, the height of the UGI or, otherwise, the height of the studied site also impacts the effectiveness of the UGI. As claimed by Dahanayake and Chow [51], GW provides a higher potential for cooling load reduction when the building height increases. For example, if the study is focused on outdoor thermal comfort, it should prioritize human comfort at the pedestrian level, although some studies claim that a GR will not provide a direct cooling effect at the pedestrian level; however, the existing surrounding buildings will still have an effect on factors such as air velocity and solar angle, etc. [52,53]. Alternatively, if the study is focused on investigating indoor thermal comfort, the building height might not be the main concern; however, the number of levels/floors of the building should be taken into account, as the thermal performance might be different on the upper floors compared with the lower floors. Consequently, the owners of a rooftop terrace on a multi-story residential building will often have the most interest in installing a green roof [54]. Figure 11b shows that the majority of the published studies, about 73%, focused on investigating the UGI in low-rise buildings (less than 4 stories or 15 m tall), compared to the UGI in high-rise buildings, which appeared in only 19% of the published studies.

Building types represent the scale and function of a building, the occupancy level, and the activities within it; hence, the energy demand can be estimated. For example, one study simulated the cooling energy demand of a primary school, with estimations of the occupant numbers and the assumption of mechanical ventilation in the computer lab and staff rooms [55]. Figure 12 shows the ratio of building types that have been studied, as well as the distribution of the building types in relation to the study scales. It shows that most micro-scale papers studied a test cell or prototype structure. In an experimental study, test cells were used with a thermal scenario that was established based on an office profile to evaluate the internal heat load [56]. Although the use of test cell and prototype structures is more economically feasible for conducting basic analysis in the early stages of a study, it might not reflect the actual scenarios at full scale on a real building.

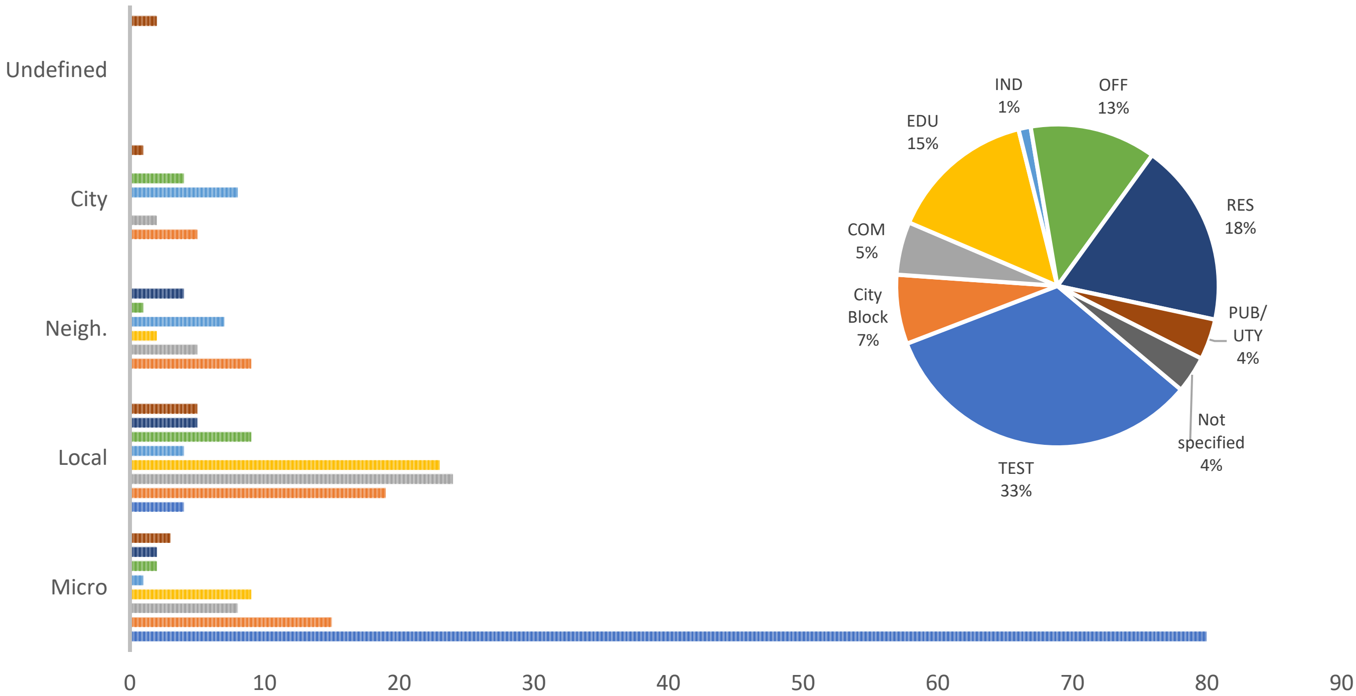


Figure 12. The scale of UGI in relation to the building type.

3.2.3. Seasons of Study Focus

Depending on the UGI application and design focus, the performance of the UGI might vary according to seasonal changes. Figure 13 shows the seasons that were studied in the reviewed papers. In terms of both thermal and electricity energy performance, the majority of the studies were focused on summer periods, with 62% for thermal performance and 46% for electrical energy performance. Winter is the second most popular study period in terms of thermal performance, at 21%. However, for electricity energy performance, the annual performance was slightly more popular, with 26% of papers in comparison to the winter period alone, at 24%. There are only a small number of studies that have focused on spring, autumn, and monsoon seasons. The results show that most studies only focused on either summer or winter, which might not represent the annual performance of the UGI. For example, one study shows that the annual HVAC energy consumption with a green roof performed better in summer and winter; however, the spring and autumn underperformed, resulting in a 3% worse performance than a conventional roof with the same effective thermal insulation in terms of annual HVAC energy use [57]. Another study also suggested that detailed seasonal and annual analyses can help to determine the best irrigation schedules with the highest reduction in energy demand [58]. Nevertheless, the lack of studies on transitional seasons might lead readers to overestimate the UGI performance.

3.2.4. Plant Characteristics

The plant characteristics of GFs vary depending on the objectives, locations, and climate of the study area. In total, 150 research papers mentioned the plant types that were used for the investigation of UGI; 55 studies out of 150 only provide the genera of the plant types, while an average of 3.4 plant species types are investigated per article. The maximum number of species that were investigated was 32 plant types. There were 83 articles using the leaf area index (LAI) as the main parameter; while 56 articles have the actual measurements of the LAI of specific plant species, the other papers either assumed the LAI values or used a reference value from other papers with the same plant types.

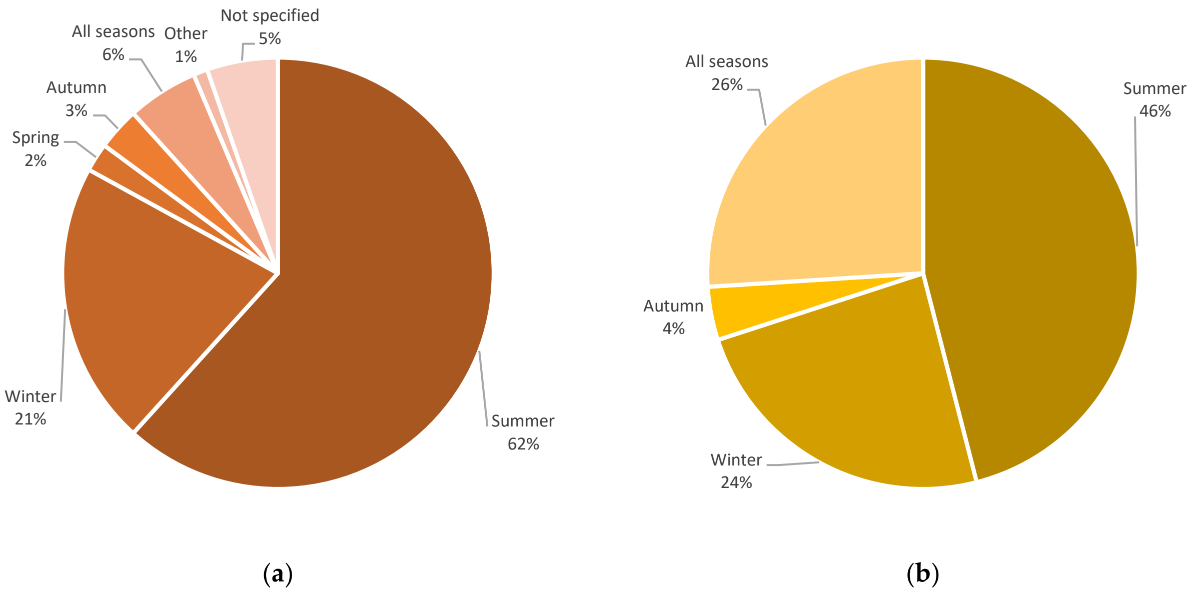


Figure 13. (**a**) The studied seasons for thermal performance; (**b**) the studied seasons for electricity energy performance.

The most common plant types used in a green roof are sedums and grass, lawn, and herbaceous plants. Most studies also investigated at least four different types of plants to compare the results. Most VGS utilized climbing plants and creepers as they naturally grow vertically, needing less substrate or supports along the building façade. There are 57 articles on VGS that investigated the plant types, including the evergreen climbing ivy (*Hedera helix*) and Boston ivy (*Parthenocissus tricuspidata*), which are relatively popular, with 7 and 8 articles, respectively. In Italian cities, a climbing shrub named *Rhyncospermum jasminoides* and a variegated form of a vine called *Pandorea jasminoides* were studied extensively and appeared in 7 articles.

The selection of plant types is dominated by multiple factors; for example, the climate zone where the UGI is located affects the survivability of the plants and the requirements for maintenance, especially in terms of irrigation water, growing substrate, and supporting structure [59–61]. The types of UGI determine the growing environment of the plants [62,63]. The orientation of the building is particularly important because VGS relies on the vegetation providing shade to reduce the thermal heat by controlling the amount of incoming solar radiation [64]. For example, some plants can achieve a better LAI value to reduce the incoming solar radiation, while other plants can achieve a better evapotranspiration rate [56].

3.3. Approaches

In this review, the approaches of the screened articles can be separated into two stages, the data collection stage and the data analysis stage. The typical methods and tools that were most often used for these two stages are illustrated in Figure 14.

3.3.1. Data Collection Setup and Tools

As shown in Figure 14, there are two main data sources—primary and secondary data. Primary data is collected by either remote sensing or an experimental setup. Remote sensing refers to technology using satellites, aerial vehicles, infrared thermal cameras, or light detection and range (LiDAR) equipment to provide topology and geometry information; these tools allow researchers to generate information for a large area simultaneously [44,65,66]. An experimental setup refers to using a test cell/cube or prototype that has been built or set up in a dedicated study area and that is solely used for research objectives [67]. Sensors and equipment setups are usually long-term or even permanent and are secured in position with limited disturbance. Although an experimental setup is more flexible so that the researcher can set up their own parameters, it requires the researcher to have a good understanding of operating the equipment correctly. Secondary data refers to collecting historical data from literature reviews, databases, or a third-party provider. The advantage of using historical data is that of time efficiency; it allows the researcher to have faster access to information, and to conduct the analysis without physical fieldwork. Figure 15 shows a bibliography network based on the sensors that were used in the reviewed articles, to illustrate how different types of sensors are associated with each other. It shows that the most commonly used sensors are thermocouples, heat flux sensors, pyranometers, anemometers, temperature-humidity sensors, and weather stations. These sensors are mainly used for collecting meteorological data, particularly the air temperature, relative humidity, heat flux of materials, wind speed and direction, and solar radiation.

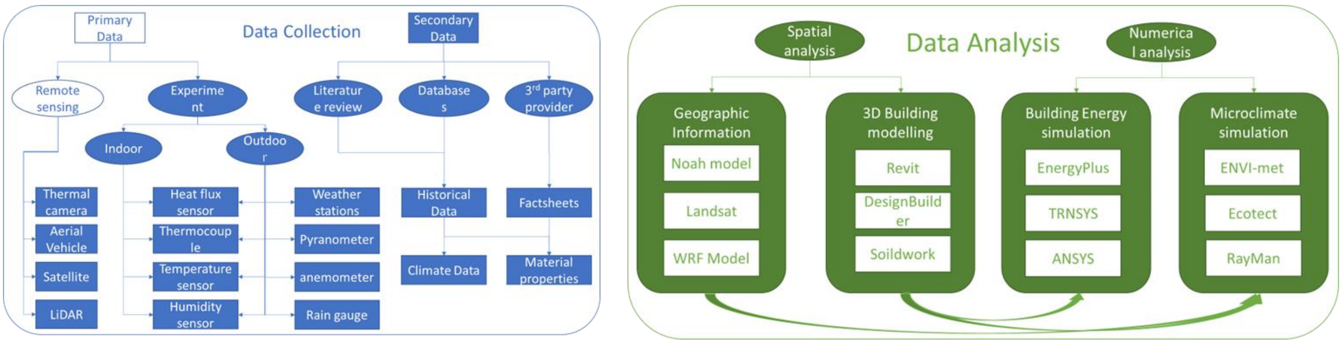


Figure 14. The typical methods and tools for data collection and analysis that were used in the reviewed articles.

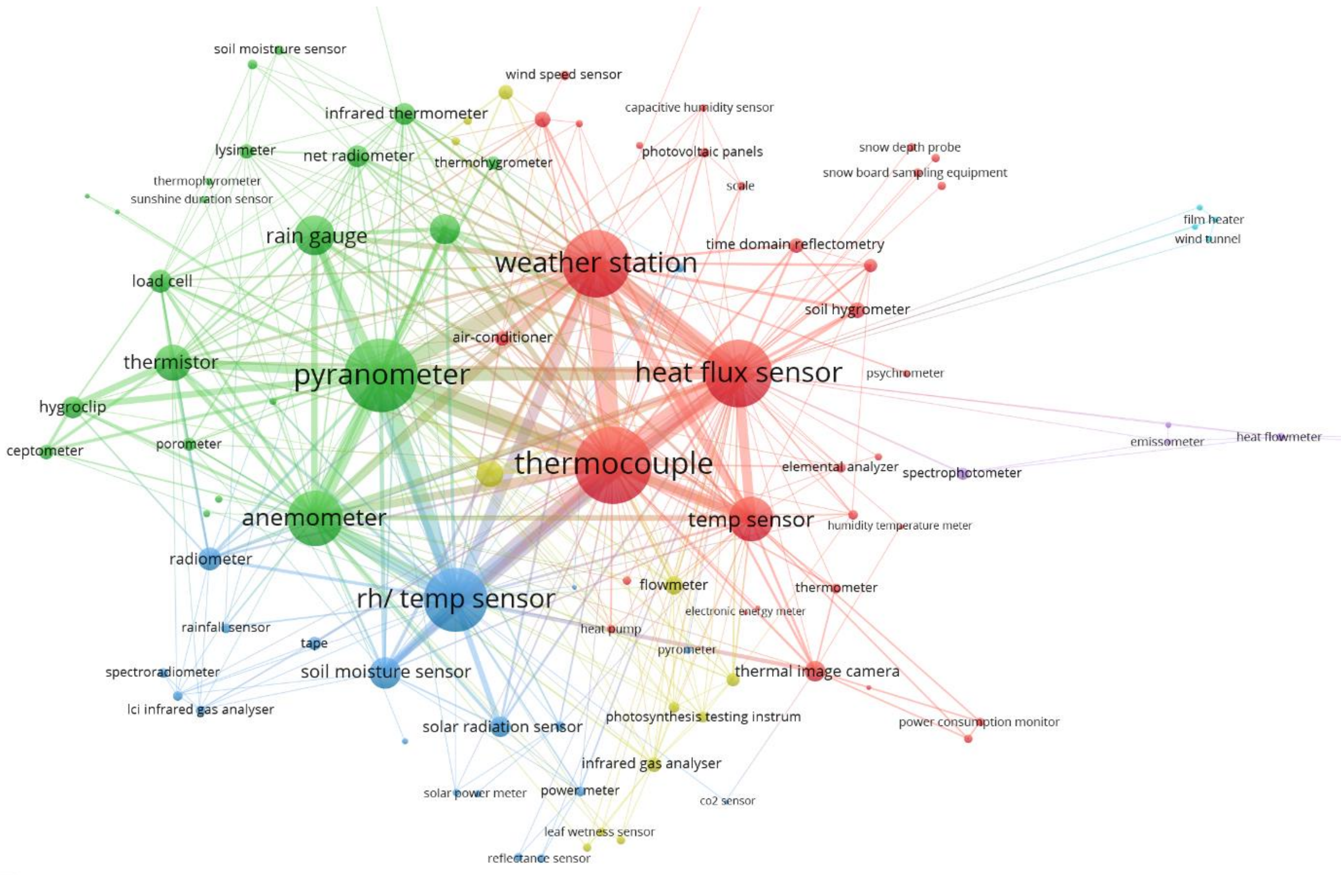


Figure 15. Bibliography network of the sensors used in the reviewed articles.

3.3.2. Data Analysis Software and Models

From the reviews, two main types of data analysis methods appear and can be grouped into spatial and numerical analyses. The spatial analysis is associated with geographical information systems (GIS) such as Landsat, the single-layer urban canopy model (SLUCM), and the weather research forecast (WRF) model [68,69], as well as three-dimensional building modeling using computer-aided design software, such as Revit, DesignBuilder, and Solidworks. Numerical analysis is useful for creating building energy simulations (BES), microclimate analysis, and computational fluid dynamics (CFD). A building energy simulation is useful to analyze energy consumption and demand, indoor climate, and the indoor thermal comfort of an individual building [70]. From the reviewed articles, EnergyPlus is the most popular software used for building energy analyses, with 69 studies. Another commonly used software program for building energy analysis is TRNSYS, a CFD software program that is used in 13 studies. A microclimate simulation is commonly used for thermal comfort analysis. ENVI-met is the most popular program, with 22 articles. Figure 16 represents the popularity of the software.

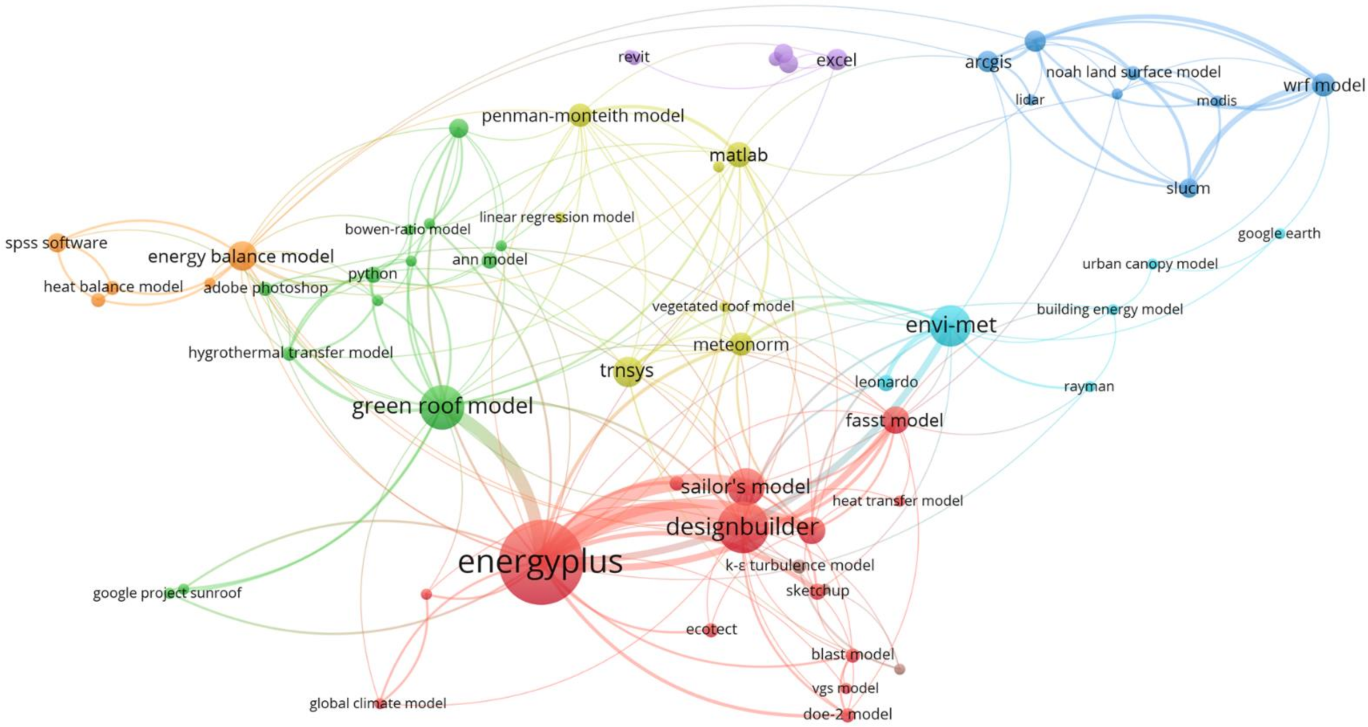


Figure 16. The connections and relationships among methods and tools. This figure was produced using a VOS viewer based on the occurrence of the tools and methods keywords. The thickness of the line represents stronger or weaker links between the keywords.

Note that statistical software such as Excel, SPSS, and CoStat are not always considered simulation software, since the majority of studies would simply generate graphs/figures from raw data without using simulation modeling. However, with the appropriate coding, coupling, and plugin mathematical modules, such as the Sailor's model or the FASST (Fast All-Season Soil Strength) model to program the software, based on equations and formulas, it will be able to run simulations for analysis [58]. Another study has combined the MATLAB, KASPRO, and TRNSYS systems to calculate the energy balance of investigated greenhouse structures [71].

The use of software is related to the scale of the UGI. For example, the WRF model is typical for mesoscale analysis, while ENVI-met is appropriate for microclimate-scale analysis [72]. EnergyPlus and DesignBuilder are more suitable for building and indoor scales [73–75]. As there are more small-scale UGI studies, the use of software for the building scales analysis is thus more common. As a result, when the study needs to analyze both indoor and outdoor environments on different scales, it will require more than one software type to complete the analysis. For example, one study used the ENVI-met to obtain the outdoor microclimate data for an urban area as the input parameter in TRNSYS for building a scale energy analysis [52].

4. Conclusions

About 60% of the studied location were in temperate climate zones (Group C), more frequently than all other climate zone groups combined. In particular, the most studied sites were in a hot-summer Mediterranean climate (Csa), a humid subtropical climate (Cfa), or a temperate oceanic climate (Cfb). The most common features of these climate zones are that they are relatively warm with distinct seasonal changes and constant rainfall during the year. Although the Csa region might experience a dry summer, overall, the temperate climate zone provides a better environment for plants to grow, resulting in better performance in terms of thermal comfort and building energy consumption, with minimal maintenance. Most UGI studies were conducted in countries and cities with a high GDP, a high density of urban area, high urban populations, high primary energy consumption, and high GHG and CO^2 emissions. Among all the countries included in the studies, China, Italy, and the USA have published the most UGI research in the past few decades; the most studied cities in these countries are Hong Kong, Bari, and Chicago, respectively. The distribution of the studied cities is concentrated in the European cities around the Mediterranean Sea, Southeast China, and the coastal area of North America.

There is an increasing trend in the number of publications that investigate the thermal and electrical performance of UGI. Green roofs are the most popular UGI types that have been studied (65%), followed by a vertical greenery system, which is the next most popular UGI (31%). There were only a few studies that investigated urban agriculture (4%). The extensive green roof was the most frequently studied UGI type in all sub-categories (48%); therefore, the extensive green roof is already the subject of more studies than both the VGS and UA categories combined. However, other studies suggested that the green roof strategy is not always the best solution to achieve thermal performance and energy-saving, as this depends on other design parameters.

Studies tend to focus on small-scale and low-level UGI structures. Nearly half of the studies were on a micro-scale (49%), then the number decreased as the scale increased from the local scale (35%) to the neighborhood scale (10%), then to the city scale (6%). Around 73% of the UGIs are located on buildings with a height below 15 m or a maximum of 4 stories tall. The most frequently studied building types are test cells or prototype structures (33%), followed by residential buildings (18%) and education buildings (15%).

This study has also investigated the sessional changes in relation to thermal comfort and energy consumption. The results show that the majority of the research into thermal comfort only focuses on either summer or winter. Although some studies have covered all the seasons, spring and autumn are largely neglected by most studies.

There is a huge variety in terms of plant types that have been studied in the past. It appears that the plant selection is highly dependent on the UGI type. For a GR, the most popular plant is sedum, while for VGS, ivy is the most common plant choice.

In terms of methodologies, the experimental method is the most common data collection method for collecting climate data, which usually consists of data from a weather station, a heat flux sensor, thermocouples, a pyranometer, and a humidity/temperature sensor. Simulation is the most common data analysis method. EnergyPlus and DesignBuilder were the most frequently used simulation software programs to analyze building energy use. Research papers studying the topic on a city scale do not usually specify the type of UGI and the plant selections. The GIS method is usually limited by the short data duration.

The current trend of UGI studies indicates that the main approaches and practices are driven by the existing physical environment and the associated economic factors. Thermal comfort performance is highly dependent on microclimate characteristics and the urban topography, but economic feasibility is the main concern when approaching large-scale UGI studies. In light of these considerations, most UGI studies are from developed countries in a temperate climate area, with the focus on extensive green roofs that will flourish with sedum plants, yielding a relatively low-cost green roof with minimal irrigation requirements.

5. Recommendations

Based on the analysis, we believe that UGI research is required in arid climates and equatorial climates, especially in the Middle East and Southeast Asia, in cities such as Riyadh in Saudi Arabic, Tehran in Iran, Jakarta in Indonesia, and Kuala Lumpur in Malaysia as these countries also have noticeable socio-economic issues, including dense urban populations, primary energy consumption, high GHG emissions, and high CO_2 emissions.

In addition, future studies should have an additional focus on UGI effectiveness in arid climatic regions, while studying the dry season in equatorial regions is strongly recommended. Therefore, the UGI design parameters in the above countries should be further investigated, especially in terms of the most suitable types of UGI and the feasibility of plant-type selection. The majority of the studies included in this review are focused on small-scale UGIs on low-rise buildings, which represent a partial urban environment in mega-cities.

It is necessary to investigate the implementation of UGI on a larger city scale and include high-rise buildings as well. Developing cost-effective technology and robust procedures to conduct large-scale UGI projects is essential to facilitate large-scale studies that provide better accessibility for the planners to assess and evaluate the UGI designs.

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Data Availability Statement: The data used in this study can be available on demand.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Keywords for UGI Terminology (Stage 1)	Keywords for Focus Aspects (Stage 2)
Green roof category “green roofs” OR “green rooftops” OR “irrigated green roofs” OR “wetland roofs” OR “roof gardens” OR “rooftop gardens” **Vertical greenery systems category** “vertical greenery systems” OR “green walls” OR “living walls” OR “green façades” OR “vegetation screens” OR “green curtains” OR “vegetation curtains “ **Urban agriculture category** “urban gardens” OR “community gardens” OR “garden farms” OR “garden beds” OR “planter boxes” OR “urban farms” OR “urban farming” OR “urban agricultures” OR “hydroponics” OR “aquaponics”	**Thermal comfort aspects** “thermal comfort” OR “thermal stress” OR “thermal performance” OR “urban heat” OR “heat island” OR “cooling effect” OR “surface temperature” OR “air temperature” **Electrical energy aspects** “energy consumption” OR “energy saving” OR “energy demand” OR “energy balance” OR “energy efficiency” OR “energy usage” OR “electricity” OR “power”

Codes used for the Web of Science search engine
TS = (“green roof*” OR “green rooftop*” OR “wetland roof*” OR “roof garden*” OR “rooftop garden*” OR “vertical greenery systems” OR “green wall*” OR “living wall*” OR “green façade*” OR “vegetation screen*” OR “green curtain*” OR “vegetation curtain*” OR “urban garden*” OR “community garden*” OR “garden farm*” OR “garden bed*” OR “planter box*” OR “urban farm*” OR “urban farming” OR “urban agricultures” OR “hydroponics*” OR “aquaponics*”) AND TS = (“thermal comfort” OR “thermal stress” OR “thermal performance” OR “urban heat” OR “heat island” OR “cooling effect” OR “surface temperature” OR “air temperature”) AND TS = (“energy consumption” OR “energy saving” OR “energy demand” OR “energy balance” OR “energy efficiency” OR “energy usage” OR “electricity” OR “power”)

Codes used for the SCOPUS search engine
TITLE-ABS-KEY(“green roof*” OR “green rooftop*” OR “wetland roof*” OR “roof garden*” OR “rooftop garden*” OR “vertical greenery systems” OR “green wall*” OR “living wall*” OR “green façade*” OR “vegetation screen*” OR “green curtain*” OR “vegetation curtain*” OR “urban garden*” OR “community garden*” OR “garden farm*” OR “garden bed*” OR “planter box*” OR “urban farm*” OR “urban farming” OR “urban agricultures” OR “hydroponics*” OR “aquaponics*”) AND TITLE-ABS-KEY(“thermal comfort” OR “thermal stress” OR “thermal performance” OR “urban heat” OR “heat island” OR “cooling effect” OR “surface temperature” OR “air temperature”) AND TITLE-ABS-KEY (“energy consumption” OR “energy saving” OR “energy demand” OR “energy balance” OR “energy efficiency” OR “energy usage” OR “electricity” OR “power”)

Appendix B

Authors	Year	Title
Abe et al. [76]	2020	Thermal mitigation of the indoor and outdoor climate by green curtains in Japanese condominiums
Aboelata [48]	2021	Assessment of green roof benefits on buildings’ energy-saving by cooling outdoor spaces in different urban densities in arid cities
Afshari [77]	2017	A new model of urban cooling demand and heat island—application to vertical greenery systems (VGS)
Andric, Kamal and Al-Ghamdi [78]	2020	Efficiency of green roofs and green walls as climate change mitigation measures in extremely hot and dry climate: case study of Qatar
Arghavani, Malakooti and Ali Akbari Bidokhti [68]	2020	Numerical assessment of the urban green space scenarios on urban heat island and thermal comfort level in Tehran metropolis
Ariff, Ahmad and Hussin [79]	2019	The green envelope as an architectural strategy for an energy-efficient library
Arkar, Domjan and Medved [80]	2018	Heat transfer in a lightweight extensive green roof under water-freezing conditions
Ascione et al. [81]	2013	Green roofs in European climates: are they effective solutions for energy savings in air-conditioning?
Assimakopoulos et al. [82]	2020	Green wall design approach toward energy performance and indoor comfort improvement: a case study in Athens
Ávila-Hernández et al. [67]	2020	Test box experiment and simulations of a green-roof: thermal and energy performance of a residential building standard for Mexico
Bano and Dervishi [83]	2021	The impact of vertical vegetation on thermal performance of high-rise office building facades in a Mediterranean climate
Barozzi, Bellazzi and Pollastro [84]	2016	The energy impact in buildings of vegetative solutions for extensive green roofs in temperate climates
Basher and Abdul Rahman [85]	2017	A simulation of a vertical greenery system in reducing energy cooling loads for high-rise residential buildings
Basher et al. [86]	2016	The use of an edible vertical greenery system to improve thermal performance in a tropical climate
Battista, Vollaro and Vollaro [52]	2021	How cool pavements and green roofs affect building energy performances
Begum et al. [87]	2021	Environmental and social dynamics of urban rooftop agriculture (URTA) and their impacts on microclimate change
Berardi [45]	2016	The outdoor microclimate benefits and energy saving resulting from green roofs retrofits

Authors	Year	Title
Bevilacqua, Bruno and Arcuri [88]	2020	Green roofs in a Mediterranean climate: energy performances based on in situ experimental data
Bevilacqua et al. [89]	2016	Experimental investigation of the thermal performances of an extensive green roof in the Mediterranean area
Bianco et al. [90]	2017	Thermal behavior assessment of a novel vertical greenery module system: first results of a long-term monitoring campaign in an outdoor test cell
Blanco et al. [91]	2021	Energy analysis of a green façade in summer: an experimental test in Mediterranean climate conditions
Blanco et al. [92]	2020	Wintertime thermal performance of green façades in a Mediterranean climate
Blanco et al. [61]	2018	Thermal behavior of green façades in summer
Blanco, Schettini and Vox [93]	2018	Effects of vertical green technology on building surface temperature
Cai et al. [94]	2019	The reduction in carbon dioxide emission and energy savings obtained by using a green roof
Cameron, Taylor and Emmett [95]	2015	A *Hedera* green façade-energy performance and saving under different maritime-temperate, winter weather conditions
Campos et al. [59]	2020	Energy and environmental comparison between a concrete wall with and without a living green wall: a case study in Mexicali, Mexico
Carlos [96]	2015	Simulation assessment of living wall thermal performance in winter in the climate of Portugal
Cascone et al. [54]	2018	A comprehensive study on green roof performance for retrofitting existing buildings
Cascone et al. [97]	2019	Thermal performance assessment of extensive green roofs investigating realistic vegetation-substrate configurations
Chagolla-Aranda et al. [98]	2017	The effect of irrigation on the experimental thermal performance of a green roof in a semi-warm climate in Mexico
Chan and Chow [99]	2013	Energy and economic performance of green roof system under future climatic conditions in Hong Kong
Charoenkit and Yiemwattana [100]	2017	The role of specific plant characteristics on thermal and carbon sequestration properties of living walls in a tropical climate
Charoenkit, Yiemwattana and Rachapradit [101]	2020	Plant characteristics and the potential for living walls to reduce temperatures and sequester carbon
Chun and Guldmann [65]	2018	Impact of greening on the urban heat island: seasonal variations and mitigation strategies
Cirkel et al. [102]	2018	Evaporation from (blue-)green roofs: assessing the benefits of a storage and capillary irrigation system based on measurements and modeling
Cirrincione et al. [103]	2020	Green roofs as effective tools for improving the indoor comfort levels of buildings-an application to a case study in Sicily
Cirrincione, Marvuglia and Scaccianoce [74]	2021	Assessing the effectiveness of green roofs in enhancing the energy and indoor comfort resilience of urban buildings to climate change: methodology proposal and application
Collins et al. [104]	2017	Thermal behavior of green roofs under Nordic winter conditions
Coma et al. [105]	2017	Vertical greenery systems for energy savings in buildings: a comparative study between green walls and green façades
Coma et al. [56]	2020	How internal heat loads of buildings affect the effectiveness of vertical greenery systems? an experimental study
Convertino et al. [62]	2020	Energy behavior of the green layer in green façades
Convertino, Vox and Schettini. [106]	2021	Evaluation of the cooling effect provided by a green façade as nature-based system for buildings
Convertino, Vox and Schettini [63]	2019	Heat transfer mechanisms in vertical green systems and energy balance equations

Authors	Year	Title
Peng et al. [107]	2016	Energy savings in buildings or UHI mitigation? comparison between green roofs and cool roofs
Coutts et al. [108]	2013	Assessing practical measures to reduce urban heat: green and cool roofs
Dabaieh and Serageldin [109]	2020	Earth air heat exchanger, Trombe wall and green wall for passive heating and cooling in premium passive refugee house in Sweden
Dahanayake and Chow [110]	2017	Studying the potential of energy saving through vertical greenery systems: using EnergyPlus simulation program
Dahanayake and Chow [51]	2018	Comparing the reduction of building cooling load through green roofs and green walls by EnergyPlus simulations
Dandou et al. [111]	2021	On the cooling potential of urban heating mitigation technologies in a coastal temperate city
De Masi et al. [112]	2019	Numerical optimization for the design of living walls in the Mediterranean climate
de Munck et al. [113]	2018	Evaluating the impacts of greening scenarios on thermal comfort and energy and water consumption for adapting Paris to climate change
Dimitrijevic et al. [114]	2016	Green living roof implementation and influences of the soil layer on its properties
Djedjig et al. [115]	2017	The thermal effects of an innovative green wall on building energy performance
Djedjig et al. [116]	2012	Development and validation of a coupled heat and mass transfer model for green roofs
D'Orazio, Di Perna and Di Giuseppe [117]	2012	Green roof yearly performance: a case study in a highly insulated building under temperate climate
Eksi et al. [118]	2017	Effect of substrate depth, vegetation type, and season on green roof thermal properties
Erdemir and Ayata [119]	2017	Prediction of temperature decreasing on a green roof by using an artificial neural network
Espinosa-Fernández, Echarri-Iribarren and Sáez [120]	2020	Water-covered roof versus inverted flat roof on the Mediterranean coast: a comparative study of thermal and energy behavior
Evangelisti et al. [121]	2020	On the energy performance of an innovative green roof in the Mediterranean climate
Fahmy et al. [122]	2017	On the green adaptation of urban developments in Egypt; predicting community future energy efficiency using coupled outdoor-indoor simulations
Fantozzi et al. [123]	2021	Do green roofs really provide significant energy saving in a Mediterranean climate? A critical evaluation based on different case studies
Feng and Hewage [124]	2014	Energy saving performance of green vegetation on LEED-certified buildings
Fitchett, Govender and Vallabh [125]	2020	An exploration of green roofs for indoor and exterior temperature regulation in the South African interior
Foustalieraki et al. [126]	2017	Energy performance of a medium scale green roof system installed on a commercial building using numerical and experimental data recorded during the cold period of the year
Gagliano et al. [127]	2015	A multi-criteria methodology for comparing the energy and environmental behavior of cool, green and traditional roofs
Nocera [128]	2016	The thermal behavior of an extensive green roof: numerical simulations and experimental investigations
Gallardo et al. [129]	2021	Evaluation of comfort and thermal efficiency in buildings with plant surroundings: an experimental study report (Avaliação de conforto e eficiência térmica em edifícios com ambientes de plantas: um relato de estudo experimental)
Gao et al. [130]	2017	Thermal performance and energy savings of white and sedum-tray garden roof: a case study in a Chongqing office building

Authors	Year	Title
Gholami et al. [40]	2020	A comparison of energy and thermal performance of rooftop greenhouses and green roofs in a Mediterranean climate: a hygrothermal assessment in WUFI
Goussous, Siam and Alzoubi [131]	2015	Prospects of green roof technology for energy and thermal benefits in buildings: case of Jordan
Guattari et al. [132]	2020	Experimental evaluation and numerical simulation of the thermal performance of a green roof
Haggag, Hassan and Elmasry [133] A., Elmasry S.	2014	Experimental study on reduced heat gain through green façades in a high heat load climate
Hao et al. [134]	2020	Influence of vertical greenery systems and green roofs on the indoor operative temperature of air-conditioned rooms
He et al. [135]	2021	Quantitative evaluation of plant evapotranspiration effect for green roof in tropical area: a case study in Singapore
He, Lin, Tan, Yu, et al. [136]	2021	Model development of roof thermal transfer value (RTTV) for a green roof in a tropical area: a case study in Singapore
He et al. [137]	2016	Thermal and energy performance assessment of extensive green roof in summer: a case study of a lightweight building in Shanghai
He et al. [138]	2020	Thermal and energy performance of green roof and cool roof: a comparison study in the Shanghai area
He et al. [139]	2017	An investigation on the thermal and energy performance of a living wall system in the Shanghai area
He et al. [140]	2017	Influence of plant and soil layer on energy balance and thermal performance of green roof system
Heidarinejad and Esmaili [141]	2015	Numerical simulation of the dual effect of green roof thermal performance
Heusinger and Weber [142]	2017	Surface energy balance of an extensive green roof as quantified by full year eddy-covariance measurements
Heusinger, Sailor and Weber [143]	2018	Modeling the reduction of urban excess heat by green roofs with respect to different irrigation scenarios
Hirano et al. [144]	2019	Simulation-based evaluation of the effect of green roofs in office building districts on mitigating the urban heat island effect and reducing CO_2 emissions
Hugo, du Plessis and Masenge [71]	2021	Retrofitting Southern African cities: a call for appropriate rooftop greenhouse designs as climate adaptation strategy
Jadaa, Aburaed and Taleb [145]	2019	Assessing the thermal effectiveness of implementing green roofs in the urban neighborhood
Jaffal, Ouldboukhitine and Belarbi [146]	2012	A comprehensive study of the impact of green roofs on building energy performance
Jiang and Tang [147]	2017	Thermal analysis of extensive green roofs combined with night ventilation for space cooling
Jim [148]	2015	Assessing the climate-adaptation effect of extensive tropical green roofs in cities
Jim and Peng [149]	2012	Weather effect on thermal and energy performance of an extensive tropical green roof
Jim [150]	2014	Passive warming of indoor space induced by a tropical green roof in winter
Madi, Bozonnet and Patrick [151]	2020	Building and urban cooling performance indexes of wetted and green roofs—a case study under current and future climates
Kadhim-Abid [152]	2014	Comfort management in changing climate conditions with the use of green roofs
Karachaliou, Santamouris and Pangalou [153]	2016	Experimental and numerical analysis of the energy performance of a large-scale intensive green roof system installed on an office building in Athens
Kenaï et al. [154]	2018	Impact of plant occultation on energy balance: experimental study
Klein and Coffman [155]	2015	Establishment and performance of an experimental green roof under extreme climatic conditions

Authors	Year	Title
Kolokotsa, Santamouris and Zerefos [156]	2013	Green and cool roofs' urban heat island mitigation potential in European climates for office buildings under free floating conditions
Kotsiris et al. [157]	2012	Dynamic u-value estimation and energy simulation for green roofs
Koura et al. [158]	2017	Seasonal variability of temperature profiles of vegetative and traditional gravel-ballasted roofs: a case study for Lebanon
Fachinello Krebs and Johansson, [159]	2021	Influence of microclimate on the effect of green roofs in southern Brazil—a study coupling outdoor and indoor thermal simulations
Kumar, Deoliya and Chan [160]	2015	Evaluation of the thermal behavior of a green roof retrofit system installed on an experimental building in the composite climate of Roorkee, India
La Roche and Berardi [161]	2014	Comfort and energy savings with active green roofs
Frota de Albuquerque Landi, Fabiani and Pisello [162]	2021	Experimental winter monitoring of a light-weight green roof assembly for building retrofit
Lassandro and Cosola [163]	2018	Climate change mitigation: resilience indicators for roof solutions
Ledesma, Nikolic and Pons-Valladares [164]	2022	Co-simulation for thermodynamic coupling of crops in buildings. case study of free-running schools in Quito, Ecuador
Lee and Jim [165]	2019	Energy benefits of green-wall shading based on novel-accurate apportionment of short-wave radiation components
Lee and Jim [166]	2020	Thermal irradiance behaviors of a subtropical intensive green roof in winter and landscape-soil design implications
Li et al. [167]	2019	Cooling and energy-saving performance of different green wall design: a simulation study of a block
Z. Li et al. [168]	2019	The effectiveness of adding horizontal greening and vertical greening to courtyard areas of existing buildings in the hot summer cold winter region of China: a case study for Ningbo
Liu et al. [169]	2018	Assessing summertime urban warming and the cooling efficacy of adaptation strategy in the Chengdu-Chongqing metropolitan region of China
Lundholm, Weddle and MacIvor [170]	2014	Snow depth and vegetation type affect green roof thermal performance in winter
Luo et al. [171]	2015	Study on the thermal effects and air quality improvement of green roof
Lynn and Lynn [172]	2020	The impact of cool and green roofs on summertime temperatures in the cities of Jerusalem and Tel Aviv
Mahmoodzadeh, Mukhopadhyaya and Valeo [173]	2020	Effects of extensive green roofs on the energy performance of school buildings in four North American climates
Maiolo et al. [174]	2020	The role of the extensive green roofs on decreasing building energy consumption in the Mediterranean climate
Malys, Musy and Inard [175]	2016	Direct and indirect impacts of vegetation on building comfort: a comparative study of lawns, green walls and green roofs
Manso and Castro-Gomes [176]	2016	Thermal analysis of a new modular system for green walls
Mazzali, Peron and Scarpa [177]	2012	Thermo-physical performances of living walls via field measurements and numerical analysis
Bagheri Moghaddam et al. [64]	2021	Understanding the performance of vertical gardens by using building simulation and its influences on urban landscape
Bagheri Moghaddam et al. [178]	2020	Building orientation in green façade performance and its positive effects on an urban landscape case study: an urban block in Barcelona
Moghbel and Erfanian Salim [179]	2017	Environmental benefits of green roofs on the microclimate of Tehran with specific focus on air temperature, humidity and CO_2 content
Mohammad Shuhaimi et al. [180]	2022	The impact of vertical greenery system on building thermal performance in tropical climates
Moody and Sailor [57]	2013	Development and application of a building energy performance metric for green roof systems

Authors	Year	Title
Mutani and Todeschi [181]	2021	Roof-integrated green technologies, energy saving and outdoor thermal comfort: insights from a case study in urban environment
Mutani and Todeschi [44]	2020	The effects of green roofs on outdoor thermal comfort, urban heat island mitigation and energy savings
Nadal et al. [182]	2017	Building-integrated rooftop greenhouses: an energy and environmental assessment in the Mediterranean context
Nan et al. [183]	2020	Assessing the thermal performance of living wall systems in wet and cold climates during the winter
Netam, Sanyal and Bhowmic [184]	2019	Assessing the impact of passive cooling on thermal comfort in LIG house using CFD
Nguyen, Bokel and van den Dobbelsteen [185]	2019	Effects of a vertical green façade on the thermal performance and cooling demand: a case study of a tube house in Vietnam
Alonso et al. [186]	2013	Thermal and illuminance performance of a translucent green wall
Olivieri, Olivieri and Neila [187]	2014	Experimental study of the thermal-energy performance of an insulated vegetal facade under summer conditions in a continental Mediterranean climate
Olivieri et al. [188]	2014	Experimental characterization and implementation of an integrated autoregressive model to predict the thermal performance of vegetal facades
Omar et al. [189]	2018	Green roof: simulation of energy balance components in Recife, Pernambuco State, Brazil
Ottelé and Perini [190]	2017	Comparative experimental approach to investigate the thermal behavior of vertical greened facades of buildings
Ouldboukhitine, Belarbi and Sailor [191]	2014	Experimental and numerical investigation of urban street canyons to evaluate the impact of green roof inside and outside buildings
Pan and Chu [192]	2016	Energy saving potential and life cycle environmental impacts of a vertical greenery system in Hong Kong: a case study
Pandey, Hindoliya and mod [193]	2012	Artificial neural network for predation of cooling load reduction using a green roof over a building in a sustainable city
Pandey, Hindoliya and Mod [194]	2013	Experimental investigation on green roofs over buildings
Parhizkar, Khoraskani and Tahbaz [195]	2020	Double skin façade with azolla; ventilation, indoor air quality and thermal performance assessment
Park and Hawkin [196]	2015	An examination of the effect of building compactness and green roofs on indoor temperature through the use of physical models
Peñalvo-López et al. [197]	2020	Study of the improvement on energy efficiency for a building in the Mediterranean area by the installation of a green roof system
Peng et al. [107]	2020	Energy savings of block-scale facade greening for different urban forms
Peng et al. [198]	2019	Thermal and energy performance of two distinct green roofs: temporal pattern and underlying factors in a subtropical climate
Pérez et al. [199]	2017	Green façade for energy savings in buildings: the influence of leaf area index and facade orientation on the shadow effect
Pérez et al. [200]	2015	The thermal behavior of extensive green roofs under low plant coverage conditions
Perini et al. [201]	2017	The use of vertical greening systems to reduce the energy demand for air conditioning. field monitoring in Mediterranean climate
Pianella et al. [202]	2017	Substrate depth, vegetation and irrigation affect green roof thermal performance in a Mediterranean-type climate
Pigliautile et al. [53]	2020	Inter-building assessment of urban heat island mitigation strategies: field tests and numerical modeling in a simplified-geometry experimental setup
Piro et al. [203]	2018	Energy and hydraulic performance of a vegetated roof in a sub-Mediterranean climate
Pisello, Piselli and Cotana [204]	2015	Thermal-physics and energy performance of an innovative green roof system: the cool-green roof

Authors	Year	Title
Poddar, Park and Chang [205]	2017	Energy performance analysis of a dormitory building based on different orientations and seasonal variations of leaf area index
Polo-Labarrios et al. [206]	2020	Comparison of thermal performance between green roofs and conventional roofs
Porcaro et al. [58]	2021	Exploring the reduction of energy demand of a building with an eco-roof under different irrigation strategies
Porcaro et al. [207]	2019	Long-term experimental analysis of thermal performance of extensive green roofs with different substrates in a Mediterranean climate
Ragab and Abdelrady [55]	2020	Impact of green roofs on energy demand for cooling in Egyptian buildings
Rakotondramiarana, Ranaivoarisoa and Morau [208]	2015	Dynamic simulation of the green roofs impact on building energy performance, case study of Antananarivo, Madagascar
Razzaghmanesh, Beecham and Salemi [209]	2016	The role of green roofs in mitigating urban heat island effects in the metropolitan area of Adelaide, south Australia
Rupasinghe and Halwatura [210]	2020	Benefits of implementing vertical greening in tropical climates
Samah, Tiwari and Nougbléga [211]	2020	Cool and green roofs as techniques to overcome heating in a building and its surroundings under a warm climate
Scarpa, Mazzali and Peron [212]	2014	Modeling the energy performance of living walls: validation against field measurements in a temperate climate
Schade, Lidelöw and Lönnqvist [213]	2021	The thermal performance of a green roof on a highly insulated building in a sub-arctic climate
Scharf and Kraus [214]	2019	Green roofs and greenpasses
Scharf and Zluwa [215]	2017	Case-study investigation of the building physical properties of seven different green roof systems
Schweitzer and Erell [216]	2014	Evaluation of the energy performance and irrigation requirements of extensive green roofs in a water-scarce Mediterranean climate
Shao et al. [217]	2021	Influence of temperature and moisture content on thermal performance of green roof media
Sharma et al. [218]	2016	Green and cool roofs to mitigate urban heat island effects in the Chicago metropolitan area: evaluation with a regional climate model
Sharma et al. [69]	2018	Role of green roofs in reducing heat stress in vulnerable urban communities—a multidisciplinary approach
Silva, Gomes and Silva [219]	2016	Green roof energy performance in a Mediterranean climate
Simões et al. [220]	2020	Comparison between cork-based and conventional green roof solutions
Sisco et al. [221]	2017	Rooftop gardens as a means to use recycled waste and a/c condensate and reduce temperature variation in buildings
Small et al. [222]	2020	Urban heat island mitigation due to enhanced evapotranspiration in an urban garden in Saint Paul, Minnesota, USA
Smalls-Mantey and Montalto [223]	2021	The seasonal microclimate trends of a large-scale extensive green roof
Squier and Davidson [224]	2016	Heat flux and seasonal thermal performance of an extensive green roof
Stella and Personne [225]	2021	Effects of conventional, extensive and semi-intensive green roofs on building conductive heat fluxes and surface temperatures in winter in Paris
Šuklje, Arkar and Medved [226]	2014	The local ventilation system, coupled with the indirect green façade: a preliminary study
Šuklje, Medved and Arkar [227]	2013	An experimental study on a microclimatic layer of a bionic façade inspired by vertical greenery
Šuklje, Medved and Arkar [228]	2016	On detailed thermal response modeling of vertical greenery systems as a cooling measure for buildings and cities in summer conditions
Sun, Grimmond and Ni [229]	2016	How do green roofs mitigate urban thermal stress under heat waves?
Susorova et al. [230]	2013	A model of vegetated exterior facades for evaluation of wall thermal performance

Authors	Year	Title
Susorova, Azimi and Stephens [231]	2014	The effects of climbing vegetation on the local microclimate, thermal performance, and air infiltration of four building facade orientations
Taleghani et al. [232]	2019	The impact of heat mitigation strategies on the energy balance of a neighborhood in Los Angeles
Taleghani, Sailor and Ban-Weiss [233]	2016	Micrometeorological simulations to predict the impacts of heat mitigation strategies on pedestrian thermal comfort in a Los Angeles neighborhood
Tan et al. [234]	2017	The impact of soil and water retention characteristics on green roof thermal performance
Tan et al. [235]	2020	Building envelope-integrated green plants for energy saving
Tang and Zheng [236]	2019	Experimental study of the thermal performance of an extensive green roof on sunny summer days
Tang and Qu [237]	2016	Phase change and thermal performance analysis for green roofs in cold climates
Tetiana and Mileikovskyi [238]	2020	Methodology of thermal resistance and cooling effect testing of green roofs
Vaezizadeh, Rashidisharifabad and Afhami [239]	2016	Investigating the cooling effect of living walls in the sunken courtyards of traditional houses in Yazd
Vaz Monteiro et al. [240]	2017	Functional green roofs: importance of plant choice in maximizing summertime environmental cooling and substrate insulation potential
Vera et al. [241]	2017	Influence of vegetation, substrate, and thermal insulation of an extensive vegetated roof on the thermal performance of retail stores in semiarid and marine climates
Kumar and Mahalle [242]	2016	Investigation of the thermal performance of green roof in a mild warm climate
Virk et al. [243]	2015	Microclimatic effects of green and cool roofs in London and their impacts on energy use for a typical office building
Vox, Blanco and Schettini [244]	2018	Green façades to control wall surface temperature in buildings
Wahba et al. [72]	2019	Green envelop impact on reducing air temperature and enhancing outdoor thermal comfort in arid climates
Wahba et al. [73]	2018	Effectiveness of green roofs and green walls on energy consumption and indoor comfort in arid climates
Linying, Huang and Li [245]	2021	The strong influence of convective heat transfer efficiency on the cooling benefits of green roof irrigation
Wei et al. [246]	2021	A random effects model to optimize soil thickness for green-roof thermal benefits in winter
Wei et al. [247]	2020	Adjusting soil parameters to improve green roof winter energy performance based on neural-network modeling
Wilkinson and Feitosa [248]	2015	Retrofitting housing with lightweight green roof technology in Sydney, Australia, and Rio de Janeiro, Brazil
Xing et al. [249]	2019	experimental investigation on the thermal performance of a vertical greening system with green roof in wet and cold climates during winter
Xing and Jones [250]	2021	In situ monitoring of energetic and hydrological performance of a semi-intensive green roof and a white roof during a heatwave event in the UK
Yaghoobian and Srebric [251]	2015	Influence of plant coverage on the total green roof energy balance and building energy consumption
Yang et al. [252]	2018	Summertime thermal and energy performance of a double-skin green façade: a case study in shanghai
J. Yang et al. [253]	2018	Green and cool roofs' urban heat island mitigation potential in a tropical climate
Yang et al. [254]	2015	Comparative study of the thermal performance of the novel green (planting) roofs against other existing roofs
Yeom and La Roche [255]	2017	Investigation on the cooling performance of a green roof with a radiant cooling system

Authors	Year	Title
Yin et al. [66]	2017	Cooling effect of direct green façades during hot summer days: an observational study in Nanjing, China using TIR and 3DPC data
Yuan and Rim [256]	2018	Cooling energy saving associated with exterior greenery systems for three us department of energy (DOE) standard reference buildings
Zeng et al. [257]	2017	Optimal parameters of green roofs in representative cities of four climate zones in China: a simulation study
Zhang et al. [60]	2019	Thermal behavior of a vertical green façade and its impact on the indoor and outdoor thermal environment
Y. Zhang et al. [75]	2019	Cooling benefits of an extensive green roof and sensitivity analysis of its parameters in subtropical areas
Zhao and Srebric [258]	2012	Assessment of green roof performance for sustainable buildings under winter weather conditions
Zhao et al. [259]	2015	Accumulated snow layer influence on the heat transfer process through green roof assemblies
Zhao et al. [260]	2014	Effects of plant and substrate selection on thermal performance of green roofs during the summer
Zheng and Weng [261]	2020	Modeling the effect of green roof systems and photovoltaic panels for building energy savings to mitigate climate change
Zheng, Dai and Tang [262]	2020	An experimental study of vertical greenery systems for window shading for energy saving in summer
Ziogou et al. [263]	2018	Implementation of green roof technology in the residential buildings and neighborhoods of Cyprus

Appendix C

Type	Description	Precipitation pattern	Temperature pattern
A	Equatorial climates		$T_{min} \geq 18°C$
Af	Equatorial rainforest, fully humid	$P_{min} \geq 60$ mm	$T_{min} \geq 18°C$
Am	Equatorial monsoon	Pmin ≥ 25 mm (100 – Pmin)	$T_{min} \geq 18°C$
As	Equatorial savannah with dry summer	$P_{min} < 60$ mm in summer	$T_{min} \geq 18°C$
Aw	Equatorial savannah with dry winter	$P_{min} < 60$ mm in winter	$T_{min} \geq 18°C$
B	Arid climates		
BSh	Steppe climate (Hot semi–arid)	$P_{ann} < 10\ P_{th}$ $P_{ann} > 5\ P_{th}$	$T_{ann} \geq 18°C$
BSk	Steppe climate (Cold semi–arid)		$T_{ann} < 18°C$
BWh	Deserts climate (Hot)	$P_{ann} \leq 5\ P_{th}$	$T_{ann} \geq 18°C$
BWk	Desert climate (Cold)		$T_{ann} < 18°C$
C	Warm temperate climates		–3°C ≤ Tmin ≤ 18°C
Cfa	Warm temperate climate, fully humid (Hot–summer)	Fully humid without dry season (neither Cs nor Cw)	$T_{max} \geq 22°C$
Cfb	Warm temperate climate, fully humid (Warm–summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Cfc	Warm temperate climate, fully humid (Cool–summer)		not (b) and Tmin ≥ –38°C
Csa	Warm temperate climate with dry summer (Hot–summer)	$P_{smin} < P_{wmin}$. $P_{wmax} > 3\ P_{smin}$ $P_{smin} < 40$mm	$T_{max} \geq 22°C$
Csb	Warm temperate climate with dry summer (Warm–summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Csc	Warm temperate climate with dry summer (Cool–summer)		not (b) and Tmin ≥ –38°C
Cwa	Warm temperate climate with dry winter (Hot–summer)	$P_{wmin} < P_{smin}$ $P_{smax} > 10\ P_{wmin}$	$T_{max} \geq 22°C$
Cwb	Warm temperate climate with dry winter (Warm–summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Cwc	Warm temperate climate with dry winter (Cool–summer)		not (b) and Tmin ≥ –38°C
D	Snow climates		Tmin ≤ –3°C
Dfa	Snow climate, fully humid (Hot–summer)	Without dry season (neither Ds nor Dw)	$T_{max} \geq 22°C$
Dfb	Snow climate, fully humid (Warm–summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Dfc	Snow climate, fully humid (Cool summer)		not (b) and Tmin ≥ –38°C
Dfd	Snow climate, fully humid (Extremely cold)		not (c) and Tmin ≤ –38°C
Dsa	Snow climate with dry summer (Hot summer)	$P_{smin} < P_{wmin}$. $P_{wmax} > 3\ P_{smin}$ $P_{smin} < 40$mm	$T_{max} \geq 22°C$
Dsb	Snow climate with dry summer (Warm summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Dsc	Snow climate with dry summer (Cool summer)		not (b) and Tmin ≥ –38°C
Dwa	Snow climate with dry winter (Hot–summer)	$P_{wmin} < P_{smin}$ $P_{smax} > 10\ P_{wmin}$	$T_{max} \geq 22°C$
Dwb	Snow climate with dry winter (Warm–summer)		not (a) and at least 4 $T_{mon} \geq 10°C$
Dwc	Snow climate with dry winter (Cool–summer)		not (b) and Tmin ≥ –38°C
Dwd	Snow climate with dry winter (Extremely cold)		not (c) and Tmin ≤ –38°C
E	Polar climates		
EF	Frost climate		$0°C < T_{max} < 10°C$
ET	Tundra climate		$T_{min} < 0°C$

Source: M. Kottek, J. Grieser, C. Beck, B. Rudolf, and F. Rubel, "World Map of the Köppen–Geiger climate classification updated," Meteorol. Zeitschrift, vol. 15, no. 3, pp. 259–263, 2006, doi: 10.1127/0941–2948/2006/0130.

References

1. United Nations. Population size, growth and age structure. In *World Population Prospects 2019*; Department of Economic and Social Affairs: New York, NY, USA, 2019. Available online: https://www.un.org/development/desa/pd/news/world-population-prospects-2019-0 (accessed on 22 March 2021).
2. United Nations. Urban and rural population growth and world urbanization prospects. In *World Urbanization Prospects: The 2018 Revision*; Department of Economic and Social Affairs: New York, NY, USA, 2018. Available online: https://desapublications.un.org/publications/2018-revision-world-urbanization-prospects (accessed on 25 March 2021).
3. Restivo, V.; Cernigliaro, A.; Casuccio, A. Urban sprawl and health outcome associations in sicily. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1350. [CrossRef]
4. Hiemstra, J.A.; Saaroni, H.; Amorim, J.H. The Urban Heat Island: Thermal Comfort and the Role of Urban Greening. In *The Urban Forest*; Springer: Cham, Switzerland, 2017.
5. Department of the Environment and Energy. "HVAC Factsheet-Energy Breakdown". 2013. Available online: https://www.energy.gov.au/sites/default/files/hvac-factsheet-energy-breakdown.pdf (accessed on 8 February 2022).
6. Air Conditioning Use Emerges as One of the Key Drivers of Global Electricity-Demand Growth. Available online: https://www.iea.org/news/air-conditioning-use-emerges-as-one-of-the-key-drivers-of-global-electricity-demand-growth (accessed on 8 February 2022).
7. Xiang, B.; Patra, P.K.; Montzka, S.A.; Miller, S.M.; Elkins, J.W.; Moore, F.L.; Atlas, E.L.; Miller, B.R.; Weiss, R.F.; Prinn, R.G.; et al. Global emissions of refrigerants HCFC-22 and HFC-134a: Unforeseen seasonal contributions. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 17379–17384. [CrossRef] [PubMed]
8. Climate Watch. *Historical Country Greenhouse Gas Emissions Data (1990–2018)*; World Resources Institute: Washington, DC, USA, 2021. Available online: https://www.climatewatchdata.org/ghg-emissions (accessed on 10 January 2022).
9. Patrick, R.; Noy, S.; Henderson-Wilson, C. Urbanisation, climate change and health equity: How can health promotion contribute? *Int. J. Health Promot. Educ.* **2016**, *54*, 34–49. [CrossRef]
10. Bureau of Meterorology and CSIRO. *State of The Climate 2020*; Commonwealth of Austrlia: Canberra, Australia, 2020. Available online: http://www.bom.gov.au/state-of-the-climate/documents/State-of-the-Climate-2020.pdf (accessed on 25 March 2021).
11. Chapman, S.; Watson, J.E.M.; Salazar, A.; Thatcher, M.; McAlpine, C.A. The impact of urbanization and climate change on urban temperatures: A systematic review. *Landsc. Ecol.* **2017**, *32*, 1921–1935. [CrossRef]
12. Sharples, J.J.; Lewis, S.C.; Perkins-Kirkpatrick, S.E. Modulating influence of drought on the synergy between heatwaves and dead fine fuel moisture content of bushfire fuels in the Southeast Australian region. *Weather Clim. Extrem.* **2021**, *31*, 100300. [CrossRef]
13. Australian Institute of Health and Welfare. *Australian Bushfires 2019–2020: Exploring the Short-Term Health Impacts*; Australian Institute of Health and Welfare: Canberra, Australia, 2020. Available online: https://www.aihw.gov.au/getmedia/a14c3205-784c-4d81-ab49-a33ed4d3d813/aihw-phe-276.pdf.aspx?inline=true. (accessed on 6 April 2021).
14. Ghiaus, C.; Allard, F.; Santamouris, M.; Georgakis, C.; Roulet, C.-A.; Germano, M.; Tillenkamp, F.; Heijmans, N.; Nicol, F.; Maldonado, E.; et al. *Natural Ventilation in Urban Areas—Results of the European Project URBVENT Part 1: Urban Environment*; Beton-Und Stahlbetonbau: Berlin, Germany, 2005.
15. Bushfire Smoke and Your Health. Available online: https://www.qld.gov.au/health/staying-healthy/environmental/after-a-disaster/bushfires/bushfire-smoke-and-your-health (accessed on 25 June 2022).
16. Mauree, D.; Naboni, E.; Coccolo, S.; Perera, A.T.D.; Nik, V.M.; Scartezzini, J.L. A review of assessment methods for the urban environment and its energy sustainability to guarantee climate adaptation of future cities. *Renew. Sustain. Energy Rev.* **2019**, *112*, 733–746. [CrossRef]
17. Balany, F.; Ng, A.W.; Muttil, N.; Muthukumaran, S.; Wong, M.S. Green Infrastructure as an Urban Heat Island Mitigation Strategy—A Review. *Water* **2020**, *12*, 3577. [CrossRef]
18. Svendsen, E.; Northridge, M.E.; Metcalf, S.S. Integrating Grey and Green Infrastructure to Improve the Health and Well-being of Urban Populations. *CATE* **2012**, *5*, 3. [CrossRef]
19. Servadio, J.L.; Lawal, A.S.; Davis, T.; Bates, J.; Russell, A.G.; Ramaswami, A.; Convertino, M.; Botchwey, N. Demographic Inequities in Health Outcomes and Air Pollution Exposure in the Atlanta Area and its Relationship to Urban Infrastructure. *J. Hered.* **2018**, *96*, 219–234. [CrossRef]
20. Boloorani, A.D.; Shorabeh, S.N.; Samany, N.N.; Mousivand, A.; Kazemi, Y.; Jaafarzadeh, N.; Zahedi, A.; Rabiei, J. Vulnerability mapping and risk analysis of sand and dust storms in Ahvaz, IRAN. *Environ. Pollut.* **2021**, *279*, 116859. [CrossRef] [PubMed]
21. Kumar, P.; Druckman, A.; Gallagher, J.; Gatersleben, B.; Allison, S.; Eisenman, T.S.; Hoang, U.; Hama, S.; Tiwari, A.; Sharma, A.; et al. The nexus between air pollution, green infrastructure and human health. *Environ. Int.* **2019**, *133*, 105181. [CrossRef]
22. Hardman, M.; Davies, N. *Green Roofs Can Make Cities Healthier and Happier. Why Aren't They Everywhere?* Fast Company: New York, NY, USA, 2019. Available online: https://www.fastcompany.com/90413645/green-roofs-can-make-cities-healthier-and-happier-why-arent-they-everywhere (accessed on 23 June 2022).
23. Vandecasteele, I.; Baranzelli, C.; Siragusa, A.; Aurambout, J.P.; Alberti, V.; Alonso Raposo, M.; Attardo, C.; Auteri, D.; Barranco, R.; Batista e Silva, F.; et al. How can Public Space in a City Help to Address Future Urban Challenges? European Commission. Available online: https://urban.jrc.ec.europa.eu/thefutureofcities/space-and-the-city#sections (accessed on 23 June 2022).

24. Maes, J.; Zulian, G.; Günther, S.; Thijssen, M.; Raynal, J. *Enhancing Resilience Of Urban Ecosystems through Green Infrastructure (EnRoute)*; European Union: Luxembourg, 2019. [CrossRef]
25. Snow, J. *Green Roofs Take Root Around the World*; National Geographic: Washington, DC, USA, 2016. Available online: https://www.nationalgeographic.com/history/article/san-francisco-green-roof-law?irgwc=1&irclickid=T36zimQYexyITJW0fEwxs2ifUkDzJFUd8RXFWE0&cmpid=org%253Dngp%253A%253Amc%253Daffiliate%253A%253Asrc%253Daffiliate%253A%253Acmp%253Dsubs_aff%253A%253Aadd%253DSki (accessed on 26 June 2022).
26. Geotab. Which US Cities Have The Most Green Space? Geotab. 2019. Available online: https://www.geotab.com/press-release/greenest-cities-in-america/ (accessed on 26 June 2022).
27. The Rooftop Project Map. Available online: https://cityofmelbourne.maps.arcgis.com/apps/MapSeries/index.html?appid=5c6bf1fc3f094e418e55eb1bce03953e (accessed on 26 June 2022).
28. CSIRO. *Establishing a National Agenda for Urban Green Infrastructure*; CSIRO: Collingwood, Australia, 2021. Available online: https://www.csiro.au/en/research/environmental-impacts/sustainability/Green-infrastructure (accessed on 28 June 2022).
29. Zuniga-Teran, A.A.; Staddon, C.; de Vito, L.; Gerlak, A.K.; Ward, S.; Schoeman, Y.; Hart, A.; Booth, G. Challenges of mainstreaming green infrastructure in built environment professions. *J. Environ. Plan. Manag.* **2020**, *63*, 710–732. [CrossRef]
30. Hagemann, F.A.; Randrup, T.B.; Sang, Å.O. Challenges to implementing the urban ecosystem service concept in green infrastructure planning: A view from practitioners in Swedish municipalities. *Socio-Ecol. Pract. Res.* **2020**, *2*, 283–296. [CrossRef]
31. Gavrilidis, A.-A.; Popa, A.-M.; Nita, M.-R.; Onose, D.-A.; Badiu, D.-L. Planning the "unknown": Perception of urban green infrastructure concept in Romania. *Urban For. Urban Green.* **2020**, *51*, 126649. [CrossRef]
32. Rydlewski, J.; Rajabi, Z.; Tariq, M.A.; Muttil, N.; Sidiqui, P.; Shah, A.A.; Khan, N.A.; Irshad, M.; Alam, A.; Butt, T.A.; et al. Identification of Embodied Environmental Attributes of Construction in Metropolitan and Growth Region of Melbourne, Australia to Support Urban Planning. *Sustainability* **2022**, *14*, 8401. [CrossRef]
33. Department of Environment and Primary Industries. *Growing Green Guide: A Guide to Green Roofs, Walls and Facades in Melbourne and Victoria, Australia*; State of Victoria: Melbourne, Australia, 2014.
34. Fernández-Cañero, R.; Emilsson, T.; Fernandez-Barba, C.; Machuca, M.Á.H. Green roof systems: A study of public attitudes and preferences in southern Spain. *J. Environ. Manag.* **2013**, *128*, 106–115. [CrossRef] [PubMed]
35. Koc, C.B.; Osmond, P.; Peters, A. A Green Infrastructure Typology Matrix to Support Urban Microclimate Studies. *Procedia Eng.* **2016**, *169*, 183–190. [CrossRef]
36. Pérez-Urrestarazu, L.; Fernández-Cañero, R.; Franco-Salas, A.; Egea, G. Vertical Greening Systems and Sustainable Cities. *J. Urban Technol.* **2015**, *22*, 65–85. [CrossRef]
37. Muhy Al-din, S.; Iranfar, M. The Validity of Beauty in the Functionality of the Vertical Greenery Systems (VGS) in Interior Surfaces of Buildings. International Conference on Contemporary Affairs in Architecture and Urbanism (ICCAUA), Anlanya, Turkey, 9–10 May 2019.
38. Andenæs, E.; Kvande, T.; Muthanna, T.M.; Lohne, J. Performance of Blue-Green Roofs in Cold Climates: A Scoping Review. *Buildings* **2018**, *8*, 55. [CrossRef]
39. Shafique, M.; Kim, R.; Lee, D. The Potential of Green-Blue Roof to Manage Storm Water in Urban Areas. *Nat. Environ. Pollut. Technol.* **2016**, *15*, 715–718.
40. Gholami, M.; Barbaresi, A.; Tassinari, P.; Bovo, M.; Torreggiani, D. A Comparison of Energy and Thermal Performance of Rooftop Greenhouses and Green Roofs in Mediterranean Climate: A Hygrothermal Assessment in WUFI. *Energies* **2020**, *13*, 2030. [CrossRef]
41. VOSviewer. *Welcome to VOSviewer*; University of Leiden: Leiden, The Netherlands, 2022. Available online: https://www.vosviewer.com/ (accessed on 28 June 2022).
42. Donthu, N.; Kumar, S.; Mukherjee, D.; Pandey, N.; Lim, W.M. How to conduct a bibliometric analysis: An overview and guidelines. *J. Bus. Res.* **2021**, *133*, 285–296. [CrossRef]
43. SCOPUS. *How do Author keywords and Indexed keywords Work?* Elesvier: Amsterdam, The Netherlands, 2022. Available online: https://service.elsevier.com/app/answers/detail/a_id/21730/supporthub/scopus/#:~{}:text=Authorkeywordsarechosenbytheauthorto,takeintoaccountsynonyms%2Cvariousspellings%2Candplurals (accessed on 28 June 2022).
44. Mutani, G.; Todeschi, V. The Effects of Green Roofs on Outdoor Thermal Comfort, Urban Heat Island Mitigation and Energy Savings. *Atmosphere* **2020**, *11*, 123. [CrossRef]
45. Berardi, U. The outdoor microclimate benefits and energy saving resulting from green roofs retrofits. *Energy Build.* **2016**, *121*, 217–229. [CrossRef]
46. Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. World map of the Köppen-Geiger climate classification updated. *Meteorol. Zeitschrift* **2006**, *15*, 259–263. [CrossRef]
47. United NationsClimate Action: Net Zero Coalition. Available online: https://www.un.org/en/climatechange/net-zero-coalition (accessed on 3 July 2022).
48. Aboelata, A. Assessment of green roof benefits on buildings' energy-saving by cooling outdoor spaces in different urban densities in arid cities. *Energy* **2021**, *219*, 119514. [CrossRef]

49. Department of Environment Land Water and Planning. *Planning a Green-Blue City*; E2Designlab: Melbourne, Australia, 2017. Available online: https://www.clearwatervic.com.au/user-data/resource-files/green-blue-guidelines-feb17-low-res.pdf#:~{}:text=Within%20the%20context%20of%20this%20guide%2C%20a%20planning,mind.%20Landscape%20Planning%20Water%20Planning%20Green-Blue%20Infrastructure%20Planning (accessed on 3 July 2022).
50. Nguyen, C.N.; Muttil, N.; Tariq, M.A.U.R.; Ng, A.W.M. Quantifying the Benefits and Ecosystem Services Provided by Green Roofs—A Review. *Water* **2021**, *14*, 68. [CrossRef]
51. Dahanayake, K.C.; Chow, C.L. Comparing reduction of building cooling load through green roofs and green walls by EnergyPlus simulations. *Build. Simul.* **2018**, *11*, 421–434. [CrossRef]
52. Battista, G.; Vollaro, E.; De, L.; Vollaro, R. How Cool Pavements and Green Roof Affect Building Energy Performances. *Heat Transf. Eng.* **2022**, *43*, 326–336. [CrossRef]
53. Pigliautile, I.; Chàfer, M.; Pisello, A.L.; Pérez, G.; Cabeza, L.F. Inter-building assessment of urban heat island mitigation strategies: Field tests and numerical modelling in a simplified-geometry experimental set-up. *Renew. Energy* **2020**, *147*, 1663–1675. [CrossRef]
54. Cascone, S.; Catania, F.; Gagliano, A.; Sciuto, G. A comprehensive study on green roof performance for retrofitting existing buildings. *Build. Environ.* **2018**, *136*, 227–239. [CrossRef]
55. Ragab, A.; Abdelrady, A. Impact of Green Roofs on Energy Demand for Cooling in Egyptian Buildings. *Sustainability* **2020**, *12*, 5729. [CrossRef]
56. Coma, J.; Chàfer, M.; Pérez, G.; Cabeza, L.F. How internal heat loads of buildings affect the effectiveness of vertical greenery systems? An experimental study. *Renew. Energy* **2020**, *151*, 919–930. [CrossRef]
57. Moody, S.S.; Sailor, D.J. Development and application of a building energy performance metric for green roof systems. *Energy Build.* **2013**, *60*, 262–269. [CrossRef]
58. Porcaro, M.; Comino, F.; Vanwalleghem, T.; Ruiz de Adana, M. Exploring the reduction of energy demand of a building with an eco-roof under different irrigation strategies. *Sustain. Cities Soc.* **2021**, *74*, 103229. [CrossRef]
59. Campos, A.; Santillán-Soto, N.; Garcia Cueto, R.; Lambert, A.; Bojorquez, G. Energy and Environmental Comparison between a Concrete Wall with and without a Living Green Wall: A Case Study in Mexicali, Mexico. *Sustainability* **2020**, *12*, 5265. [CrossRef]
60. Zhang, L.; Deng, Z.; Liang, L.; Zhang, Y.; Meng, Q.; Wang, J.; Santamouris, M. Thermal behavior of a vertical green facade and its impact on the indoor and outdoor thermal environment. *Energy Build.* **2019**, *204*, 109502. [CrossRef]
61. Blanco, I.; Schettini, E.; Scarascia, G.; Vox, G. Thermal behaviour of green façades in summer. *J. Agric. Eng.* **2018**, *49*, 183–190. [CrossRef]
62. Convertino, F.; Blanco, I.; Scarascia, G.; Schettini, E.; Vox, G. Energy behaviour of the green layer in green façades. *Acta Hortic.* **2020**, *1296*, 723–730. [CrossRef]
63. Convertino, F.; Vox, G.; Schettini, E. Heat transfer mechanisms in vertical green systems and energy balance equations. *Int. J. Des. Nat. Ecodynamics* **2019**, *14*, 7–18. [CrossRef]
64. Bagheri Moghaddam, F.; Navarro, I.; Redondo, E.; Mir, J.; Mateu, L. Understanding the Performance of Vertical Gardens by Using Building Simulation and its Influences on Urban Landscape. *ACE Q.* **2021**, *16*, 10321. [CrossRef]
65. Chun, B.; Guldmann, J.-M. Impact of greening on the urban heat island: Seasonal variations and mitigation strategies. *Comput. Environ. Urban Syst.* **2018**, *71*, 165–176. [CrossRef]
66. Yin, H.; Kong, F.; Middel, A.; Dronova, I.; Xu, H.; James, P. Cooling effect of direct green façades during hot summer days: An observational study in Nanjing, China using TIR and 3DPC data. *Build. Environ.* **2017**, *116*, 195–206. [CrossRef]
67. Ávila-Hernández, A.; Simá, E.; Xamán, J.; Hernández-Pérez, I.; Téllez-Velázquez, E.; Chagolla-Aranda, M.A. Test box experiment and simulations of a green-roof: Thermal and energy performance of a residential building standard for Mexico. *Energy Build.* **2020**, *209*, 109709. [CrossRef]
68. Arghavani, S.; Malakooti, H.; Ali Akbari Bidokhti, A.-A. Numerical assessment of the urban green space scenarios on urban heat island and thermal comfort level in Tehran Metropolis. *J. Clean. Prod.* **2020**, *261*, 121183. [CrossRef]
69. Sharma, A.; Woodruff, S.; Budhathoki, M.; Hamlet, A.F.; Chen, F.; Fernando, H.J.S. Role of green roofs in reducing heat stress in vulnerable urban communities—A multidisciplinary approach. *Environ. Res. Lett.* **2018**, *13*, 94011. [CrossRef]
70. Toparlar, Y.; Blocken, B.; Maiheu, B.; van Heijst, G.J.F. A review on the CFD analysis of urban microclimate. *Renew. Sustain. Energy Rev.* **2017**, *80*, 1613–1640. [CrossRef]
71. Hugo, J.; du Plessis, C.A.; Masenge, A. Retrofitting Southern African cities: A call for appropriate rooftop greenhouse designs as climate adaptation strategy. *J. Clean. Prod.* **2021**, *312*, 127663. [CrossRef]
72. Wahba, S.; Kamil, B.; Nassar, K.; Abdelsalam, A. Green Envelop Impact on Reducing Air Temperature and Enhancing Outdoor Thermal Comfort in Arid Climates. *Civ. Eng. J.* **2019**, *5*, 1124–1135. [CrossRef]
73. Wahba, S.; Kamel, B.; Nassar, K.; Abdelsalam, A. Effectiveness of Green Roofs and Green Walls on Energy Consumption and Indoor Comfort in Arid Climates. *Civ. Eng. J.* **2018**, *4*, 2284. [CrossRef]
74. Cirrincione, L.; Marvuglia, A.; Scaccianoce, G. Assessing the effectiveness of green roofs in enhancing the energy and indoor comfort resilience of urban buildings to climate change: Methodology proposal and application. *Build. Environ.* **2021**, *205*, 108198. [CrossRef]
75. Zhang, Y.; Zhang, L.; Ma, L.; Meng, Q.; Ren, P. Cooling Benefits of an Extensive Green Roof and Sensitivity Analysis of Its Parameters in Subtropical Areas. *Energies* **2019**, *22*, 4278. [CrossRef]

76. Abe, H.; Rijal, H.B.; Hiroki, R.; Iijima, K.; Ohta, A. Thermal Mitigation of the Indoor and Outdoor Climate by Green Curtains in Japanese Condominiums. *Climate* **2020**, *8*, 8. [CrossRef]
77. Afshari, A. A new model of urban cooling demand and heat island—application to vertical greenery systems (VGS). *Energy Build.* **2017**, *157*, 204–217. [CrossRef]
78. Andric, I.; Kamal, A.; Al-Ghamdi, S.G. Efficiency of green roofs and green walls as climate change mitigation measures in extremely hot and dry climate: Case study of Qatar. *Energy Rep.* **2020**, *6*, 2476–2489. [CrossRef]
79. Ariff, A.; Ahmad, S.; Hussin, M. Green envelope as an architectural strategy for energy efficiency in a library building. *MATEC Web Conf.* **2019**, *266*, 1004. [CrossRef]
80. Arkar, C.; Domjan, S.; Medved, S. Heat transfer in a lightweight extensive green roof under water-freezing conditions. *Energy Build.* **2018**, *167*, 187–199. [CrossRef]
81. Ascione, F.; Bianco, N.; de' Rossi, F.; Turni, G.; Vanoli, G.P. Green roofs in European climates. Are effective solutions for the energy savings in air-conditioning? *Appl. Energy* **2013**, *104*, 845–859. [CrossRef]
82. Assimakopoulos, M.-N.; De Masi, R.F.; de Rossi, F.; Papadaki, D.; Ruggiero, S. Green Wall Design Approach Towards Energy Performance and Indoor Comfort Improvement: A Case Study in Athens. *Sustainability* **2020**, *12*, 3772. [CrossRef]
83. Bano, P.; Dervishi, S. The impact of vertical vegetation on thermal performance of high-rise office building facades in Mediterranean climate. *Energy Build.* **2021**, *236*, 110761. [CrossRef]
84. Barozzi, B.; Bellazzi, A.; Pollastro, M.C. The Energy Impact in Buildings of Vegetative Solutions for Extensive Green Roofs in Temperate Climates. *Buildings* **2016**, *6*, 33. [CrossRef]
85. Basher, H.S.; Abdul Rahman, A.R. Simulation of vertical greenery system in reducing energy cooling loads for high rise residential building. *J. Mech. Eng.* **2017**, *1*, 185–196.
86. Basher, H.S.; Ahmad, S.S.; Rahman, A.M.A.; Zaman, N.Q. The use of edible vertical greenery system to improve thermal performance in tropical climate. *J. Mech. Eng.* **2016**, *13*, 58–66.
87. Begum, M.S.; Bala, S.K.; Islam, A.K.M.S.; Roy, D. Environmental and Social Dynamics of Urban Rooftop Agriculture (URTA) and Their Impacts on Microclimate Change. *Sustainbility* **2021**, *13*, 9053. [CrossRef]
88. Bevilacqua, P.; Bruno, R.; Arcuri, N. Green roofs in a Mediterranean climate: Energy performances based on in-situ experimental data. *Renew. Energy* **2020**, *152*, 1414–1430. [CrossRef]
89. Bevilacqua, P.; Mazzeo, D.; Bruno, R.; Arcuri, N. Experimental investigation of the thermal performances of an extensive green roof in the Mediterranean area. *Energy Build.* **2016**, *122*, 63–79. [CrossRef]
90. Bianco, L.; Serra, V.; Larcher, F.; Perino, M. Thermal behaviour assessment of a novel vertical greenery module system: First results of a long-term monitoring campaign in an outdoor test cell. *Energy Effic.* **2017**, *10*, 625–638. [CrossRef]
91. Blanco, I.; Convertino, F.; Schettini, E.; Vox, G. Energy analysis of a green façade in summer: An experimental test in Mediterranean climate conditions. *Energy Build.* **2021**, *245*, 111076. [CrossRef]
92. Blanco, I.; Convertino, F.; Schettini, E.; Vox, G. Wintertime thermal performance of green façades in a Mediterranean climate. *WIT Trans. Ecol. Environ.* **2020**, *243*, 47–56. [CrossRef]
93. Blanco, I.; Schettini, E.; Vox, G. Effects of vertical green technology on building surface temperature. *Int. J. Des. Nat. Ecodynamics* **2018**, *13*, 384–394. [CrossRef]
94. Cai, L.; Feng, X.-P.; Yu, J.-Y.; Xiang, Q.-C.; Chen, R. Reduction in Carbon Dioxide Emission and Energy Savings Obtained by Using a Green Roof. *Aerosol Air Qual. Res.* **2019**, *19*, 2432–2445. [CrossRef]
95. Cameron, R.W.F.; Taylor, J.; Emmett, M. A Hedera green façade – Energy performance and saving under different maritime-temperate, winter weather conditions. *Build. Environ.* **2015**, *92*, 111–121. [CrossRef]
96. Carlos, J.S. Simulation assessment of living wall thermal performance in winter in the climate of Portugal. *Build. Simul.* **2014**, *8*, 3–11. [CrossRef]
97. Cascone, S.; Gagliano, A.; Poli, T.; Sciuto, G. Thermal performance assessment of extensive green roofs investigating realistic vegetation-substrate configurations. *Build. Simul.* **2019**, *12*, 379–393. [CrossRef]
98. Chagolla-Aranda, M.A.; Simá, E.; Xamán, J.; Álvarez, G.; Hernández-Pérez, I.; Téllez-Velázquez, E. Effect of irrigation on the experimental thermal performance of a green roof in a semi-warm climate in Mexico. *Energy Build.* **2017**, *154*, 232–243. [CrossRef]
99. Chan, A.L.S.; Chow, T.T. Energy and economic performance of green roof system under future climatic conditions in Hong Kong. *Energy Build.* **2013**, *64*, 182–198. [CrossRef]
100. Charoenkit, S.; Yiemwattana, S. Role of specific plant characteristics on thermal and carbon sequestration properties of living walls in tropical climate. *Build. Environ.* **2017**, *115*, 67–79. [CrossRef]
101. Charoenkit, S.; Yiemwattana, S.; Rachapradit, N. Plant characteristics and the potential for living walls to reduce temperatures and sequester carbon. *Energy Build.* **2020**, *225*, 110286. [CrossRef]
102. Cirkel, D.G.; Voortman, B.R.; van Veen, T.; Bartholomeus, R.P. Evaporation from (Blue-)Green Roofs: Assessing the Benefits of a Storage and Capillary Irrigation System Based on Measurements and Modeling. *Water* **2018**, *10*, 1253. [CrossRef]
103. Cirrincione, L.; La Gennusa, M.; Peri, G.; Rizzo, G.; Scaccianoce, G.; Sorrentino, G.; Aprile, S. Green Roofs as Effective Tools for Improving the Indoor Comfort Levels of Buildings—An Application to a Case Study in Sicily. *Appl. Sci.* **2020**, *10*, 893. [CrossRef]
104. Collins, S.; Kuoppamäki, K.; Kotze, D.J.; Lü, X. Thermal behavior of green roofs under Nordic winter conditions. *Build. Environ.* **2017**, *122*, 206–214. [CrossRef]

105. Coma, J.; Pérez, G.; de Gracia, A.; Burés, S.; Urrestarazu, M.; Cabeza, L.F. Vertical greenery systems for energy savings in buildings: A comparative study between green walls and green facades. *Build. Environ.* **2017**, *111*, 228–237. [CrossRef]
106. Convertino, F.; Vox, G.; Schettini, E. Evaluation of the cooling effect provided by a green façade as nature-based system for buildings. *Build. Environ.* **2021**, *203*, 108099. [CrossRef]
107. Peng, L.L.H.; Jiang, Z.; Yang, X.; Wang, Q.; He, Y.; Chen, S.S. Energy savings of block-scale facade greening for different urban forms. *Appl. Energy* **2020**, *279*, 115844. [CrossRef]
108. Coutts, A.M.; Daly, E.; Beringer, J.; Tapper, N.J. Assessing practical measures to reduce urban heat: Green and cool roofs. *Build. Environ.* **2013**, *70*, 266–276. [CrossRef]
109. Dabaieh, M.; Serageldin, A.A. Earth air heat exchanger, Trombe wall and green wall for passive heating and cooling in premium passive refugee house in Sweden. *Energy Convers. Manag.* **2020**, *209*, 112555. [CrossRef]
110. Dahanayake, K.W.D.K.C.; Chow, C.L. Studying the potential of energy saving through vertical greenery systems: Using EnergyPlus simulation program. *Energy Build.* **2017**, *138*, 47–59. [CrossRef]
111. Dandou, A.; Papangelis, G.; Kontos, T.; Santamouris, M.; Tombrou, M. On the cooling potential of urban heating mitigation technologies in a coastal temperate city. *Landsc. Urban Plan.* **2021**, *212*, 104106. [CrossRef]
112. De Masi, R.F.; de Rossi, F.; Ruggiero, S.; Vanoli, G.P. Numerical optimization for the design of living walls in the Mediterranean climate. *Energy Convers. Manag.* **2019**, *195*, 573–586. [CrossRef]
113. de Munck, C.; Lemonsu, A.; Masson, V.; Le Bras, J.; Bonhomme, M. Evaluating the impacts of greening scenarios on thermal comfort and energy and water consumptions for adapting Paris city to climate change. *Urban Clim.* **2018**, *23*, 260–286. [CrossRef]
114. Dimitrijevic, D.; Živković, P.; Stojiljković, M.; Todorović, M.; Spasić Đorđević, S. Green living roof implementation and influences of the soil layer on its properties. *Therm. Sci.* **2016**, *20*, 1511–1520. [CrossRef]
115. Djedjig, R.; El Ganaoui, M.; Belarbi, R.; Bennacer, R. Thermal effects of an innovative green wall on building energy performance. *Mech. Ind.* **2016**, *18*, 104. [CrossRef]
116. Djedjig, R.; Ouldboukhitine, S.-E.; Belarbi, R.; Bozonnet, E. Development and validation of a coupled heat and mass transfer model for green roofs. *Int. Commun. Heat Mass Transf.* **2012**, *39*, 752–761. [CrossRef]
117. D'Orazio, M.; Di Perna, C.; Di Giuseppe, E. Green roof yearly performance: A case study in a highly insulated building under temperate climate. *Energy Build.* **2012**, *55*, 439–451. [CrossRef]
118. Eksi, M.; Rowe, D.B.; Wichman, I.S.; Andresen, J.A. Effect of substrate depth, vegetation type, and season on green roof thermal properties. *Energy Build.* **2017**, *145*, 174–187. [CrossRef]
119. Erdemir, D.; Ayata, T. Prediction of temperature decreasing on a green roof by using artificial neural network. *Appl. Therm. Eng.* **2017**, *112*, 1317–1325. [CrossRef]
120. Espinosa-Fernández, A.; Echarri-Iribarren, V.; Sáez, C.A. Water-Covered Roof Versus Inverted Flat Roof on the Mediterranean Coast: A Comparative Study of Thermal and Energy Behavior. *Appl. Sci.* **2020**, *10*, 2288. [CrossRef]
121. Evangelisti, L.; Guattari, C.; Grazieschi, G.; Roncone, M.; Asdrubali, F. On the Energy Performance of an Innovative Green Roof in the Mediterranean Climate. *Energies* **2020**, *13*, 5163. [CrossRef]
122. Fahmy, M.; El-Hady, H.; Mahdy, M.; Abdelalim, M.F. On the green adaptation of urban developments in Egypt; predicting community future energy efficiency using coupled outdoor-indoor simulations. *Energy Build.* **2017**, *153*, 241–261. [CrossRef]
123. Fantozzi, F.; Bibbiani, C.; Gargari, C.; Rugani, R.; Salvadori, G. Do green roofs really provide significant energy saving in a Mediterranean climate? Critical evaluation based on different case studies. *Front. Archit. Res.* **2021**, *10*, 447–465. [CrossRef]
124. Feng, H.; Hewage, K. Energy saving performance of green vegetation on LEED certified buildings. *Energy Build.* **2014**, *75*, 281–289. [CrossRef]
125. Fitchett, A.; Govender, P.; Vallabh, P. An exploration of green roofs for indoor and exterior temperature regulation in the South African interior. *Environ. Dev. Sustain.* **2020**, *22*, 5025–5044. [CrossRef]
126. Foustalieraki, M.; Assimakopoulos, M.N.; Santamouris, M.; Pangalou, H. Energy performance of a medium scale green roof system installed on a commercial building using numerical and experimental data recorded during the cold period of the year. *Energy Build.* **2017**, *135*, 33–38. [CrossRef]
127. Gagliano, A.; Detommaso, M.; Nocera, F.; Evola, G. A multi-criteria methodology for comparing the energy and environmental behavior of cool, green and traditional roofs. *Build. Environ.* **2015**, *90*, 71–81. [CrossRef]
128. Gagliano, A.; Nocera, F.; DeTommaso, M.; Evola, G. Thermal Behavior of an Extensive Green Roof: Numerical Simulations and Experimental Investigations. *Int. J. Heat Technol.* **2016**, *34*, S226–S234. [CrossRef]
129. Gallardo, N.P.; Alves, E.D.L.; Silva, M.S.D.; de Sousa, F.L.N.; Santos, B.C. Evaluation of comfort and thermal efficiency in buildings with plant surroundings: An experimental study report. *Rev. Bras. Gest. Desenvolv. Reg.* **2021**, *17*. Available online: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85121050723&doi=10.54399%2FRBGDR.V17I2.6348&partnerID=40&md5=e8599021c9a3a2c71bec5c0b2eda9479 (accessed on 10 July 2022).
130. Gao, Y.; Shi, D.; Levinson, R.; Guo, R.; Lin, C.; Ge, J. Thermal performance and energy savings of white and sedum-tray garden roof: A case study in a Chongqing office building. *Energy Build.* **2017**, *156*, 343–359. [CrossRef]
131. Goussous, J.; Siam, H.; Alzoubi, H. Prospects of green roof technology for energy and thermal benefits in buildings: Case of Jordan. *Sustain. Cities Soc.* **2015**, *14*, 425–440. [CrossRef]
132. Guattari, C.; Evangelisti, L.; Asdrubali, F.; Vollaro, R.D.L. Experimental Evaluation and Numerical Simulation of the Thermal Performance of a Green Roof. *Appl. Sci.* **2020**, *10*, 1767. [CrossRef]

133. Haggag, M.; Hassan, A.; Elmasry, S. Experimental study on reduced heat gain through green façades in a high heat load climate. *Energy Build.* **2014**, *82*, 668–674. [CrossRef]
134. Hao, X.; Xing, Q.; Long, P.; Lin, Y.; Hu, J.; Tan, H. Influence of vertical greenery systems and green roofs on the indoor operative temperature of air-conditioned rooms. *J. Build. Eng.* **2020**, *31*, 101373. [CrossRef]
135. He, Y.; Lin, E.S.; Tan, C.L.; Tan, P.Y.; Wong, N.H. Quantitative evaluation of plant evapotranspiration effect for green roof in tropical area: A case study in Singapore. *Energy Build.* **2021**, *241*, 110973. [CrossRef]
136. He, Y.; Lin, E.S.; Tan, C.L.; Yu, Z.; Tan, P.Y.; Wong, N.H. Model development of Roof Thermal Transfer Value (RTTV) for green roof in tropical area: A case study in Singapore. *Build. Environ.* **2021**, *203*, 108101. [CrossRef]
137. He, Y.; Yu, H.; Dong, N.; Ye, H. Thermal and energy performance assessment of extensive green roof in summer: A case study of a lightweight building in Shanghai. *Energy Build.* **2016**, *127*, 762–773. [CrossRef]
138. He, Y.; Yu, H.; Ozaki, A.; Dong, N. Thermal and energy performance of green roof and cool roof: A comparison study in Shanghai area. *J. Clean. Prod.* **2020**, *267*, 122205. [CrossRef]
139. He, Y.; Yu, H.; Ozaki, A.; Dong, N.; Zheng, S. An investigation on the thermal and energy performance of living wall system in Shanghai area. *Energy Build.* **2017**, *140*, 324–335. [CrossRef]
140. He, Y.; Yu, H.; Ozaki, A.; Dong, N.; Zheng, S. Influence of plant and soil layer on energy balance and thermal performance of green roof system. *Energy* **2017**, *141*, 1285–1299. [CrossRef]
141. Heidarinejad, G.; Esmaili, A. Numerical simulation of the dual effect of green roof thermal performance. *Energy Convers. Manag.* **2015**, *106*, 1418–1425. [CrossRef]
142. Heusinger, J.; Weber, S. Surface energy balance of an extensive green roof as quantified by full year eddy-covariance measurements. *Sci. Total Environ.* **2017**, *577*, 220–230. [CrossRef]
143. Heusinger, J.; Sailor, D.J.; Weber, S. Modeling the reduction of urban excess heat by green roofs with respect to different irrigation scenarios. *Build. Environ.* **2018**, *131*, 174–183. [CrossRef]
144. Hirano, Y.; Ihara, T.; Gomi, K.; Fujita, T. Simulation-Based Evaluation of the Effect of Green Roofs in Office Building Districts on Mitigating the Urban Heat Island Effect and Reducing CO2 Emissions. *Sustainability* **2019**, *11*, 2055. [CrossRef]
145. Jadaa, D.; Aburaed, A.; Taleb, H. Assessing the Thermal Effectiveness of Implementing Green Roofs in the Urban Neighborhood. *Jordan J. Mech. Ind. Eng.* **2019**, *13*, 161–174.
146. Jaffal, I.; Ouldboukhitine, S.-E.; Belarbi, R. A comprehensive study of the impact of green roofs on building energy performance. *Renew. Energy* **2012**, *43*, 157–164. [CrossRef]
147. Jiang, L.; Tang, M. Thermal analysis of extensive green roofs combined with night ventilation for space cooling. *Energy Build.* **2017**, *156*, 238–249. [CrossRef]
148. Jim, C. Assessing climate-adaptation effect of extensive tropical green roofs in cities. *Landsc. Urban Plan.* **2015**, *138*, 54–70. [CrossRef]
149. Jim, C.Y.; Peng, L.L.H. Weather effect on thermal and energy performance of an extensive tropical green roof. *Urban For. Urban Green.* **2012**, *11*, 73–85. [CrossRef]
150. Jim, C.Y. Passive warming of indoor space induced by tropical green roof in winter. *Energy* **2014**, *68*, 272–282. [CrossRef]
151. Madi, K.; Bozonnet, E.; Patrick, S. Building and Urban Cooling Performance Indexes of Wetted and Green Roofs—A Case Study under Current and Future Climates. *Energies* **2020**, *13*, 6192. [CrossRef]
152. Kadhim-Abid, A.L. Comfort management in changing climate conditions with the use of green roofs. *Manag. Mark.* **2014**, *9*, 3–12.
153. Karachaliou, P.; Santamouris, M.; Pangalou, H. Experimental and numerical analysis of the energy performance of a large scale intensive green roof system installed on an office building in Athens. *Energy Build.* **2016**, *114*, 256–264. [CrossRef]
154. Kenaï, M.-A.; Libessart, L.; Lassue, S.; Defer, D. Impact of plants occultation on energy balance: Experimental study. *Energy Build.* **2018**, *162*, 208–218. [CrossRef]
155. Klein, P.M.; Coffman, R. Establishment and performance of an experimental green roof under extreme climatic conditions. *Sci. Total Environ.* **2015**, *512*, 82–93. [CrossRef]
156. Kolokotsa, D.; Santamouris, M.; Zerefos, S.C. Green and cool roofs' urban heat island mitigation potential in European climates for office buildings under free floating conditions. *Sol. Energy* **2013**, *95*, 118–130. [CrossRef]
157. Kotsiris, G.; Androutsopoulos, A.; Polychroni, E.; Nektarios, P.A. Dynamic U-value estimation and energy simulation for green roofs. *Energy Build.* **2012**, *45*, 240–249. [CrossRef]
158. Koura, J.; Manneh, R.; Belarbi, R.; El Khoury, V.; El Bachawati, M. Seasonal variability of temperature profiles of vegetative and traditional gravel-ballasted roofs: A case study for Lebanon. *Energy Build.* **2017**, *151*, 358–364. [CrossRef]
159. Fachinello Krebs, L.; Johansson, E. Influence of microclimate on the effect of green roofs in Southern Brazil–A study coupling outdoor and indoor thermal simulations. *Energy Build.* **2021**, *241*, 110963. [CrossRef]
160. Kumar, A.; Deoliya, R.; Chani, P.S. Evaluation on Thermal Behavior of a Green Roof Retrofit System Installed on Experimental Building in Composite Climate of Roorkee, India. *J. Inst. Eng. Ser. A* **2015**, *96*, 277–284. [CrossRef]
161. La Roche, P.; Berardi, U. Comfort and energy savings with active green roofs. *Energy Build.* **2014**, *82*, 492–504. [CrossRef]
162. Landi, F.F.D.A.; Fabiani, C.; Pisello, A. Experimental Winter Monitoring of a Light-Weight Green Roof Assembly for Building Retrofit. *Sustainability* **2021**, *13*, 4604. [CrossRef]
163. Lassandro, P.; Cosola, T. Climate change mitigation: Resilience indicators for roof solutions. *Int. J. Disaster Resil. Built Environ.* **2018**, *9*, 4–17. [CrossRef]

164. Ledesma, G.; Nikolic, J.; Pons-Valladares, O. Co-simulation for thermodynamic coupling of crops in buildings. Case study of free-running schools in Quito, Ecuador. *Build. Environ.* **2022**, *207*, 108407. [CrossRef]
165. Lee, L.S.H.; Jim, C.Y. Energy benefits of green-wall shading based on novel-accurate apportionment of short-wave radiation components. *Appl. Energy* **2019**, *238*, 1506–1518. [CrossRef]
166. Lee, L.S.H.; Jim, C.Y. Thermal-irradiance behaviours of subtropical intensive green roof in winter and landscape-soil design implications. *Energy Build.* **2020**, *209*, 109692. [CrossRef]
167. Li, J.; Zheng, B.; Shen, W.; Xiang, Y.; Chen, X.; Qi, Z. Cooling and Energy-Saving Performance of Different Green Wall Design: A Simulation Study of a Block. *Energies* **2019**, *12*, 2912. [CrossRef]
168. Li, Z.; Chow, D.H.C.; Yao, J.; Zheng, X.; Zhao, W. The effectiveness of adding horizontal greening and vertical greening to courtyard areas of existing buildings in the hot summer cold winter region of China: A case study for Ningbo. *Energy Build.* **2019**, *196*, 227–239. [CrossRef]
169. Liu, X.; Tian, G.; Feng, J.; Wang, J.; Kong, L. Assessing summertime urban warming and the cooling efficacy of adaptation strategy in the Chengdu-Chongqing metropolitan region of China. *Sci. Total Environ.* **2018**, *610–611*, 1092–1102. [CrossRef]
170. Lundholm, J.T.; Weddle, B.M.; MacIvor, J.S. Snow depth and vegetation type affect green roof thermal performance in winter. *Energy Build.* **2014**, *84*, 299–307. [CrossRef]
171. Luo, H.; Wang, N.; Chen, J.; Ye, X.; Sun, Y.-F. Study on the Thermal Effects and Air Quality Improvement of Green Roof. *Sustainability* **2015**, *7*, 2804–2817. [CrossRef]
172. Lynn, B.H.; Lynn, I.M. The impact of cool and green roofs on summertime temperatures in the cities of Jerusalem and Tel Aviv. *Sci. Total Environ.* **2020**, *743*, 140568. [CrossRef] [PubMed]
173. Mahmoodzadeh, M.; Mukhopadhyaya, P.; Valeo, C. Effects of Extensive Green Roofs on Energy Performance of School Buildings in Four North American Climates. *Water* **2019**, *12*, 6. [CrossRef]
174. Maiolo, M.; Pirouz, B.; Bruno, R.; Palermo, S.A.; Arcuri, N.; Piro, P. The Role of the Extensive Green Roofs on Decreasing Building Energy Consumption in the Mediterranean Climate. *Sustainability* **2020**, *12*, 359. [CrossRef]
175. Malys, L.; Musy, M.; Inard, C. Direct and Indirect Impacts of Vegetation on Building Comfort: A Comparative Study of Lawns, Green Walls and Green Roofs. *Energies* **2016**, *9*, 32. [CrossRef]
176. Manso, M.; Castro-Gomes, J. Thermal analysis of a new modular system for green walls. *J. Build. Eng.* **2016**, *7*, 53–62. [CrossRef]
177. Mazzali, U.; Peron, F.; Scarpa, M. Thermo-physical performances of living walls via field measurements and numerical analysis. In *WIT Transactions on Ecology and the Environment*; WIT Press: Southampton, UK, 2012; Volume 165, pp. 251–259.
178. Moghaddam, F.; Mir, J.F.; Yanguas, A.B.; Delgado, I.N.; Dominguez, E.R. Building Orientation in Green Facade Performance and Its Positive Effects on Urban Landscape Case Study: An Urban Block in Barcelona. *Sustainability* **2020**, *12*, 9273. [CrossRef]
179. Moghbel, M.; Erfanian Salim, R. Environmental benefits of green roofs on microclimate of Tehran with specific focus on air temperature, humidity and CO2 content. *Urban Clim.* **2017**, *20*, 46–58. [CrossRef]
180. Mohammad Shuhaimi, N.D.A.; Mohamed Zaid, S.; Esfandiari, M.; Lou, E.; Mahyuddin, N. The impact of vertical greenery system on building thermal performance in tropical climates. *J. Build. Eng.* **2022**, *45*, 103429. [CrossRef]
181. Mutani, G.; Todeschi, V. Roof-Integrated Green Technologies, Energy Saving and Outdoor Thermal Comfort: Insights from a Case Study in Urban Environment. *Int. J. Sustain. Dev. Plan.* **2021**, *16*, 13–23. [CrossRef]
182. Nadal, A.; Llorach-Massana, P.; Cuerva, E.; López-Capel, E.; Montero, J.I.; Josa, A.; Rieradevall, J.; Royapoor, M. Building-integrated rooftop greenhouses: An energy and environmental assessment in the mediterranean context. *Appl. Energy* **2017**, *187*, 338–351. [CrossRef]
183. Nan, X.; Yan, H.; Wu, R.; Shi, Y.; Bao, Z. Assessing the thermal performance of living wall systems in wet and cold climates during the winter. *Energy Build.* **2020**, *208*, 109680. [CrossRef]
184. Netam, N.; Sanyal, S.; Bhowmick, S. Assessing the impact of passive cooling on thermal comfort in LIG house using CFD. *J. Therm. Eng.* **2019**, *5*, 414–421.
185. Nguyen, P.A.; Bokel, R.; van den Dobbelsteen, A. Effects of a Vertical Green Façade on the Thermal Performance and Cooling Demand: A Case Study of a Tube House in Vietnam. *J. Facade Des. Eng.* **2019**, *7*, 45–64. [CrossRef]
186. Alonso, O.J.; Mariana, C.; Vidal, R.P.; Francesca, O.; Guerra, A.R.; Javier, N.G.F.; Bedoya, F.C. Thermal and Illuminance Performance of a Translucent Green Wall. *J. Archit. Eng.* **2013**, *19*, 256–264. [CrossRef]
187. Olivieri, F.; Olivieri, L.; Neila, J. Experimental study of the thermal-energy performance of an insulated vegetal façade under summer conditions in a continental mediterranean climate. *Build. Environ.* **2014**, *77*, 61–76. [CrossRef]
188. Olivieri, F.; Redondas, D.; Neila, J. Experimental characterization and implementation of an integrated autoregressive model to predict the thermal performance of vegetal façades. *Energy Build.* **2014**, *72*, 309–321. [CrossRef]
189. Omar, A.; Vigoderis, R.; Pandorfi, H.; Moura, G.; Guiselini, C. Green roof: Simulation of energy balance components in Recife, Pernambuco State, Brazil. *Eng. Agrícola* **2018**, *38*, 334–342. [CrossRef]
190. Ottelé, M.; Perini, K. Comparative experimental approach to investigate the thermal behaviour of vertical greened façades of buildings. *Ecol. Eng.* **2017**, *108*, 152–161. [CrossRef]
191. Ouldboukhitine, S.-E.; Belarbi, R.; Sailor, D.J. Experimental and numerical investigation of urban street canyons to evaluate the impact of green roof inside and outside buildings. *Appl. Energy* **2014**, *114*, 273–282. [CrossRef]
192. Pan, L.; Chu, L.M. Energy saving potential and life cycle environmental impacts of a vertical greenery system in Hong Kong: A case study. *Build. Environ.* **2016**, *96*, 293–300. [CrossRef]

193. Pandey, S.; Hindoliya, D.A.; Mod, R. Artificial neural network for predation of cooling load reduction using green roof over building in Sustainable City. *Sustain. Cities Soc.* **2012**, *3*, 37–45. [CrossRef]
194. Pandey, S.; Hindoliya, D.A.; Mod, R. Experimental investigation on green roofs over buildings. *Int. J. Low-Carbon Technol.* **2013**, *8*, 37–42. [CrossRef]
195. Parhizkar, H.; Khoraskani, R.A.; Tahbaz, M. Double skin façade with Azolla; ventilation, Indoor Air Quality and Thermal Performance Assessment. *J. Clean. Prod.* **2020**, *249*, 119313. [CrossRef]
196. Park, G.; Hawkins, T.W. An Examination of the Effect of Building Compactness and Green Roofs on Indoor Temperature through the Use of Physical Models. *Geogr. Bull.* **2015**, *56*, 93–101.
197. Peñalvo-López, E.; Cárcel-Carrasco, J.; Alfonso-Solar, D.; Valencia-Salazar, I.; Hurtado-Pérez, E. Study of the Improvement on Energy Efficiency for a Building in the Mediterranean Area by the Installation of a Green Roof System. *Energies* **2020**, *13*, 1246. [CrossRef]
198. Peng, L.L.H.; Yang, X.; He, Y.; Hu, Z.; Xu, T.; Jiang, Z.; Yao, L. Thermal and energy performance of two distinct green roofs: Temporal pattern and underlying factors in a subtropical climate. *Energy Build.* **2019**, *185*, 247–258. [CrossRef]
199. Pérez, G.; Coma, J.; Sol, S.; Cabeza, L.F. Green facade for energy savings in buildings: The influence of leaf area index and facade orientation on the shadow effect. *Appl. Energy* **2017**, *187*, 424–437. [CrossRef]
200. Pérez, G.; Vila, A.; Solé, C.; Coma, J.; Castell, A.; Cabeza, L.F. The thermal behaviour of extensive green roofs under low plant coverage conditions. *Energy Effic.* **2015**, *8*, 881–894. [CrossRef]
201. Perini, K.; Bazzocchi, F.; Croci, L.; Magliocco, A.; Cattaneo, E. The use of vertical greening systems to reduce the energy demand for air conditioning. Field monitoring in Mediterranean climate. *Energy Build.* **2017**, *143*, 35–42. [CrossRef]
202. Pianella, A.; Aye, L.; Chen, Z.; Williams, N.S.G. Substrate Depth, Vegetation and Irrigation Affect Green Roof Thermal Performance in a Mediterranean Type Climate. *Sustainability* **2017**, *9*, 1451. [CrossRef]
203. Piro, P.; Carbone, M.; De Simone, M.; Maiolo, M.; Bevilacqua, P.; Arcuri, N. Energy and Hydraulic Performance of a Vegetated Roof in Sub-Mediterranean Climate. *Sustainability* **2018**, *10*, 3473. [CrossRef]
204. Pisello, A.L.; Piselli, C.; Cotana, F. Thermal-physics and energy performance of an innovative green roof system: The Cool-Green Roof. *Sol. Energy* **2015**, *116*, 337–356. [CrossRef]
205. Poddar, S.; Park, D.; Chang, S. Energy performance analysis of a dormitory building based on different orientations and seasonal variations of leaf area index. *Energy Effic.* **2017**, *10*, 887–903. [CrossRef]
206. Polo-Labarrios, M.A.; Quezada-García, S.; Sánchez-Mora, H.; Escobedo-Izquierdo, M.A.; Espinosa-Paredes, G. Comparison of thermal performance between green roofs and conventional roofs. *Case Stud. Therm. Eng.* **2020**, *21*, 100697. [CrossRef]
207. Porcaro, M.; de Adana, M.R.; Comino, F.; Peña, A.; Martín-Consuegra, E.; Vanwalleghem, T. Long term experimental analysis of thermal performance of extensive green roofs with different substrates in Mediterranean climate. *Energy Build.* **2019**, *197*, 18–33. [CrossRef]
208. Rakotondramiarana, H.T.; Ranaivoarisoa, T.F.; Morau, D. Dynamic Simulation of the Green Roofs Impact on Building Energy Performance, Case Study of Antananarivo, Madagascar. *Buildings* **2015**, *5*, 497–520. [CrossRef]
209. Razzaghmanesh, M.; Beecham, S.; Salemi, T. The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia. *Urban For. Urban Green.* **2016**, *15*, 89–102. [CrossRef]
210. Rupasinghe, H.T.; Halwatura, R.U. Benefits of implementing vertical greening in tropical climates. *Urban For. Urban Green.* **2020**, *53*, 126708. [CrossRef]
211. Samah, H.-A.; Tiwari, G.N.; Nougbléga, Y. Cool and Green Roofs as Techniques to Overcome Heating in Building and its Surroundings under Warm Climate. *Int. Energy J.* **2020**, *20*, 359–372.
212. Scarpa, M.; Mazzali, U.; Peron, F. Modeling the energy performance of living walls: Validation against field measurements in temperate climate. *Energy Build.* **2014**, *79*, 155–163. [CrossRef]
213. Schade, J.; Lidelöw, S.; Lönnqvist, J. The thermal performance of a green roof on a highly insulated building in a sub-arctic climate. *Energy Build.* **2021**, *241*, 110961. [CrossRef]
214. Scharf, B.; Kraus, F. Green Roofs and Greenpass. *Buildings* **2019**, *9*, 205. [CrossRef]
215. Scharf, B.; Zluwa, I. Case study investigation of the building physical properties of seven different green roof systems. *Energy Build.* **2017**, *151*, 564–573. [CrossRef]
216. Schweitzer, O.; Erell, E. Evaluation of the energy performance and irrigation requirements of extensive green roofs in a water-scarce Mediterranean climate. *Energy Build.* **2014**, *68*, 25–32. [CrossRef]
217. Shao, B.; Valeo, C.; Mukhopadhyaya, P.; He, J. Influence of Temperature and Moisture Content on Thermal Performance of Green Roof Media. *Energies* **2021**, *14*, 2421. [CrossRef]
218. Sharma, A.; Conry, P.; Fernando, H.; Hamlet, A.; Hellmann, J.; Chen, F. Green and cool roofs to mitigate urban heat island effects in the Chicago metropolitan area: Evaluation with a regional climate model. *Environ. Res. Lett.* **2016**, *11*, 64004. [CrossRef]
219. Silva, C.M.; Gomes, M.G.; Silva, M. Green roofs energy performance in Mediterranean climate. *Energy Build.* **2016**, *116*, 318–325. [CrossRef]
220. Simões, N.; Almeida, R.; Tadeu, A.; Brett, M.; Almeida, J. Comparison between cork-based and conventional green roof solutions. *Build. Environ.* **2020**, *175*, 106812. [CrossRef]
221. Sisco, L.; Monzer, S.; Farajalla, N.; Bashour, I.; Saoud, I.P. Roof top gardens as a means to use recycled waste and A/C condensate and reduce temperature variation in buildings. *Build. Environ.* **2017**, *117*, 127–134. [CrossRef]

222. Small, G.; Jimenez, I.; Salzl, M.; Shrestha, P. *Urban Heat Island Mitigation Due to Enhanced Evapotranspiration in an Urban Garden in Saint Paul, Minnesota, USA*; WIT Transactions on Ecology and the Environment: Southampton, UK, 2020; Volume 243.
223. Smalls-Mantey, L.; Montalto, F. The seasonal microclimate trends of a large scale extensive green roof. *Build. Environ.* **2021**, *197*, 107792. [CrossRef]
224. Squier, M.; Davidson, C.I. Heat flux and seasonal thermal performance of an extensive green roof. *Build. Environ.* **2016**, *107*, 235–244. [CrossRef]
225. Stella, P.; Personne, E. Effects of conventional, extensive and semi-intensive green roofs on building conductive heat fluxes and surface temperatures in winter in Paris. *Build. Environ.* **2021**, *205*, 108202. [CrossRef]
226. Šuklje, T.; Arkar, C.; Medved, S. The Local Ventilation System Coupled With The Indirect Green Façade: A Priliminary Study. *Int. J. Des. Nat. Ecodynamics* **2014**, *9*, 314–320. [CrossRef]
227. Šuklje, T.; Medved, S.; Arkar, C. An Experimental Study on a Microclimatic Layer of a Bionic Façade Inspired by Vertical Greenery. *J. Bionic Eng.* **2013**, *10*, 177–185. [CrossRef]
228. Šuklje, T.; Medved, S.; Arkar, C. On detailed thermal response modeling of vertical greenery systems as cooling measure for buildings and cities in summer conditions. *Energy* **2016**, *115*, 1055–1068. [CrossRef]
229. Sun, T.; Grimmond, C.S.B.; Ni, G.-H. How do green roofs mitigate urban thermal stress under heat waves? *J. Geophys. Res. Atmos.* **2016**, *121*, 5320–5335. [CrossRef]
230. Susorova, I.; Angulo, M.; Bahrami, P. Brent Stephens A model of vegetated exterior facades for evaluation of wall thermal performance. *Build. Environ.* **2013**, *67*, 1–13. [CrossRef]
231. Susorova, I.; Azimi, P.; Stephens, B. The effects of climbing vegetation on the local microclimate, thermal performance, and air infiltration of four building facade orientations. *Build. Environ.* **2014**, *76*, 113–124. [CrossRef]
232. Taleghani, M.; Crank, P.J.; Mohegh, A.; Sailor, D.J.; Ban-Weiss, G.A. The impact of heat mitigation strategies on the energy balance of a neighborhood in Los Angeles. *Sol. Energy* **2019**, *177*, 604–611. [CrossRef]
233. Taleghani, M.; Sailor, D.; Ban-Weiss, G.A. Micrometeorological simulations to predict the impacts of heat mitigation strategies on pedestrian thermal comfort in a Los Angeles neighborhood. *Environ. Res. Lett.* **2016**, *11*, 24003. [CrossRef]
234. Tan, C.L.; Tan, P.Y.; Wong, N.H.; Takasuna, H.; Kudo, T.; Takemasa, Y.; Lim, C.V.J.; Chua, H.X.V. Impact of soil and water retention characteristics on green roof thermal performance. *Energy Build.* **2017**, *152*, 830–842. [CrossRef]
235. Tan, H.; Hao, X.; Long, P.; Xing, Q.; Lin, Y.; Hu, J. Building envelope integrated green plants for energy saving. *Energy Explor. Exploit.* **2019**, *38*, 222–234. [CrossRef]
236. Tang, M.; Zheng, X. Experimental study of the thermal performance of an extensive green roof on sunny summer days. *Appl. Energy* **2019**, *242*, 1010–1021. [CrossRef]
237. Tang, X.; Qu, M. Phase change and thermal performance analysis for green roofs in cold climates. *Energy Build.* **2016**, *121*, 165–175. [CrossRef]
238. Tetiana, T.; Mileikovskyi, V. Methodology of thermal resistance and cooling effect testing of green roofs. *Songklanakarin J. Sci. Technol.* **2020**, *42*, 50–56.
239. Vaezizadeh, F.; Rashidisharifabad, S.; Afhami, R. Investigating the Cooling Effect of Living Walls in the Sunken Courtyards of Traditional Houses in Yazd. *Eur. J. Sustain. Dev.* **2016**, *5*, 27–40.
240. Vaz Monteiro, M.; Blanuša, T.; Verhoef, A.; Richardson, M.; Hadley, P.; Cameron, R.W.F. Functional green roofs: Importance of plant choice in maximising summertime environmental cooling and substrate insulation potential. *Energy Build.* **2017**, *141*, 56–68. [CrossRef]
241. Vera, S.; Pinto, C.; Tabares-Velasco, P.C.; Bustamante, W.; Victorero, F.; Gironás, J.; Bonilla, C.A. Influence of vegetation, substrate, and thermal insulation of an extensive vegetated roof on the thermal performance of retail stores in semiarid and marine climates. *Energy Build.* **2017**, *146*, 312–321. [CrossRef]
242. Kumar, V.; Mahalle, A.M. Investigation of the thermal performance of green roof on a mild warm climate. *Int. J. Renew. Energy Res.* **2016**, *6*, 487–493.
243. Virk, G.; Jansz, A.; Mavrogianni, A.; Mylona, A.; Stocker, J.; Davies, M. Microclimatic effects of green and cool roofs in London and their impacts on energy use for a typical office building. *Energy Build.* **2015**, *88*, 214–228. [CrossRef]
244. Vox, G.; Blanco, I.; Schettini, E. Green façades to control wall surface temperature in buildings. *Build. Environ.* **2018**, *129*, 154–166. [CrossRef]
245. Linying, W.; Huang, M.; Li, D. Strong influence of convective heat transfer efficiency on the cooling benefits of green roof irrigation. *Environ. Res. Lett.* **2021**, *16*, 84062. [CrossRef]
246. Wei, T.; Jim, C.Y.; Chen, A.; Li, X. A random effects model to optimize soil thickness for green-roof thermal benefits in winter. *Energy Build.* **2021**, *237*, 110827. [CrossRef]
247. Wei, T.; Jim, C.Y.; Chen, A.; Li, X. Adjusting soil parameters to improve green roof winter energy performance based on neural-network modeling. *Energy Rep.* **2020**, *6*, 2549–2559. [CrossRef]
248. Wilkinson, S.; Feitosa, R.C. Retrofitting Housing with Lightweight Green Roof Technology in Sydney, Australia, and Rio de Janeiro, Brazil. *Sustainability* **2015**, *7*, 1081–1098. [CrossRef]
249. Xing, Q.; Hao, X.; Lin, Y.; Tan, H.; Yang, K. Experimental investigation on the thermal performance of a vertical greening system with green roof in wet and cold climates during winter. *Energy Build.* **2019**, *183*, 105–117. [CrossRef]

250. Xing, Y.; Jones, P. In-situ monitoring of energetic and hydrological performance of a semi-intensive green roof and a white roof during a heatwave event in the UK. *Indoor Built Environ.* **2019**, *30*, 56–69. [CrossRef]
251. Yaghoobian, N.; Srebric, J. Influence of plant coverage on the total green roof energy balance and building energy consumption. *Energy Build.* **2015**, *103*, 1–13. [CrossRef]
252. Yang, F.; Yuan, F.; Qian, F.; Zhuang, Z.; Yao, J. Summertime thermal and energy performance of a double-skin green facade: A case study in Shanghai. *Sustain. Cities Soc.* **2018**, *39*, 43–51. [CrossRef]
253. Yang, J.; Kumar, D.L.M.; Pyrgou, A.; Chong, A.; Santamouris, M.; Kolokotsa, D.; Lee, S.E. Green and cool roofs' urban heat island mitigation potential in tropical climate. *Sol. Energy* **2018**, *173*, 597–609. [CrossRef]
254. Yang, W.; Wang, Z.; Cui, J.; Zhu, Z.; Zhao, X. Comparative study of the thermal performance of the novel green (planting) roofs against other existing roofs. *Sustain. Cities Soc.* **2015**, *16*, 1–12. [CrossRef]
255. Yeom, D.; La Roche, P. Investigation on the cooling performance of a green roof with a radiant cooling system. *Energy Build.* **2017**, *149*, 26–37. [CrossRef]
256. Yuan, S.; Rim, D. Cooling energy saving associated with exterior greenery systems for three US Department of Energy (DOE) standard reference buildings. *Build. Simul.* **2018**, *11*, 625–631. [CrossRef]
257. Zeng, C.; Bai, X.; Sun, L.; Zhang, Y.; Yuan, Y. Optimal parameters of green roofs in representative cities of four climate zones in China: A simulation study. *Energy Build.* **2017**, *150*, 118–131. [CrossRef]
258. Zhao, M.; Srebric, J. Assessment of green roof performance for sustainable buildings under winter weather conditions. *J. Cent. South Univ.* **2012**, *19*, 639–644. [CrossRef]
259. Zhao, M.; Srebric, J.; Berghage, R.D.; Dressler, K.A. Accumulated snow layer influence on the heat transfer process through green roof assemblies. *Build. Environ.* **2015**, *87*, 82–91. [CrossRef]
260. Zhao, M.; Tabares-Velasco, P.C.; Srebric, J.; Komarneni, S.; Berghage, R. Effects of plant and substrate selection on thermal performance of green roofs during the summer. *Build. Environ.* **2014**, *78*, 199–211. [CrossRef]
261. Zheng, Y.; Weng, Q. Modeling the Effect of Green Roof Systems and Photovoltaic Panels for Building Energy Savings to Mitigate Climate Change. *Remote Sens.* **2020**, *12*, 2402. [CrossRef]
262. Zheng, X.; Dai, T.; Tang, M. An experimental study of vertical greenery systems for window shading for energy saving in summer. *J. Clean. Prod.* **2020**, *259*, 120708. [CrossRef]
263. Ziogou, I.; Michopoulos, A.; Voulgari, V.; Zachariadis, T. Implementation of green roof technology in residential buildings and neighborhoods of Cyprus. *Sustain. Cities Soc.* **2018**, *40*, 233–243. [CrossRef]