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Thermal Comfort in Academic Green Spaces: a comparative perception analysis of two universities in Finland and Sri Lanka

Egodawaththe Gedara Isurika Sevwandi

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Dr. Eeva Aarrevaara</td></tr>
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Climate change has significantly impacted human physical and mental health worldwide, with increasing global temperatures and urban heat island effect exacerbating challenges to outdoor thermal comfort in densely populated urban areas, where academic institutions are often situated. These adverse impacts extend beyond mere discomfort, affecting the health, productivity, and overall well-being of students, who are more exposed to increasing temperatures and demanding thermally comfortable outdoor spaces in academic premises. This research investigates the objective thermal conditions and thermal comfort perceptions among university students in Finland and Sri Lanka, aiming at identifying the factors affecting outdoor thermal comfort, which can inform design and management suggestions for thermally comfortable academic green spaces in similar climatic regions. The study reveals that most students perceive their thermal environments as warm or hot, with a stronger preference for cooler conditions among Sri Lankan students. Objective measurements show significantly higher temperatures and humidity in Sri Lanka, leading to greater discomfort compared to Finland. Factors such as past activity levels, environmental parameters, surface materials, and cultural influences significantly affect thermal comfort perceptions. The findings emphasize the importance of climate-specific and culturally sensitive design strategies to enhance thermal comfort with future predictions of increasing temperatures. Recommendations for Finland include flexible shading, breathable materials, and support for versatile outdoor activities. Constant shade and improved ventilation are crucial for Sri Lanka. Both settings benefit from the integration of water features, appropriate surface materials, and enhanced shaded areas to minimize heat retention and promote well-being. The research also highlights limitations, such as the short data collection period and the focus on specific locations, suggesting that future studies should take more holistic approach. This study underscores the need for climate resilient academic green spaces that support student well-being and foster community engagement, providing valuable insights for sustainable campus planning across diverse climates.</td></tr>
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LIST OF ABBREVIATIONS

AGS – Academic green spaces

DI – Discomfort Index

HI – Humidity Index

MTS – Mean Thermal Sensation

OTC – Outdoor thermal comfort

PMV – Predicted Mean Vote

PPD - Predicted Percentage of Dissatisfied

SET – Standard Effective Temperature

STHI – Simplified Thermal Heat Index

TCV – Thermal Comfort Vote

Teq – Equivalent Temperature

TPV – Thermal Preference Vote

TSV – Thermal Sensation Vote

UHI – Urban Heat Island

UTCI - Universal Thermal Climate Index

CHAPTER 1: INTRODUCTION

1.1. Background of the Study

Climate change has adversely affected human physical health globally and mental health in assessed regions with a very high confidence (Calvin *et al.*, 2023). With the escalating global temperatures attributed to climate change, the prevalence of heat island effects in urban areas has become increasingly pronounced. These localized areas of heightened temperatures pose significant challenges to outdoor thermal comfort (hereafter OTC), particularly within densely populated urban environments where academic institutions are often situated. The adverse impacts of heat islands extend beyond mere discomfort, affecting the health, productivity, and overall well-being of individuals, including students and faculty members utilizing outdoor spaces for academic pursuits. Consequently, ensuring and improving OTC in educational settings has become a pressing imperative in the face of ongoing climate change.

In the realm of academic environments, the significance of creating conducive spaces for learning and well-being is paramount. Among the factors contributing to the overall comfort and satisfaction of students, thermal comfort plays a crucial role, particularly in outdoor settings such as academic green spaces (hereafter referred as AGS) where students spontaneously gather to seek comfort while outdoor learning and commuting on foot. These spaces not only serve as extensions of classrooms but also as areas for relaxation, social interaction, and rejuvenation amidst the rigors of academic life.

The concept of thermal comfort, defined as the condition of mind that expresses satisfaction with the thermal environment (ASHRAE, 2004), has garnered increasing attention in the context of educational institutions. Understanding and addressing thermal comfort perceptions in AGS is vital not only for enhancing student experiences but also for promoting sustainable and user-centric campus design and management practices.

1.2. Rationale

The design and management of outdoor spaces, particularly green areas, have gained increasing attention due to its potential impact on student well-being and academic performance which is supported by extensive research literature. Among the various factors influencing the quality of these spaces, thermal comfort emerges as a critical consideration. Despite its significance, there exists a gap in understanding thermal comfort perceptions specifically within different types of AGS.

The need to comprehend thermal comfort perceptions in AGS arises from several pressing concerns. Firstly, addressing the comfort needs of students in outdoor environments become imperative as educational institutions increasingly prioritize sustainable and user-centric campus design. AGS significantly contribute to the overall campus experience serving as multifunctional areas for studying, socializing, and relaxation. Therefore, a thorough understanding of thermal comfort perceptions within these spaces is essential for creating environments that foster student well-being and engagement.

Secondly, the importance of outdoor learning environments has been underscored by research highlighting their positive impacts on cognitive function, mental health, and academic performance. However, the effectiveness of these spaces is contingent upon their ability to provide thermal comfort across varying climatic conditions. Without a comprehensive understanding of how students perceive and experience thermal comfort in AGS, efforts to design and manage these areas may prove inadequate of meeting user needs and expectations.

Moreover, the global trend towards urbanization and climate change necessitates a re-evaluation of outdoor space utilization strategies in educational institutions. As cities become increasingly prone to UHI effect and extreme weather events, the provision of comfortable outdoor environments becomes a crucial adaptation strategy. AGS have potential to serve as microclimatic refuges, mitigating the adverse effects of urban heat and contributing to the resilience of educational institutions if optimized for thermal comfort.

Hence, the statement of the problem emphasizes the need for a comprehensive understanding of OTC perceptions in AGS. By addressing this gap in knowledge, educational institutions can make informed decisions regarding the design, management, and utilization of outdoor spaces, ultimately enhancing the well-being, academic success, and satisfaction of students. Accordingy, the comparative analysis between two universities in Finland and Sri Lanka offers a unique opportunity to explore the influence of diverse climatic conditions and cultural adaptations on thermal comfort perceptions in AGS.

1.3. Research Aim and Objectives

This study aims to explore OTC perception in AGS by juxtaposing two widely contrasting climate and social contexts found in Finland and Sri Lanka. Through this comparison, the research endeavours to unveil the fundamental factors influencing similarities and disparities in thermal perception experiences.

The four research objectives outlined for the study on OTC in AGS in universities in Finland and Sri Lanka are:

1. To analyse and compare the objective thermal conditions, including air temperature and relative humidity in three AGS locations of the selected universities in Finland and Sri Lanka
2. To assess and compare the subjective perception of thermal comfort among students in three AGS locations of the selected universities in Finland and Sri Lanka
3. To identify the factors influencing OTC perception in AGS at the selected universities in Finland and Sri Lanka
4. To provide recommendations for the design and management of AGS, based on the findings, to enhance OTC and overall user satisfaction in educational institutions, considering the diverse climatic contexts similar to Finland and Sri Lanka.

1.4. Scope and Methodology

The scope of the study encompasses a comparative analysis of OTC perceptions in AGS between universities in Finland and Sri Lanka. The selection of universities, AGS, and climatic factors is carefully defined to ensure the study's focus and feasibility.

1.4.1. Selection of Countries

Finland and Sri Lanka represent two distinct climatic regions characterized by varying temperature ranges, humidity levels, and solar radiation patterns. By comparing AGS situated in these contrasting environments, the study can elucidate how different climatic conditions shape green space qualities, OTC preferences and experiences among students. Conducting the study across universities in two different countries provides an opportunity to examine cross-cultural differences in OTC perceptions, enhances the generalizability of findings to inform effective adaptation measures and fosters knowledge exchange and collaboration between academic institutions in different countries.

1.4.2. Selection of Universities

LAB University of Applied Sciences in Lahti is considered for Finland with its continental climate with cold winters and mild summers. University of Peradeniya in Kandy is selected for Sri Lanka characterized by a tropical climate with high temperatures and humidity. The selection process involves considering factors such as academic reputation, accessibility, and feasibility in the study.

1.4.3. Selection of AGS

Within both selected universities, AGS are identified based on their popularity among students and their suitability for outdoor activities. These spaces may include courtyards, gardens, parks, vegetated routes or designated outdoor study areas within the university campus. The selection criteria prioritize spaces that are frequently utilized by students for studying, socializing, or relaxation, ensuring the relevance of the study to student experiences.

1.4.4. Climatic Factors

The study acknowledges that a range of climatic factors influence thermal comfort in outdoor environments. Yest, it considers air temperature and relative humidity for methodological limitations.

By clarifying the scope of the study, the research aims to ensure a systematic and rigorous investigation of OTC perceptions in academic environments. This approach enables meaningful comparisons between different geographical contexts and facilitates the development of practical recommendations for enhancing OTC in educational settings.

The study methodology employs a mixed-methods approach, where objective environmental measurements are taken using mobile weather instruments and weather station sensors. Surveys and semi-structured interviews are administered to assess subjective perceptions of thermal comfort in the selected AGS. Data analysis includes descriptive statistics, correlation analysis and a thematic analysis to generate insights

1.5. Outline of the Thesis

Chapter one provides an overview of the rationale, aims and objectives and methodology of the study. Subsequent chapter two delves into a comprehensive review of relevant literature, contextualizing the research within existing scholarly discourse and identifying gaps in knowledge. Chapter three provides insight into the methodology employed, detailing the research design, data collection procedures, and analytical approaches utilized in the study to achieve each objective stated with an overview of methodological strengths and weaknesses. Chapter four presents the results of the research, including objective environmental measurements and subjective perceptions of thermal comfort in AGS along with a discussion on the analysis. Following this, chapter five provides real world implications of the findings through a landscape design analysis of two locations from both cases. Finally, chapter six offers a synopsis of the findings, and drawing conclusions to address the research objectives, acknowledging limitations, and providing recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1. Theoretical Framework

Explanation of key concepts related to OTC in AGS, and their significance in educational settings is of utmost importance before delving deep into the evolution of academic research in the sphere of thermal comfort studies. OTC has been studied multidisciplinary as of its increasing practical relevance especially in the mid-20th century. The study of conditions related to human thermal comfort in indoor spaces began in 1956 (Orosa, 2009). The 1990s marked a pivotal moment with the launch of the Indoor Air journal, focusing on thermal comfort research (De Dear *et al.,* 2013). Overall, the exploration of factors influencing thermal comfort has evolved over decades, with key studies and developments shaping our understanding of this crucial aspect of human well-being and productivity.

Thermal comfort has been defined through different terms by numerous scholars. It is considered as human body's degree of satisfaction or indifference to the thermal environment (Liu, Z., Li & Xi, 2023). The mostly cited definition is proposed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), and it is the condition of mind which expresses satisfaction with the thermal environment (ASHRAE, 2020).

Thermal comfort encompasses various factors such as surrounding temperature, air velocity, humidity, clothing, and physical activity that influence an individual's comfort level (Olesen, 2020). Recent research evaluating 232 high-quality articles in the field of urban thermal comfort identified urban climate, microclimate, physiological, psychological, and social/ cultural factors as influencing factors for OTC (Liu, Z., Li & Xi, 2023). Overall, it is evident that thermal comfort is a complex interplay of environmental and personal factors that contribute to how warm or cold a person feels in each setting.

AGS denotes areas within educational institutions that are characterized by vegetation, such as forests, parks, gardens, and street trees. Research has shown a significant positive correlation between AGS and academic achievement, with effects on mental health being both direct and indirect (Liu, W., Sun, Guo & Zheng, 2022). A study on comprehensive portrayal of greenness at both school campuses and workplaces revealed improved performance of the students in classrooms with greener views, further proving that students can cope with stressful events when they have proximity to nature (Rao, P., Islary, & Natawadkar, 2022).

2.1.1. Theoretical models/ frameworks used to study OTC perception

A growing body of research has studied the concept of thermal comfort, and several theoretical models and frameworks are commonly employed to understand and analyse human responses to thermal environments.

The adaptive theory, widely accepted in 1978, has influenced the interpretation of thermal comfort data by shifting towards models that consider not only physical aspects but also adaptive behaviours (Shooshtarian, 2019). This theory acknowledges that humans have the capacity to adapt to a range of thermal conditions through various behavioural and physiological mechanisms. De Dear in 1998 proposed a framework for adaptive comfort based on three dimensions: behaviour adaptation, physiological acclimatization, and psychological factors (Elnabawi & Hamza, 2019). This framework has contributed to the evolution of thermal comfort theory and informed the design of more responsive and user-centred environments that prioritize human well-being and comfort. A comprehensive review study summarized existing thermal comfort models applied in various environments, highlighting the complexity of factors influencing OTC such as physical, physiological, psychological, social, cultural, and personal aspects (Zhao, Lian & Lai, 2021).

Behavioural perspectives also play a crucial role in understanding OTC in urban areas. Factors like spatial features, sociocultural dimensions, and personal drivers influence thermal comfort perception (Elnabawi & Hamza, 2019). Current studies on OTC encompass benchmarks like neutral temperature, preferred temperature, and acceptable temperature. These studies analyse various influencing factors and adaptation phenomena related to OTC perception (Lai *et al.*, 2020). In a nutshell, the study of OTC perception involves a multidimensional approach that considers not only physical parameters but also behavioural, physiological, psychological, social, and cultural aspects. The theoretical models and frameworks mentioned provide a foundation for understanding how individuals perceive and adapt to thermal conditions in outdoor environments.

2.2. Methods of Assessing Outdoor Thermal Comfort

2.2.1. Overview of different methodologies and their relevance for AGS

In the realm of OTC research, both thermal comfort indices and thermal comfort evaluation methods are considered to provide a standardized and simplified way to evaluate the thermal environment and its potential impact on individuals. While thermal comfort indices focus on specific mathematical models like PMV/PPD, SET, UTCI or Teq to quantify comfort levels, thermal comfort evaluation methods consider a broader range of factors like human physiology, psychology, behaviour, culture, and microclimate influences to assess and improve overall thermal comfort conditions.

Catering to different research contexts and objectives, these evaluation methods include both subjective and objective approaches consisting of various methodologies and instruments to assess OTC. Objective assessment is often conducted utilizing various thermal indices which can be rational (based on heat transfer physics) or empirical (derived from subjective estimates). Objective methods provide empirical data that can complement subjective assessments and help understand the physical characteristics influencing thermal comfort. The following table 2.1 provides an overview of commonly used methods and their relevance for assessing OTC in AGS.

Table 2.1 :OTC Assessment methods

Objective Assessment		
OTC Method	**Protocol**	**Pros and Cons for AGS research**
Environmental Monitoring	Instruments such as temperature sensors, humidity sensors, anemometers for wind speed measurement, and pyranometers for solar radiation measurement are deployed to continuously monitor environmental conditions	Highly suitable for studying thermal comfort in AGS as it offers precise and quantitative data on environmental conditions, installation and maintenance of monitoring equipment may require resources and expertise

Thermal Imaging	Infrared cameras are used to capture thermal images, allowing visualization of temperature variations across the space	Offers a visual representation of temperature distributions, require specialized equipment and expertise for data interpretation
Microclimate Modelling	Computational Fluid Dynamics (CFD) simulations or microclimate modelling software are used to simulate airflow, temperature, and other microclimate parameters	Provides detailed insights into the effects of design elements and environmental factors on thermal conditions, requires expertise in modelling and involve simplifications and assumptions that could affect accuracy
Radiant Temperature Measurements	Globe thermometers or radiometers are used to measure radiant temperature, which represents the temperature of surfaces exposed to solar radiation	Suitable for outdoor spaces with significant solar exposure, require careful positioning of sensors to capture accurate data
Physiological Measurements	Physiological sensors such as skin temperature sensors are used to measure individuals' physiological responses	Offer objective indicators of individuals' thermal responses, require specialized equipment and considerations for participant comfort and safety
Subjective Assessment		
Surveys/ Questionnaires	Participants are asked to rate their thermal comfort or discomfort on a Likert scale (e.g., from very cold to very hot) or provide qualitative descriptions of their thermal sensation	Straightforward administration, substantial data collection from diverse participants, less insights into specific factors influencing, depends on questionnaire design and individual biases

Visual Analog Scales (VAS)	Participants mark their level of thermal comfort/discomfort on a continuous line, typically anchored with extreme conditions	Capture subtle variations in OTC perceptions, challenging to accurately position participants on the scale without clear reference points which can affect reliability
Semantic Differential Scales	Participants rate their thermal comfort using pairs of opposing adjectives (e.g., comfortable-uncomfortable, pleasant-unpleasant, relaxation-stress) along a scale	Generate rich qualitative data, suitable for exploring emotional and affective aspects of OTC in AGS, requires cognitive effort from participants, interpretation of the results can be subjective
Field Interviews/Observations	Researchers conduct interviews with participants while observing their behaviour and interactions with the outdoor environment	Suitable for gaining in-depth understanding and context-specific information, resource-intensive and subject to researcher bias
Thermal Comfort Maps	Participants mark locations on a map where they feel comfortable or uncomfortable	Useful for identifying hotspots and areas for improvement in AGS design, require sophisticated data collection techniques and analysis tools, limiting their feasibility
Diary Studies	Participants keep a diary or log where they record their thermal sensations, comfort/discomfort levels, and contextual factors throughout the day	Provide longitudinal data/ insights into daily routines, activities, and adaptation strategies in AGS, rely on participants' compliance and subjected to bias

Source: Author's interpretation based on literature review

In a nutshell, subjective assessment dive deep into individual's OTC perception and sensation but can be influenced by individual biases, variations in interpretation, and the lack of standardization across different studies, impacting the reliability and comparability of results (Aghamolaei, Azizi, Aminzadeh & O'donnell, 2022). Objective methods such as thermal indices and instruments for micrometeorological measurements offer quantitative data on environmental conditions in AGS, providing a more systematic and measurable approach to assessing thermal comfort (Aghamolaei, Azizi, Aminzadeh & O'donnell, 2022). Yet, they may require specialized equipment, expertise, and calibration to ensure accuracy. Variations in instrument setup, sensor accuracy, and data processing methods can introduce uncertainties in the evaluation process (Elnabawi & Hamza, 2019).

When studying OTC in AGS, a combination of subjective and objective assessment methods is essential to gain a comprehensive understanding of how individuals perceive and interact with their thermal environment. While subjective methods offer direct insights into human experiences, objective measurements provide quantitative data for a more systematic analysis. It is essential to consider the strengths and limitations of each method to ensure a robust evaluation.

2.3. Existing Literature around AGS

Most of the existing research related to AGS is focused on its therapeutic value and implications on students' wellbeing. Some scholarly studies have empirically demonstrated that students' perception of their overall academic experience and the campus environment is related to academic accomplishment. Table 2.2 summarizes existing studies and how they have revealed the effects of AGS towards students.

Table 2.2: Summary of studies revealing AGS effects on students

AGS effect on students	Relevant literature
Health and well-being	AGS impact on mental well-being exhibits a greater significance among males compared to females, whereas the influence of such AGS on academic performance showed

	negligible variance based on gender (Liu, W. et al., 2022)
	Universities’ perceived naturalness contributed positively to students’ self-rated restoration and health (Liu, Q. et al., 2018)
	The Healthy Academic Greenery Framework (HAGF) (Foellmer, Kistemann & Anthonj, 2021), (Völker & Kistemann, 2011) summarizes the most important relationship between academic greenery and the physical, mental, and social well-being of students
	Students are keen to experience spacious green spaces that are free, and it is possible to find areas not crossed by roads and lots of tree’s space (Zainal, & Sahimi, 2022)
Academic performance	Factors such as the presence of greenery, tree density, and vegetative land coverage within a radius of 2000 meters surrounding schools had positive associations with end-of-semester grades and college preparatory exams (Browning & Rigolon, 2019)
	Undergraduate student use of campus green spaces and perceptions of quality of life were related to each other (Mcfarland, Waliczek & Zajicek, 2008).
	Students who frequently engage with green spaces in active ways report higher quality of life, better overall mood, and lower perceived stress (Holt et al., 2019)
	AGS serves as a potent emblem of a university, enriching students' campus life experience and fostering a sense of

	connection with the local place identity. These spaces offer numerous avenues for enhancing students' understanding of local biodiversity and its conservation (Speake, Edmondson & Nawaz, 2013)
Overall perception	Aesthetic qualities of the campus and its design and management style, influence perceptions and use of its green spaces with formal, manicured gardens and lawns being much preferred over more naturalistic areas (Speake, Edmondson & Nawaz, 2013)
University placemaking	Open, green areas were not identified as the most pleasing to students, but rather accessible landscaped gardens were selected by students (Poplin et al., 2017 in Verdiguel, 2021).
	Designing for real-world contexts is complex due to the contextual nature of green spaces and their users, making it challenging to create transferable evidence (Veen et al., 2020)
	Biophilic design principles emphasize elements like environmental features, natural shapes and forms, restorative patterns and processes, light and space, place-based relationships, and evolved place attachment to enhance human-nature connections in built environments (Bochart, 2019)

Source: Author's interpretation based on literature review

The table moreover emphasizes that students tend to incline more towards meticulously maintained green landscapes, rather than naturalness which underscore the importance of evidence-based approaches, understanding the complexity of design contexts, considering diverse user needs, and integrating biophilic design elements to create comfortable and sustainable AGS. It is noteworthy that students lack awareness regarding the ecological significance of AGS where thermal comfort comes as a regulatory ecosystem service under climate regulation.

2.4. Cross-Cultural Perspectives on Thermal Comfort in AGS

2.4.1. Existing literature

Studies have shown that cultural background plays a dominant role in shaping how people perceive thermal comfort, impacting their adaptation to the thermal environment. Additionally, research has explored the relationship between cultural factors and thermal adaptation, emphasizing the importance of considering cultural diversity in understanding how people experience climate change and respond to thermal conditions in urban settings (Naheed & Shooshtarian, 2021). OTC benchmarks like thermal sensation, preference, comfort level, and acceptability are crucial in determining whether individuals feel neutral, desire changes in the thermal environment, or find it comfortable and acceptable (Lai *et al.*, 2020).

A study conducted in the American University of Sharjah Campus in UAE states that hot humid microclimate makes the thermal adaptation of the university’s occupants quite challenging due to exposure to variation air temperatures (Al Kahawaja, 2016). The case study's setting experiences significant humidity levels during summer months, leading to a notable reduction in evaporation. Consequently, the study highlights relative humidity as a more influential factor in determining hot weather conditions in this context. Another study conducted in the Kuala Lumpur, Malaysia proposed the design of outdoor areas in tropical regions by prioritizing shading and vegetation to create frequently utilized outdoor spaces and offer increased comfort levels (Ghaffarianhoseini, Berardi, Ghaffarianhoseini & Al-Obaidi, 2019). Similar study about secondary school children in the same city reported if given a choice, 76% of the students preferred a cooler environment although 56% accepted the current thermal environment, being constantly exposed to 32.7°C PET while the expected neutral temperature was found to be 25.1°C PET. This showed traits of thermal acclimatization (Cs *et al.*, 2020).

Another study in a Taiwanese campus representing hot humid climate identified Sky View Factor (SVF) significantly influencing the thermal environment by affecting solar radiation fluxes and subsequently impacting outdoor thermal sensation. However, given the low cold tolerance of local residents, excessive shading can lead to discomfort during winter due to low air temperatures. The findings also underscore the importance of considering both the thermal adaptation characteristics of local individuals and the local climate, in outdoor shading and urban planning initiatives (Hwang, Lin & Matzarakis, 2009). Another case study in Universitas Kebangsaan, Indonesia identified OTC conditions had different thermal satisfactory situations, due to differences in physical characteristics in each zone based on the presence of vegetation and the use of pavement material and interconnection between open gaps in buildings (wind distribution) (Ramadhan, Jurizat, Syafrina & Rahmat, 2021). Research done in Xi'an Eurasia University approached OTC in a different perspective by considering sunlight sensitivity as a subjective measurement. The study revealed the change of sunlight perception, changed the expected temperature of the crowd recommending increasing outdoor shade in autumn while appropriately increasing the light place in the winter for thermally comfortable universities in cold areas (Ning, Jing & Ge, 2023). Similar study in University of Groningen, in Netherlands revealed non-physical environmental and subjective factors (natural view, quiet environment, and emotional background) were more important in perceiving comfort than the actual thermal conditions with comfort being 22.2 °C and the preferred temperature at a surprisingly high 35.7 °C proving individuals residing in temperate regions commonly express a preference for feeling "warmer," even when they already perceive themselves as being warm (Wang *et al.*, 2016).

2.4.2. Knowledge Gaps

Even though recent literature draw attention to the intricate interplay between culture, climate, and individual perceptions of thermal comfort, highlighting the need for a comprehensive understanding of these factors, substantial research has not incorporated the cross-cultural perspective (Naheed & Shooshtarian, 2021). There is limited geographic representation as much of the existing literature focuses on Europe, Asia and Middle East, with fewer studies investigating thermal comfort preferences in diverse cultural settings such as Africa, and South America. Studies often fail to account for the thermal comfort preferences of minority or marginalized groups within a given cultural context. This gap is particularly significant in regions with diverse populations where cultural perspectives on comfort may vary widely, for instance ethnicity directly affects clothing choices which have an impact on thermal sensation especially in multiethnic communities. Hence, there is still a lack of comprehensive understanding of how social norms, traditions, and cultural practices intersect with thermal comfort preferences in academic green spaces.

There is also a scarcity of longitudinal studies tracking changes in thermal comfort preferences within cultural groups over time, making it challenging to discern trends and identify factors driving shifts in preferences, especially in the context of climate change and academic green spaces. Moreover, inadequate attention given to research exploring how gender and age influence thermal comfort preferences in academic green spaces across different cultures. Understanding these variations is crucial for designing inclusive and equitable environments. Addressing these knowledge gaps requires interdisciplinary approaches that integrate cultural anthropology, environmental psychology, landscape architecture, and urban planning to develop holistic frameworks for understanding and designing academic green spaces that cater to diverse cultural preferences for thermal comfort.

2.4.3. Contribution to sustainability and climate change discourse

Understanding cross-cultural variations in OTC perception in AGS informs the design of climate-responsive outdoor spaces in academic environments. By incorporating features such as shading, natural ventilation, greenery, and water elements based on cultural preferences, outdoor areas can offer comfortable microclimates while minimizing energy consumption and reliance on mechanical cooling/heating systems. By designing academic campuses with heat-absorbing materials, vegetation cover, and considering cultural preferences for shade and cooling elements, the UHI effect can be minimized, contributing to local climate resilience.

By designing outdoor areas that align with diverse cultural preferences for thermal comfort, academic institutions can create environments that support holistic health and contribute to a sustainable campus culture focused on well-being (Lamberti *et al.*, 2021). Comfortable outdoor environments encourage walking, cycling, and other forms of active transportation, so designing pedestrian-friendly pathways and rest areas that consider cultural preferences for outdoor comfort, academic campuses can promote sustainable transportation practices and contribute to climate change mitigation efforts.

Outdoor spaces in academic environments serve as living laboratories for climate education and awareness. By engaging green infrastructure, and climate-resilient landscapes that resonate with cultural values, academic institutions can engage students and the broader community in experiential learning about climate change adaptation and mitigation strategies. Incorporating natural elements and biodiversity-friendly design principles into outdoor spaces enhances habitat quality and supports local biodiversity contributing to ecosystem resilience and promoting biodiversity conservation in urban areas. Insights from OTC research inform urban planning and policy decisions related to green space provision in academic institutions eventually leading policymakers to prioritize investments in green infrastructure, equitable access to comfortable outdoor spaces, and climate-resilient urban development strategies.

In summary, addressing knowledge gaps in comparing outdoor thermal comfort perception in academic environments contributes to the sustainability and climate change discourse by informing climate-responsive design, reducing UHI effects, enhancing health and well-being, encouraging sustainable transportation, facilitating climate education, supporting biodiversity conservation, and informing urban planning and policy decisions. By creating comfortable and culturally sensitive outdoor spaces, academic institutions play a vital role in fostering sustainable and resilient communities in the face of climate change.

2.4. Summary and justification for current study’s approach

Recapitulation of literature makes apparent that the predominant focus within the academic community pertains to the impact of AGS on the mental well-being of students, often correlating with academic achievement. However, scant attention has been directed towards investigating the thermal comfort effects of AGS. There has been a concurrent acknowledgment of the significance of OTC within AGS, catalysed by the pandemic's emphasis on the necessity of outdoor spaces for safe congregation and ventilation. Consequently, a burgeoning body of research has emerged, exploring OTC in educational settings, encompassing strategies to augment comfort levels and facilitate outdoor learning and social interactions. Despite the extensive literature on design strategies and management practices for ensuring thermal comfort in urban outdoor spaces, there remains a dearth of specific attention towards educational institutions or AGS in general, thereby complicating the contextualization of these principles across diverse climates and environments.

Notably absent are substantive research endeavours that adopt cross-cultural perspectives in evaluating thermal comfort within a range of different AGS through perception analysis. Recognizing the imperative of such cross-cultural insights, particularly in the distinct climates and socio-cultural milieus hence assumes paramount importance.

This study seeks to bridge these gaps in research by advocating for a cross-cultural perspective on OTC, with a specific emphasis on AGS comparing Finland and Sri Lanka through two case studies. By integrating a comprehensive approach encompassing both subjective and objective assessments, the design and management of AGS can be optimized to cater to the diverse needs and preferences of users within each context. Such an approach not only fosters inclusivity and sustainability but also promotes well-being and academic excellence within educational environments.

CHAPTER 3: METHODOLOGY

3.1. Introduction to methodology

Choosing the right approach to investigate thermal comfort in academic green spaces requires careful consideration of various factors, including the research objectives, the complexity of the phenomenon under study, and the available resources. This section delves into the methodological framework guiding the exploration of OTC perception across universities in two distinct climate zones in Finland and Sri Lanka. For effective representation, the research design in figure 3.1 follows the research onion model by Saunders, Lewis, and Thornhill in their book titled Research Methods for Business Students (Saunders, Lewis & Thornhill, 2007).

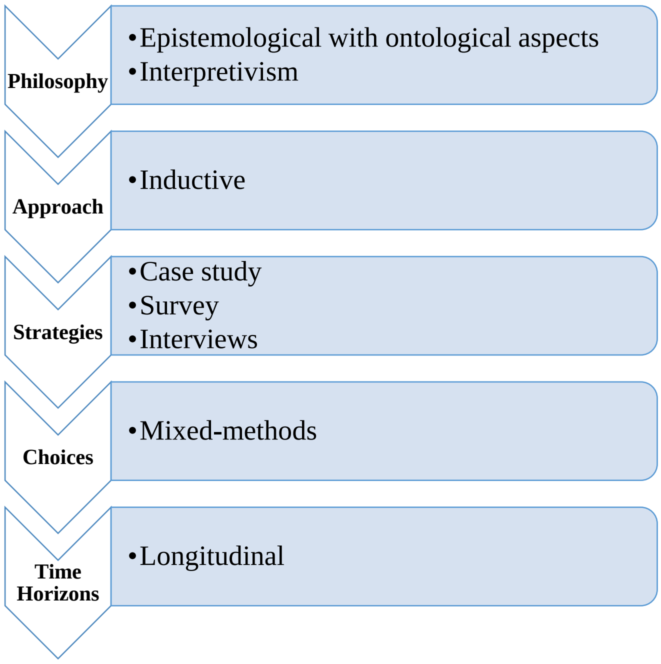


Figure 3.1: Research Design

Source: Author's interpretation

The primary aim is to understand how individuals perceive and experience thermal comfort within the context of academic green spaces, considering the unique environmental, cultural, personal and contextual factors at play. By comparing universities situated in contrasting climatic regions, the study seeks to uncover insights into the interplay between climate, environmental design, human behaviour, and thermal comfort preferences.

Central to the methodology is a mixed-methods approach, combining quantitative environmental monitoring with qualitative surveys, interviews and observations. This hybrid approach allows capturing both objective environmental data and subjective perceptions, providing a comprehensive understanding of thermal comfort dynamics.

Throughout this section, the rationale behind the research design will be outlined, detailing the selection of research sites, participants, and data collection methods. Additionally, the ethical considerations guiding the research conduct will be discussed and acknowledge potential limitations inherent in the methodology.

The detailed articulation of the methodological choices ensures the rigor and validity of the findings while offering valuable insights for future research endeavours in the field of urban climate and sustainable urban design. Furthermore, it will shed light on the nuanced relationship between academic green spaces and thermal comfort, contributing to the advancement of sustainable and user-centric design principles in educational environments.

3.2. Research Design

This study takes the form of a comparative analysis for gaining insights into the influence of climate, culture, and environmental design on subjective experiences of thermal comfort. Insights gained from such analysis can offer broader implications for educational institutions in similar climates, especially those operating in tropical and continental climatic contexts. The findings can inform best practices for designing and managing academic green spaces that prioritize thermal comfort across different geographical locations while contributing to resilience-building efforts in educational institutions during the prevalence of climate change.

The research design for this study takes a mixed-methods approach, combining both quantitative and qualitative methodologies. This approach allows for a comprehensive exploration of thermal comfort in academic green spaces, capturing both objective environmental data and subjective perceptions from individuals. Methods are selected after assessing their suitability and feasibility for AGS research, which was conducted as a part of the reviewing of existing literature (reference to table 2.1). The table 3.1 demonstrates how each research objective was addressed by selected methods justifying the research design.

Table 3.1: Alignment of research objectives with research methods

Research Objectives	Qualitative Method	Quantitative Method
To analyse and compare the objective thermal conditions in AGS in Finland and Sri Lanka		Environmental monitoring Weather station data (secondary data source)
To assess and compare the subjective OTC perception in AGS in Finland and Sri Lanka	Semi-structured survey Questionnaires Field Observations	
To identify the factors influencing OTC perception in AGS in Finland and Sri Lanka	Semi-structured survey Questionnaires Field Observations	Environmental monitoring Weather station data
To provide recommendations for the design and management of AGS	Face-to-face direct interviews Field observations	

Source: Author's interpretation

The integration of quantitative and qualitative data will enable a holistic examination of thermal comfort in academic green spaces, considering both objective environmental factors and subjective human experiences. By triangulating findings from multiple data sources, this mixed-methods approach aims to provide a nuanced and comprehensive understanding of thermal comfort dynamics within the context of different climates and cultural settings.

The research philosophy guiding this study is rooted in interpretivism, which focuses on meaning and employ multiple methods in order to reflect different aspects of the issue. Interpretivist approach is based on naturalistic approach of data collection such as interviews and observations, hence meanings emerge usually towards the end of the research process (Dudovskiy, 2024). Within the context of exploring thermal comfort in AGS across Finland and Sri Lanka, interpretivism serves as a theoretical framework that acknowledges the socially constructed nature of individuals' perceptions and experiences. By adopting an interpretivist stance, this study acknowledges that thermal comfort is not solely determined by objective environmental factors but is also shaped by cultural, contextual, and individual factors. Through qualitative methods such as semi-structured surveys and face-to-face interviews, this research seeks to uncover the subjective meanings and interpretations associated with outdoor thermal comfort, while also complementing these insights with quantitative data on environmental conditions. By embracing interpretivism as the underlying research philosophy, this study aims to provide nuanced insights into thermal comfort perceptions in AGS and contribute to the development of contextually relevant design and management strategies.

This research design was chosen to address the complexity of the research question and objectives, which necessitate a multifaceted approach to capture the diverse factors influencing thermal comfort. By combining quantitative measurements with qualitative insights, this approach allows for a more robust analysis and interpretation of the findings, ultimately contributing to a deeper understanding of how academic green spaces can be designed to enhance thermal comfort and well-being.

3.2.1. Case Study Selection

Finland and Sri Lanka represent two distinct climatic regions characterized by varying temperature ranges, humidity levels, and solar radiation patterns. By comparing AGS in two universities situated in these contrasting environments, the study can elucidate how different climatic conditions shape thermal comfort preferences and experiences among students, along with their cultural identity.

3.3. Data Collection Methods

Data collection methods were meticulously selected to align with the research objectives, encompassing both qualitative and quantitative approaches. The process includes subjective and objective measures grounded in their ability to capture both subjective and objective aspects of thermal comfort.

3.3.1. Qualitative Methods

A semi-structured survey questionnaire (annex. I) was utilized to gather subjective perceptions of OTC from participants who were present within AGS. This questionnaire was designed to elicit responses regarding individuals' thermal sensation, comfort level, and overall satisfaction with the outdoor environment. The survey instrument was comprised of three sections consisting of eleven questions overall including sub sections.

Field observations were conducted concurrently with survey administration to gather contextual data on environmental factors and user behaviours that may be influenced by OTC perception. Separate field observations were conducted to complement the qualitative data on how the students utilize the selected green spaces in the university, the duration, and their behaviour. These were captured as photographs for interpretation in the analysis.

Face-to-face direct interviews (annex. II) were conducted with students under their consent to share their perspectives on OTC. Questions were open-ended and belonged to eight different sections encouraging students to express their opinion, satisfaction, and suggestions of alterations for better OTC in AGS. These interviews elicited diverse opinions and insights on effective design and management strategies for AGS stressing what was already absent from a frequent user point of view.

3.3.2. Quantitative Methods

To comprehensively analyse the objective thermal conditions within AGS in Finland and Sri Lanka, this study employs a robust quantitative data collection strategy.

Environmental monitoring, which is a primary quantitative method used the Tinytag data logger and the utilization of weather station data. These methods provide relatively accurate and reliable measurements of key environmental variables like temperature and relative humidity, enabling a detailed comparison of thermal conditions across the two case studies. The choice of Tinytag data logger is informed by its reliability, ease of use, and precision. This device can operate in diverse environmental conditions, making it suitable for the contrasting climates of Finland and Sri Lanka. The data collected during peak hours (12:00 – 15:00) was averaged to each day and AGS location to make it easy for comparison over various locations.

Weather station data is utilized to obtain measurements of the same variables over the past five years to identify trends and make general predictions. This data is sourced from local meteorological stations situated in proximity to the selected AGS. Weather station data complement the environmental monitoring and cross-check the precision of data collected by mobile weather trackers.

Figure 3.2: TinyTag weather tracker; covered in foil, used in the field in Sri Lanka, interviews in Finland, survey in Finland

Source: Author's field work in April – June 2024

3.3.3. Data Collection Procedure

3.3.3.1. Sample Selection

The sample selection process for this study is carefully designed to ensure that the chosen academic green spaces (AGS) and survey respondents provide a representative and diverse understanding of thermal comfort in the selected contexts of Finland and Sri Lanka.

AGS location selection

The fieldwork started in Sri Lanka, and five AGS locations was purposively selected within the University of Peradeniya premises. The selection process involved preliminary observations by the author to identify green spaces that are frequently utilized by students. Frequent utilization is determined based on the number of users observed during the afternoon of the day and across various days of the week. This approach ensures that the selected locations are popular and timely relevant for assessing OTC perceptions.

Following the preliminary selection, a pilot survey was conducted over the course of one day (30.04.2024) at each of the five locations. The pilot survey aimed to test the responsiveness of the questionnaire and gather initial feedback on its effectiveness. Based on the results of the pilot survey, the five locations were narrowed down to three. The final selection considered the diversity of the locations, ensuring that they vary in terms of physical layout, vegetation cover, shading, and access to amenities. This diversity is crucial for capturing a wide range of thermal comfort experiences and perceptions. The subsequent maps in figure 3.4 and 3.5 delineates the selected AGS location in each case study.

Case 01– University of Peradeniya, Kandy, Sri Lanka

Case 02 – LAB University of Applied

Figure 3.3: AGS locations for pilot study – Case 1

Source: Google Earth Imagery

Figure 3.4: Selected AGS locations for the research – Case 1

Source: Google Earth Imagery

Case 02 - LAB University of Applied Science Lahti, Finland

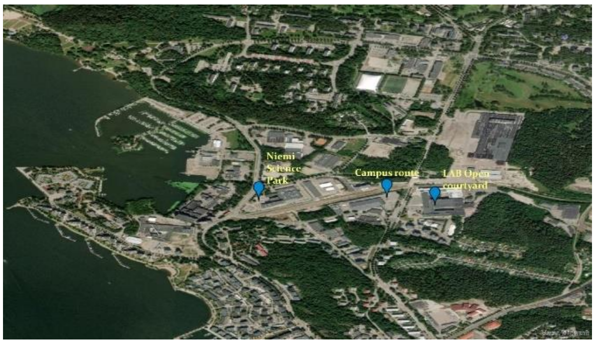


Figure 3.5: Selected AGS locations for the research – Case 2

Source: Google Earth Imagery

Selection of survey respondents

Ethics approval was obtained from the relevant institutional review boards of the universities involved. Permission to conduct research, including surveys and interviews with students, was granted by university officials.

Survey respondents were selected on a voluntary basis, ensuring that participation is open and unbiased. Recruitment took place directly within the selected AGS locations, where the researcher approached students and invited them to participate in the survey. Information about the study's purpose, the voluntary nature of participation, anonymity and the confidentiality of responses was clearly communicated to all potential participants.

The sample included 50 survey respondents and 10 interviewees from each of the three selected AGS locations in Sri Lanka, whereas 15 respondents and 10 interviewees from each location in Finland due to less students being present in the university because of the summer vacation. This sample size is chosen to ensure adequate responses for meaningful statistical analysis while also allowing for an in-depth qualitative exploration of thermal comfort perceptions. By engaging a substantial number of participants from each location, the study aims to capture a comprehensive range of perspectives and experiences related to OTC in AGS.

3.3.4. Data collection protocol

The following table 3.2 provides a concise overview of the methods and procedures used for data collection in this study to ensure consistent and reliable process of data collection.

Table 3.2: Data collection protocol

Method	Deployment	Data collection/ logging	Data retrieval	Quality control
Questionnaire Survey	Distributed to students at selected AGS locations	Responses recorded on paper	Collected by the researcher and stored securely	Pre-tested with pilot survey to refine questions and format
Face-to-Face Direct Interviews	Scheduled voluntarily with students and conducted in a quiet setting	Audio recorded with consent and notes taken	Transcribed verbatim and anonymized	Interview protocol followed
Field Observations	Conducted by researcher at selected AGS locations	Notes taken and photographs captured on environmental conditions and student activities	Field notes compiled, digitized and photos transferred to analyse	Undisturbed observations to capture real situation
Environmental Monitoring	Hung outside a bag carried by the researcher during site visits to AGS locations.	TinyTag data logger automatically recorded temperature and humidity readings at the specified intervals.	The recorded data were downloaded from the data loggers using Tinytag Explorer software provided	The bag was always positioned in the same central location within each AGS to ensure optimal placement.

		The data loggers were left undisturbed during the data collection time (12:00-15:00) to ensure continuous and reliable monitoring. Data logging continued over a one-week period in each AGS location to capture a comprehensive dataset of thermal conditions.	by the manufacturer. Data from each data logger were transferred to a secure storage device for subsequent analysis.	Data logger was protected from direct sunlight and moisture by covering it in aluminium foil to prevent damage and ensure accurate measurements.
Weather Station Data	Accessed from local meteorological stations near AGS locations	Automated recording of air temperature and relative humidity data	Data downloaded from weather station databases	Cross-referenced with Tinytag data for consistency

Source: Author's interpretation

3.4. Data Analysis

Quantitative data, collected through environmental monitoring with Tinytag data loggers and weather station data (measuring temperature and humidity) were analysed using descriptive statistical methods. This analysis summarized the environmental conditions and compared them across the AGS locations in both countries. By integrating the qualitative insights from the questionnaires and interviews with the quantitative environmental data, the study triangulated findings to provide a comprehensive understanding of the factors influencing OTC perception and develop evidence-based recommendations for enhancing thermal comfort in AGS.

The data analysis of this study employs a combination of qualitative and quantitative methods to address the research objectives. Qualitative data from semi-structured survey questionnaires were coded into eight themes and sub themes using NVivo software following the sections and subsections in the interview questions as depicted in the figure 3.6. Thematic analysis assessed and compared general impressions, subjective OTC perceptions and students' suggestions to modify AGS in Finland and Sri Lanka.

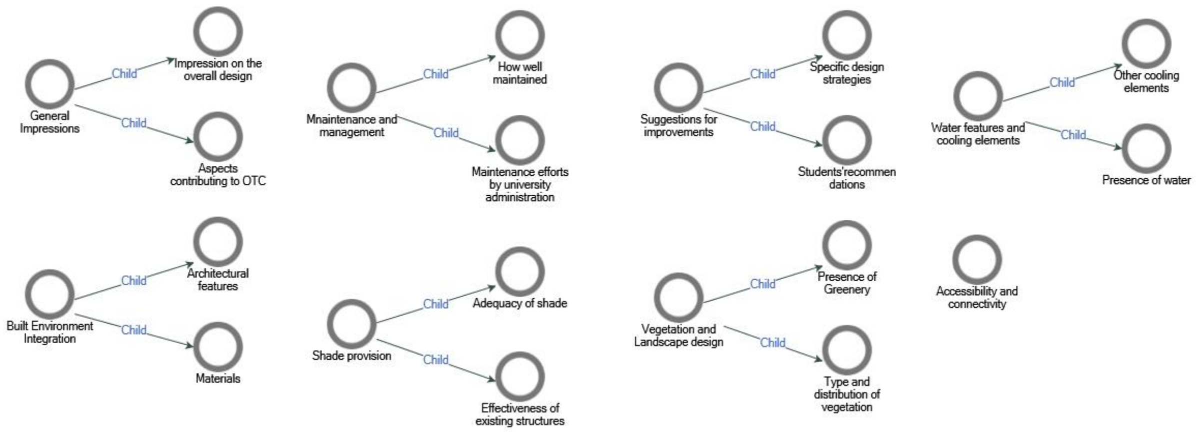


Figure 3.6: Parental codes and child codes used in the thematic coding

Source: NVivo

3.5. Ethical Considerations

The author received the ethical clearance from Glasgow Caledonian University, United Kingdom and the approval for the research permit application from the LAB University of Applied Sciences, Finland to conduct this study, as it involved university students' active participation. The survey instruments and interview procedures were explained in the process and the author is bound to discard all the materials related to data collection upon completion of the study.

Informed consent was obtained from all participants, ensuring they were fully aware of the study's purpose, procedures, and their right to withdraw at any time. Confidentiality and anonymity were strictly maintained by anonymizing data and securely storing all collected information. Cultural sensitivity was observed throughout the research, respecting the norms and values of participants in both Finland and Sri Lanka. The findings were reported without revealing any personal identifiers, ensuring the privacy and respect of all participants involved.

3.6. Limitations

This study acknowledges several limitations that may impact the generalizability and comprehensiveness of its findings.

Firstly, the environmental measurements were conducted only during the month of April for Sri Lanka and End of May to Early June for Finland. This limited timeframe does not account for seasonal variations, which are crucial for a thorough understanding of OTC across different times of the year. As a result, the findings may not fully capture how thermal comfort varies with seasonal changes.

Secondly, environmental data were collected over a period of one week in each location due to time constraints. This short duration is insufficient to capture all possible diurnal variations and transient weather conditions that could influence thermal comfort. Consequently, the environmental measurements may not reflect the full range of thermal conditions experienced in AGS.

Additionally, the sample selection, based on voluntary participation, may not be entirely representative of the broader student population. Participant number varied for both cases for questionnaire survey and the responded participants might introduce a selection bias, as those who choose to participate may have different perceptions and experiences compared to those who do not participate.

These limitations highlight the need for caution when interpreting the results and suggest that future research should aim for longer measurement periods across different seasons and a more extensive and randomized sampling approach to enhance the robustness and generalizability of the findings.

3.7. Summary

In this chapter, the research design guiding the investigation OTC in AGS across Finland and Sri Lanka was explained using a mixed methods approach. Data collection involved surveys, interviews, field observations, and environmental monitoring with Tinytag data loggers and weather station data, conducted over a week in April (Sri Lanka) and May - June (Finland). Five AGS locations were selected and narrowed to three after a pilot survey, with voluntary participants from each site. Qualitative data were analysed thematically using NVivo, and quantitative data were analysed using descriptive statistics. Ethical considerations, including informed consent and confidentiality, were strictly followed, with necessary approvals obtained. Limitations include a restricted measurement period and potential sample bias. Despite these, the study offers valuable insights into OTC in AGS which is explained in detail over the next chapter.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Introduction

This chapter aims to analyse the subjective and objective data collected on thermal comfort perceptions at three different green spaces in two universities in Finland and Sri Lanka. The data includes survey responses, interviews, observations and environmental measurements. The focus of this chapter is on

1. analysing and comparing the objective thermal conditions
2. assessing and comparing the subjective perception of thermal comfort among students,

in order to facilitate understanding different factors affecting thermal comfort perceptions in academic green spaces in these two countries. These findings will guide the recommendations for improving green space designs and management which will be addressed in the fifth chapter.

4.2. Analysis of Objective Thermal Conditions

4.2.1. Environmental Data Analysis

Temperature and DI, HI relationships

The data in the table 4.1 shows higher and more variable temperatures, for the case of university of Peradeniya particularly at the Milk Bar location which had the most shade provision due to its extensive canopy, indicating potential heat stress and discomfort during certain days. The Management Faculty experienced the most significant temperature drop on April 9, even though it was the most exposed area for direct sunlight with a lot of concrete seating arrangements. Field notes indicated a high prevalence of wind that affected the temperature drop on 9th April. In the case 2 representing LAB University of Applied Sciences in Lahti, the temperatures are more stable and generally lower compared to Peradeniya, suggesting a more comfortable thermal environment. The LAB open courtyard and Niemi science park recorded the lowest temperatures, indicating these areas might be relatively cooler with abundance of green spaces and building design and placement.

Table 4.1: Heat map table for temperature variation over one week in case 1 and case 2

Peradeniya	April 6			April 7			April 8			April 9			April 10			April 11			April 12		
Polonnaruwa	29.5	83.3	94.3	31.1	85.2	91.2	32.2	87.4	95.2	32.2	86.4	87.7	31.9	86.5	91.8	30.6	84.7	92.1	32.5	86.4	83.3
Management Faculty	31.6	86.4	93.9	33.7	89.4	92.0	31.1	85.6	93.8	25.6	76.3	87.1	32.0	86.6	91.5	33.3	88.8	92.7	29.2	80.9	79.7
Milk Bar	33.2	88.8	93.4	35.3	91.7	92.0	31.2	85.8	94.0	32.6	87.1	87.6	31.7	86.2	91.9	32.4	87.5	92.8	27.9	79.6	84.2

Lahti	28-May			29-May			30-May			31-May			1-Jun			2-Jun			3-Jun		
LAB open courtyard	26.8	77.6	82.1	27.1	78.1	82.8	28.1	79.7	83.5	29.9	82.6	84.9	29.5	81.9	83.7	26.6	77.6	85.1	27.2	78.5	84.9
Campus route	27.2	78.2	83.2	29.6	81.7	81.3	26.6	77.4	84.0	28.8	80.9	83.8	29.9	82.7	84.7	28.1	80.1	85.8	26.3	76.1	83.8
Niemi science park	26.9	77.8	83.1	28.8	80.4	80.8	26.4	77.0	82.9	28.1	79.7	83.3	28.4	80.2	83.8	25.7	76.3	84.9	27.4	78.9	85.3

Low T	High T	DI	HI

Source: Author's field survey _April - June 2024

Discomfort index value typically increases with temperature. For example, in Polonnaruwa (University of Peradeniya), as the temperature rises from 29.5°C to 32.2°C, the heat discomfort values generally increase from 83.3 to 87.4. However, there are slight anomalies due to other factors like humidity or wind. In Lahti, similar trends are observed with higher temperatures correlating to higher discomfort values. For example, in LAB Open Courtyard, when the temperature rises from 26.8°C to 29.9°C, discomfort values increase from 77.6 to 82.6.

Heat index also tends to increase with temperature, though it can be influenced more significantly by humidity. Higher temperatures combined with high humidity led to a higher heat index. In Polonnaruwa, with temperatures around 32°C, the heat index fluctuates, showing that other factors like humidity play a significant role. Similarly, in Lahti, a temperature rise from 26.8°C to 29.9°C increases the heat index from 82.1 to 84.9 in the LAB Open Courtyard, indicating a consistent relationship between temperature and perceived heat.

Temperature and Relative Humidity Relationships

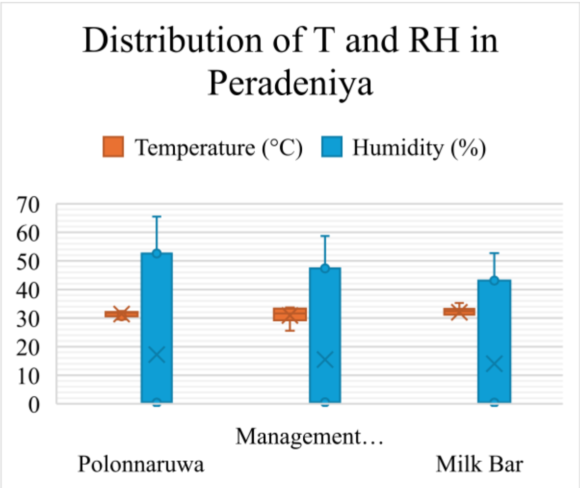
As clearly shown in figure 4.1, AGS locations in case 1 have recorded higher temperature with daily variations specifically in location 2 and 3. Even though humidity levels fluctuate over different days during peak hours, they are higher in comparison to the locations in case 2.

Figure 4.1: Temperature and relative humidity variation across three AGS locations in case 1 and case 2

Source: Author's field survey_April - June 2024

The selected AGS locations in Lahti show huge variation in recorded temperature ranging from 25.7 up to 29.8 Celsius degrees with campus route having the highest temperature records over the week. Field notes indicate construction work happening in proximity which can influence for elevated temperatures. Relative humidity levels in case 2 range between 29% to 50% which is lesser than in case 1.

As figure 4.2 shows temperature and humidity data for the three locations during April, Polonnaruwa shows a median temperature of approximately 31.8°C with some variability, indicated by an interquartile range (IQR) of around 30.6°C to 32.5°C, and outliers reaching up to 32.5°C. Management Faculty has a slightly higher median temperature of about 31.9°C, with an IQR from 29.2°C to 33.7°C, and outliers up to 33.7°C, indicating greater variability. Milk Bar displays a median temperature of around 32.4°C, with an IQR from 27.9°C to 33.2°C, and fewer outliers. Regarding humidity, Polonnaruwa has a median of 52% with an IQR of 40% to 65%, and outliers reaching up to 65%. The Management Faculty shows a median humidity of 51% with an IQR from 26% to 60%, indicating higher variability and outliers up to 60%. Milk Bar's median humidity is around 53%, with an IQR from 38% to 60%, and outliers up to 61%. These observations highlight the slight variations in temperature and humidity across different locations, with Management Faculty being the place with the highest variability.



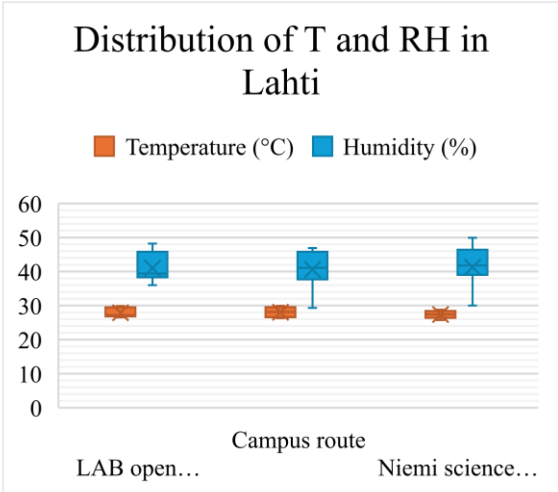


Figure 4.2: Distribution of temperature and relative humidity in case 1 and case 2

Source: Author's field survey_April – June 2024

From the temperature and humidity boxplots for the case 2 three locations, the LAB open courtyard shows a median temperature of approximately 28°C with some variability, as indicated by an interquartile range (IQR) of around 26.8°C to 29.9°C, and outliers reaching up to 29.9°C. Campus route has a slightly higher median temperature of about 29°C, with an IQR from 26.6°C to 29.9°C, and outliers up to 29.9°C, indicating greater variability. Niemi science park displays a median temperature similar to LAB open courtyard, around 27°C, with an IQR from 26.4°C to 28.8°C, and fewer outliers. Regarding humidity, LAB open courtyard has a median of 39% with an IQR of 36% to 46%, and outliers reaching up to 48%.

Campus route shows a median humidity of 38% with an IQR from 29% to 46%, indicating higher variability and outliers up to 47%. Niemi science park's median humidity is around 39%, with an IQR from 30% to 46%, and outliers up to 50%. These observations also highlight the slight variations in temperature and humidity across different locations, with Campus route exhibiting the highest variability.

Weather Station Data Analysis - Trends of last five years

This combo chart displays the Simplified Thermal Heat Index (STHI), average temperature, and relative humidity at the University of Peradeniya over the past five years from 2019 to 2023 and the values are taken for the peak hours during exact same dates when the 2024 field work was done.

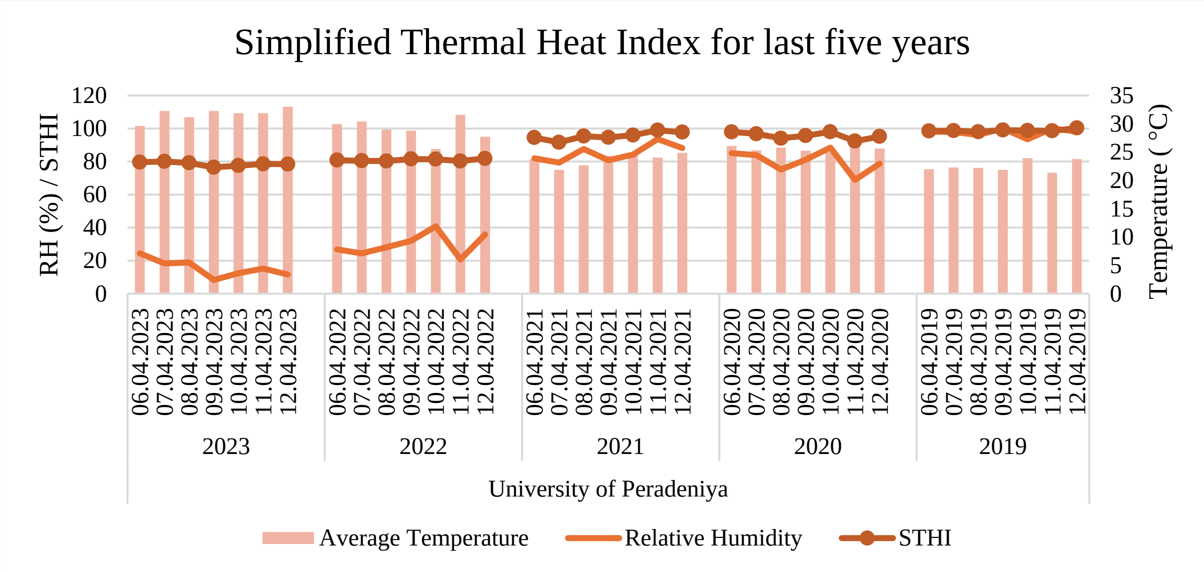


Figure 4.3: STHI over last five years – Case 1

Source: Department of Geography, University of Peradeniya watchdog weather station

The average temperature shows consistency across the years yet showing an increasing trend. Relative humidity has recorded daily fluctuations. For instance, 2023 shows lower relative humidity values (8% to 24%). In contrast 2019 shows very high relative humidity values (93% to 100%). The STHI, represented by the line with markers closely follows the trends in temperature and humidity, indicating that these factors directly influence the heat index. It is clear when humidity levels increased (2021, 2020 and 2019), STHI increment is noticeable, unlike the temperature increments with low level humidity in 2022 and 2023.

Figure 4.4 presents the Simplified Thermal Heat Index (STHI), average temperature, and relative humidity for Lahti over the past five years, from 2019 to 2023. The average temperature, depicted by the bar graph, shows seasonal fluctuations over the years, with temperatures generally ranging from around 5°C to 20°C.

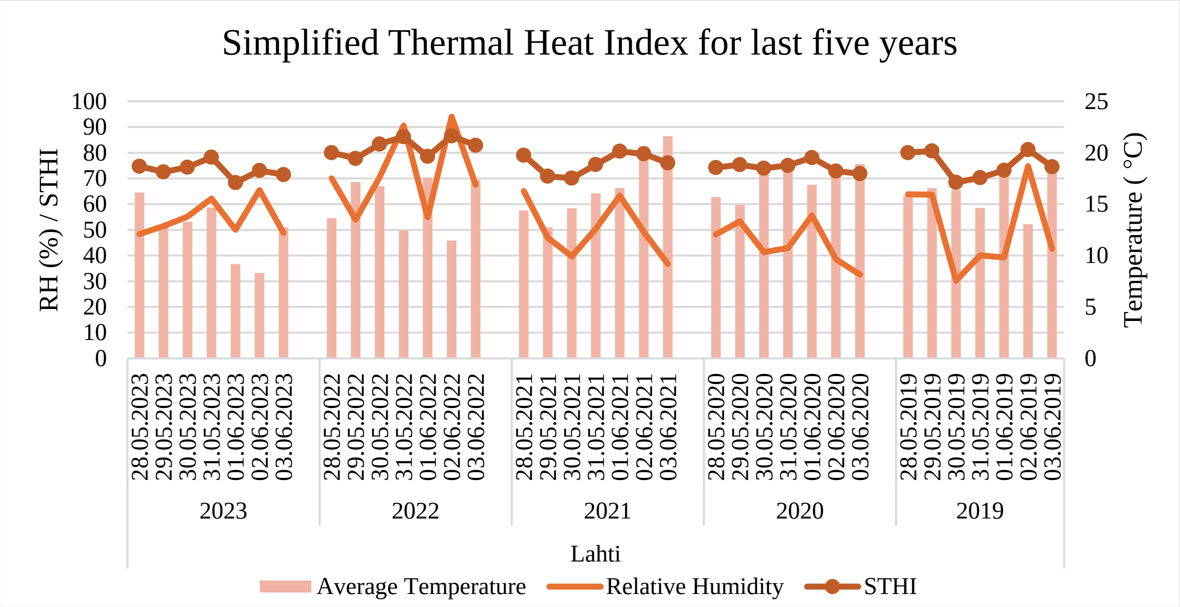


Figure 4.4: STHI over last five years – Case 2

Source: Weather sensor near Lahti Sibelius Hall by Soumi, 2019-2023

There are noticeable peaks in temperature around mid-year (late May to early June), indicating the transition to warmer months. Relative humidity, represented by the smooth line graph, shows variations in a range of 30% - 90% with some peaks and troughs. The STHI, shown by the line with markers, aligns closely with the relative humidity. This index fluctuates between 60 and 90, suggesting that both temperature and humidity influence the perceived thermal comfort. Peaks in temperature are accompanied by slight dips in relative humidity, suggesting an inverse relationship, but overall, both variables contribute to a stable thermal heat index.

Future predictions made on the above figures anticipate the University of Peradeniya likely to remain stable with minor fluctuations unless influenced by significant climate change factors. Relative Humidity is expected to remain high, maintaining the current range due to the region's tropical climate. STHI can remain stable due to the consistent temperature and humidity levels with minor variations. Lahti's seasonal variations in temperature will continue, with peaks in temperature likely during late spring to early summer. Relative Humidity fluctuations between

30% and 90% will likely continue, with some seasonal variation. Accordingly, STHI will continue to fluctuate in line with RH and temperature changes, with noticeable peaks and troughs reflecting seasonal changes.

In the long term, there could be a gradual increase in average temperatures in Peradeniya along with the global temperature rise. High humidity might persist, potentially leading to higher STHI values if temperatures increase significantly. Warming trends due to climate change could lead to higher average temperatures and potentially more extreme seasonal variations in Lahti. RH levels might decrease slightly if temperatures rise significantly, but STHI could still increase due to higher temperatures.

Overall, both locations could experience higher STHI values in the future if global warming trends continue, but the relative stability or variability in each region's temperature and humidity patterns will dictate the extent and nature of these changes. For the case 1, the region itself is prone to higher heat stress due to consistently high temperatures (Eggeling *et al.*, 2024). Hence, adaptation strategies such as improved shading and cooling systems will be crucial. For the Finnish case, increased temperature variability and humidity fluctuations might lead to more extreme weather events. Infrastructure improvements and adaptive measures will be necessary to cope with these changes.

4.3. Analysis of Subjective Thermal Comfort Perceptions

4.3.1. Survey Data Analysis

The survey respondents consisted of students from two universities: the University of Peradeniya in Sri Lanka and LAB University of Applied Sciences in Lahti, Finland.

Survey respondent demographics

The demographics covered physiological parameters, gender, ethnicity, and residential area to understand the context. In both cases, students were within the 20 – 30 age limit covering both undergraduate and postgraduate studies. Their height and weight were in the average range of within 150 – 170 cm for height and 50 – 65 kg in weight.

In the case of Peradeniya, Sri Lanka, majority of the respondents were Sinhalese females and over half of the study sample were originally from Kandy, where the university is located. Yet, the students' sample were diverse which ensured different perceptions.

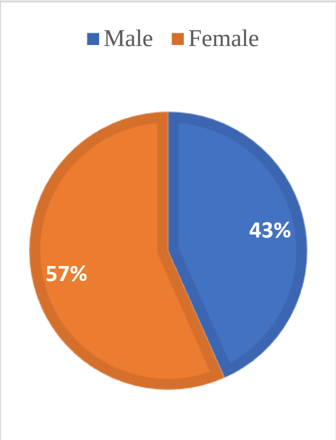


Figure 4.7: Gender distribution – Case 01

Source: Author's field survey – April 2024

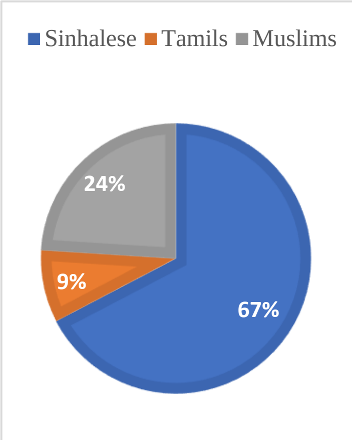


Figure 4.6: Ethnic Distribution – Case 01

Source: Author's field survey – April 2024

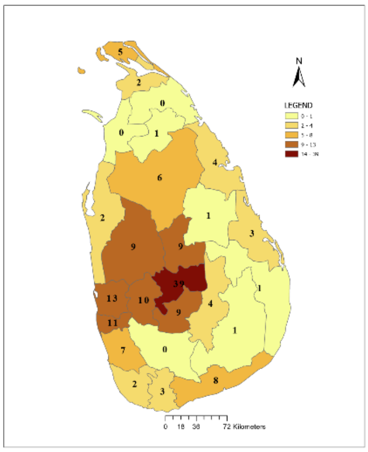


Figure 4.5: Residential districts – Case 01

Source: Author's field survey – April 2024

Like Peradeniya, Lahti, Finland also represented majority female respondents without any ethnic diversity. Students represented different cities, but the majority were from Lahti itself.

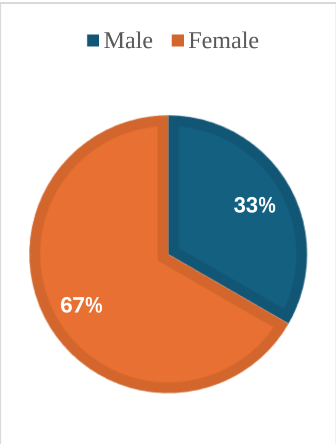


Figure 4.8: Gender Distribution – Case 02

Source: Author's field survey - May - June 2024

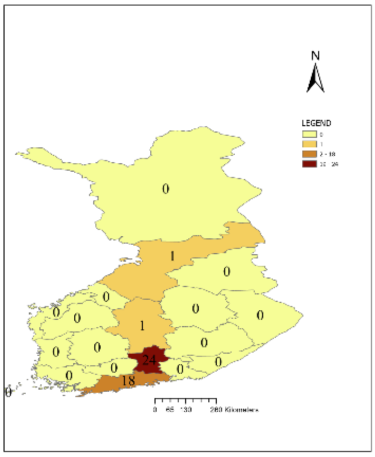
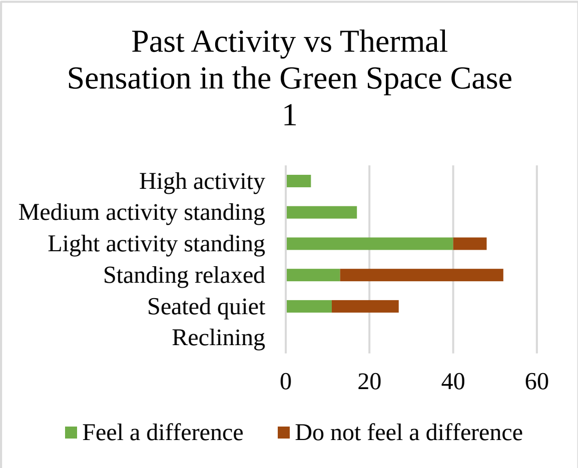


Figure 4.9: Residential Regions – Case 02

Source: Author's field survey – May - June 2024

Statistical analysis of survey responses

The second section of the survey questionnaire examined the thermal history (an individual's recent exposure to different thermal conditions leading up to the moment when they are asked to evaluate their comfort) and past activity (physical exertion or level of activity a person has engaged in prior to being surveyed about their comfort) of respondents, and their overall impression whether to feel a difference after staying longer (at least 10 mins.) in the green space. As illustrated in figure number 4.10, most of the students in the University of Peradeniya recorded less intense past activity and still felt a difference after staying in the green spaces.



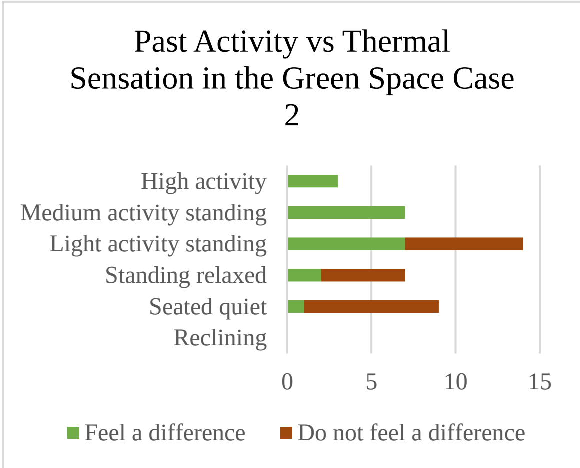


Figure 4.10: Past Activity and green space sensation in case 1 and case 2

Source: Author's field survey_April - June 2024

In the case of Lahti, past activity of students was less intense but their sensation on green spaces was negative as majority did not feel a difference between the green space and other outdoor places.

Correlation between thermal history and past activity

According to the correlation matrix analysis in the table 4.2 for the case 1 in Peradeniya, Thermal History Value and Thermal Comfort is strong, indicating that students' thermal history has a noticeable impact on their perceived thermal comfort. The correlation between Past Activity and Thermal Comfort is strong, indicating that the activities students were involved in directly prior to assessing their thermal comfort have a significant impact on their thermal comfort perception. The correlation between Thermal History Value and Past Activity is very weak, suggesting that these two factors are not strongly related. These results highlight the importance of considering both past activity and recent thermal history when evaluating students' thermal comfort in green spaces. This insight will be considered to guide the management and design of such spaces to enhance thermal comfort for students.

Table 4.2: Correlation matrix for thermal history, past activity and thermal comfort - Case 1

	Thermal History	Past Activity	Thermal Comfort
Thermal History	1		
Past Activity	0.068937	1	
Thermal Comfort	0.586407	0.695433	1

Source: Author's field survey_April 2024

With reference to the second case in Lahti referring table 4.3, all the correlation coefficients are close to zero, indicating very weak correlations between the variables. The negative correlations between Thermal History Value and Thermal Comfort, and between Past Activity and Thermal Comfort, suggest a slight tendency for increased Thermal History Value and Past Activity to be associated with lower Thermal Comfort. The very weak positive correlation between Thermal History Value and Past Activity suggests a negligible association between these two variables. These weak correlations imply that there may be other factors influencing Thermal Comfort that are not captured by Thermal History Value and Past Activity. Further analysis with environmental variables might provide more insights into the factors affecting thermal comfort in Lahti.

Table 4.3: Correlation matrix for thermal history, past activity and thermal comfort - Case 2

	Thermal History	Past Activity	Thermal Comfort
Thermal History	1		
Past Activity	0.031505	1	
Thermal Comfort	-0.117590	-0.090010	1

Source: Author's field survey_May - June 2024

Comparison of subjective thermal comfort perceptions between the two universities

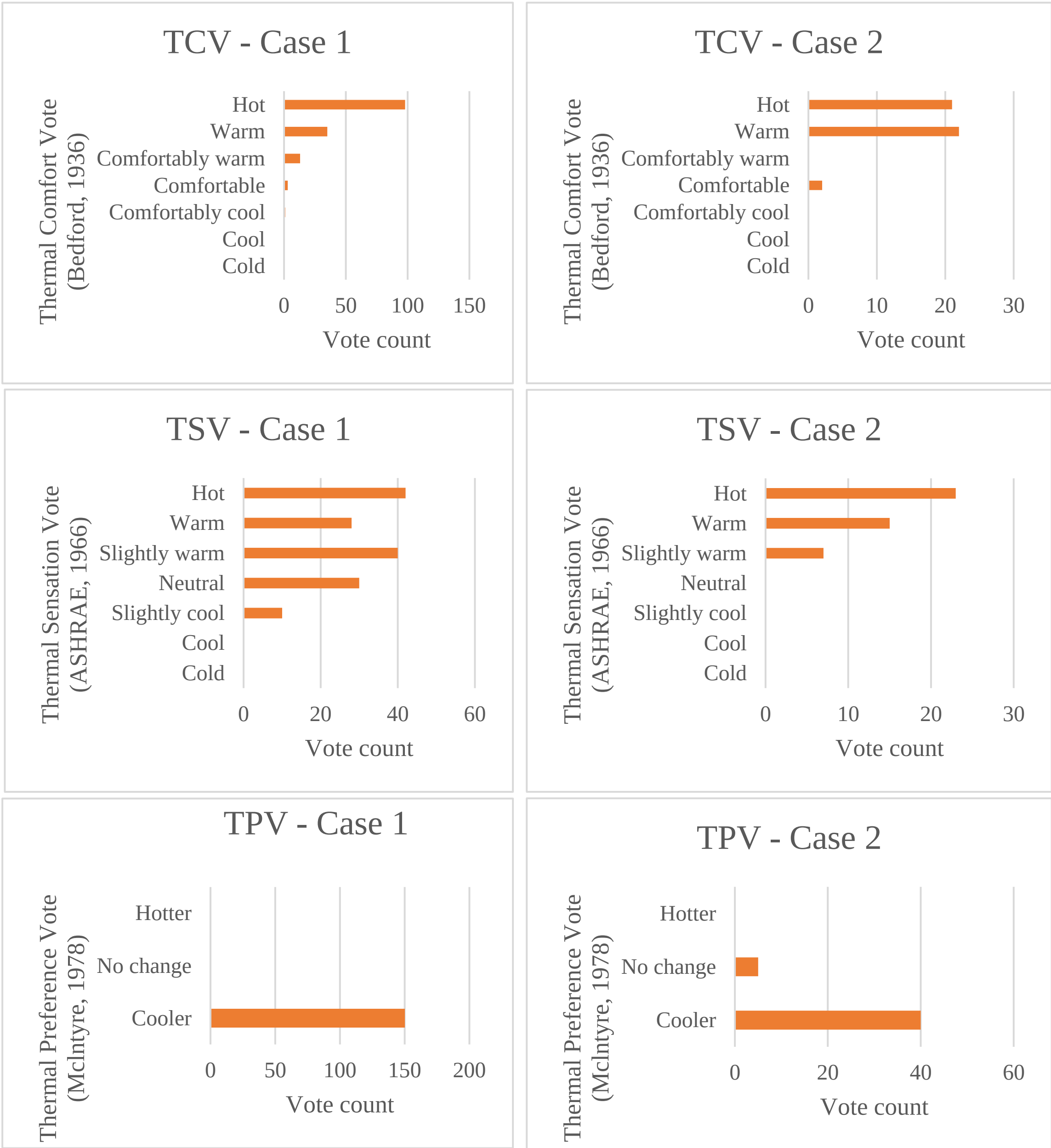


Figure 4.11: Case 1 and Case 2 TCV, TSV and TPV analysis

Source: Author's field survey_April - June 2024

The charts in figure 4.11 display the results of thermal comfort perception based on three different metrics: Thermal Comfort Vote (TCV), Thermal Sensation Vote (TSV), and Thermal Preference Vote (TPV) for case 1 in Peradeniya, and case 2 in Lahti. In both cases, most students report feeling hot and warm indicating that the thermal conditions are above acceptable level. Case 2 has a slightly higher percentage of students feeling hot and warm suggesting that the students' perception is more inclined towards feeling hot irrespective of thermal conditions.

In terms of thermal sensation, case 1 shows diverse perceptions ranging from slightly cooler to majority voting for hot conditions depending on the green space qualities, on site thermal conditions and their physiological characteristics, whereas case two shows slightly warm to hot perceptions depending on the same factors in effect.

With reference to thermal preference votes, most students in both cases prefer it "Cooler," indicating that the current thermal conditions are perceived as too warm. The preference for "No change" is higher in Case 2 compared to Case 1, suggesting a slightly better acceptance of the thermal conditions in Case 2.

Most students in both cases prefer cooler conditions, indicating a general perception of warmth. TCV and TSV results align with TPV results, reinforcing the observation that the environment is perceived as warm. Case 1 shows a more balanced perception of comfort but still leans towards warmth. Case 2 has a higher perception of warmth with a significant number of students feeling "Hot" or "Warm."

The data indicates that students generally perceive the thermal environment as warm albeit of having green spaces in their academic premises and prefer cooler conditions. The results suggest that adjustments to reduce the temperature might improve overall comfort. The consistent findings across TCV, TSV, and TPV validate the reliability of the thermal comfort assessment. It’s noteworthy that this analysis is a generalization for both cases as the votes are location specific and sample biased which proves the complexity of analysing OTC perceptions.

This finding can be backed up by recent research in the field of outdoor thermal comfort studies. Research which investigated the impact of sunlight perception on outdoor thermal comfort among university students in cold regions found that as sunlight perception increased, a higher proportion of students reported feeling hot (Ning, Jing & Ge, 2023). Another study focused on the thermal responses of students in a cold climate, revealing that students adapt their expectations and comfort levels based on their climatic backgrounds. This adaptation influences their thermal preferences, suggesting that students from colder regions might have different comfort thresholds compared to those from warmer climates (Disci, Lawrence & Sharples, 2024).

4.4. Thematic Analysis of Qualitative Data

4.4.1. Comparison of themes between the two university settings

Case 01 – University of Peradeniya, Sri Lanka

Matrix coding query results of face-to-face direct interviews done with students revealed insights under 8 thematic categories according to the 8 subsections of the interview design. As indicated in figure 4.12, General Impressions and Accessibility and Connectivity appear frequently across most interviews, highlighting these as common themes of interest or concern in the case of AGS in University of Peradeniya, Sri Lanka. Students tend to value easy access to academic green spaces when necessary and express their emotional bond and utility value of these places in their daily interactions. Some themes like Water Features and Cooling Elements appear selectively, suggesting that these are specific to certain locations or contexts.

This highlights the importance of delving deeper into contextual nuances in better understanding the OTC context in each AGS. Less common but significant themes like Water Features and Cooling Elements need in detail assessment for targeted improvements or interventions.

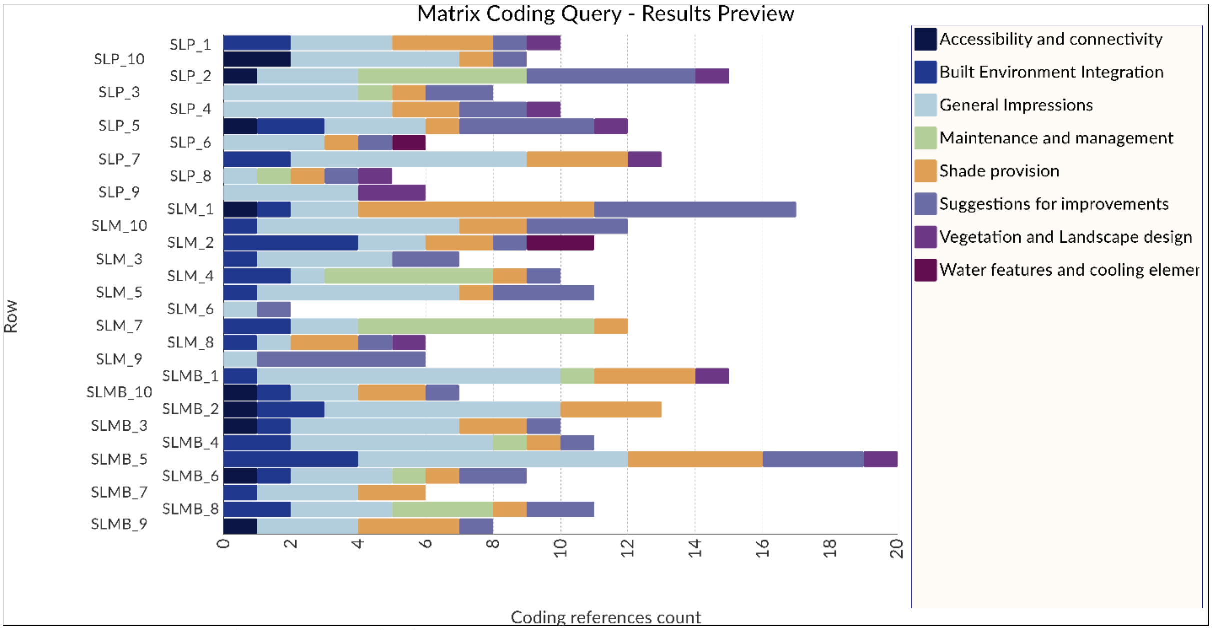


Figure 4.12: Matrix coding query results for 30 interviews in Case – 1

Source: Author's field interviews_April 2024

AGS Location 01 – Polonnaruwa area

Figure 4.13: Site photographs of AGS 01 - Case 01

Source: Author's field work – April 2024

Natural Environment Elements:

According to preliminary observations, this AGS location has an **extensive tree canopy** which provides substantial shade, reducing direct solar radiation and thereby lowering ambient temperatures beneath the trees minimizing heat absorption by the ground and surrounding surfaces, contributing to cooler microclimates. Presence of grass and other ground-level **vegetation** helps in cooling through evapotranspiration. This process releases moisture into the air, which can reduce the ambient temperature. Vegetation also absorbs less heat compared to paved surfaces, further contributing to a cooler environment. The open arrangement of trees and the presence of gaps between them facilitate **natural airflow**, which helps in dissipating heat and improving thermal comfort.

Built Environment Elements:

Surrounding **buildings are strategically placed** to potentially block harsh winds while allowing breezes to pass through the green space. Their placement also creates shaded areas depending on the time of day, contributing to varying levels of comfort within the space. The clear, **unpaved pathways** help in reducing heat retention compared to concrete or asphalt pathways, thus maintaining lower temperatures. Open spaces between the trees and buildings allow for recreational activities and social gatherings in a comfortable environment.

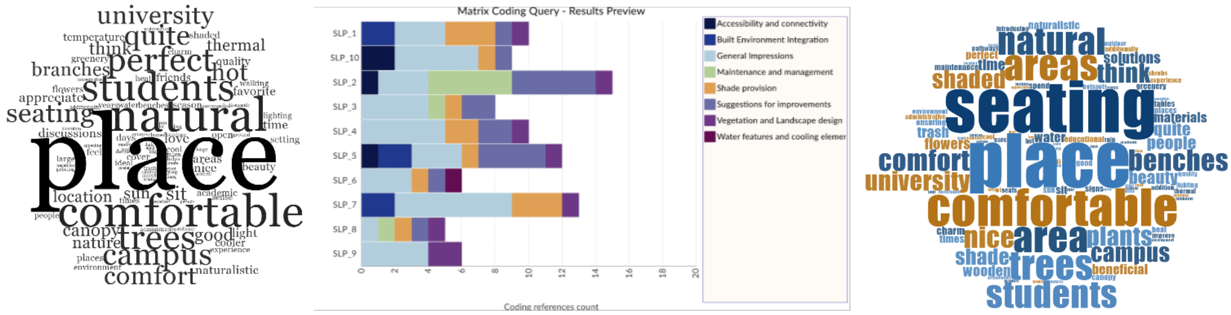


Figure 4.14: impressions, frequency of themes and suggestions for improving AGS 01 - Case 01

Source: NVivo thematic coding analysis

As in the figure 4.14 above, the word cloud indicating the general impressions of students regarding the ‘Polonnaruwa area’ revolve around its place(making) value. Many students have identified it as a comfortable place in the middle of the faculty of arts due to its natural landscaping, abundance of trees and flowering veins, quietness and tranquillity. With reference to the matrix query, many of the student responses come under the theme of general impressions with a lot of suggestions to improvements as depicted in the second word cloud. Suggestions include increasing vegetation density and diversity, enhance seating arrangements, adding more cooling elements, more waste disposal facilities and providing Wi-Fi hotspot facilities to enhance the utilization of the space for more academic engagements.

<u>AGS Location 02 – Management Faculty seating area</u>

Figure 4.15: Site photographs of AGS 02 - Case 01

Source: Author’s field work – April 2024

Natural Environment Elements:

The **large tree canopy** provides substantial shade, which significantly reduces direct solar radiation and helps to lower temperatures in the shaded areas. Shaded areas beneath the tree canopy offer a cooler microclimate, making the space more comfortable for students to sit and engage in activities. The **presence of grass and surrounding greenery** contributes to cooling through evapotranspiration, where plants release moisture into the air, thereby reducing ambient temperatures. The green landscape absorbs less heat compared to paved surfaces, maintaining a cooler ground temperature. The open design allows for **natural air circulation**, which helps dissipate heat and improve thermal comfort. The spacing between trees and other vegetation facilitates airflow, creating a cooling effect through natural breezes.

Built Environment Elements:

The **concrete** tables and stools provide functional outdoor seating. Their placement under the tree canopy ensures they remain in the shade for most of the day, keeping the surfaces cooler. The materials used for seating, although concrete, are mostly positioned in shaded areas to avoid excessive heat buildup. The **layout of the seating arrangements** in clusters allows for social interactions and group activities while benefiting from the shade provided by the trees. The distribution of seating ensures that users can find comfortable spots throughout the day, depending on their thermal comfort preferences.

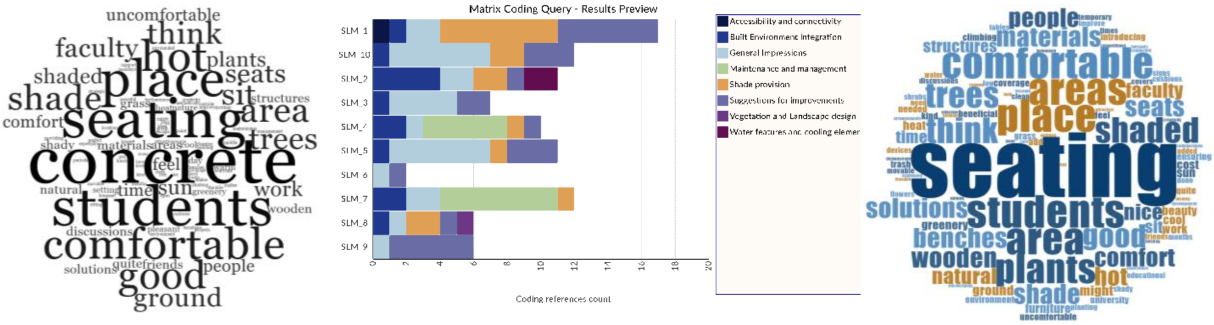


Figure 4.16: General impressions, frequency of themes and suggestions for improving AGS 01 - Case 01

Source: NVivo thematic coding analysis

Figure 4.16 clearly illustrates that most of the students were not happy about concrete seating in their general impressions, while acknowledging the opportunity to blend with nature during their academic discussions. Students appreciated the existing shade provision even though they were not happy with their maintenance, especially after the weekend where outsiders come and dine in this green space. Interviews around this green space covered almost all the thematic areas and a lot of suggestions were offered by students as depicted in the second word cloud. Main suggestions included installing additional shade structures through students led designs and sustainable materials, replacing concrete seating to more durable wooden furniture or adding back support to existing seating, using lighter-coloured, reflective materials for seating and pathways and incorporating variety of planting.

Location 03 – Milk Bar Shaded Tree

Figure 4.17: Site photographs of AGS 03 - Case 01

Source: Author's field work – April 2024

Natural Environment Elements:

The **extensive and dense canopy** of the large tree provides significant shade, reducing direct solar radiation and thereby lowering the ambient temperature. The branches spread widely, creating a large, shaded area where students can comfortably gather, sit, and interact. The presence of leaf litter on the ground helps to insulate the soil, reducing heat absorption and promoting cooler ground temperatures. The **natural ground cover** also prevents the reflection of heat back into the environment, maintaining a cooler microclimate.

Built Environment Elements:

The **design of pathways and open spaces** around the tree allows for free movement of air, enhancing natural ventilation and promoting thermal comfort. The positioning of open spaces in relation to the shaded areas ensures that users can move between sun and shade as needed for comfort. Proximity to the main road covered in tar and the milk bar constructed in concrete and its concrete seating contributes to increased temperatures.

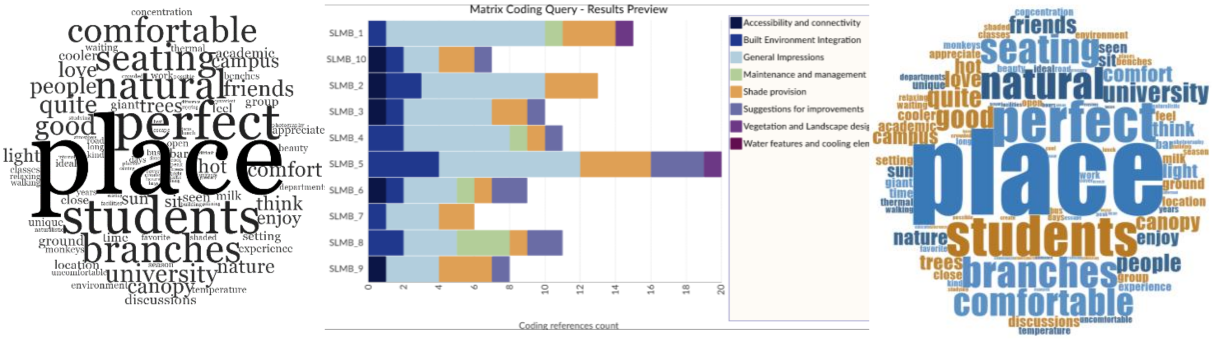


Figure 4.18: General impressions, frequency of themes and suggestions for improving AGS 03 - Case 01

Source: NVivo thematic coding analysis

All three locations in the Sri Lankan case contained ‘place’ values as demonstrated by the word clouds of students’ general impressions. Students commented on the natural setup of this giant tree and its branches being the seating arrangement itself. They appreciated the canopy cover and the shade provision, especially during peak hours as an escape from heat. A lot of students had personal memories attached to this place, for instance they wait for their friends, revise before exams, enjoy an ice cream and have society meetings under the shade of this tree. It is noteworthy that many students did not want to suggest any alterations to the existing design of this green space as proved by the matrix query and shade provision was mostly mentioned by students. Those who made suggestions stated the importance of having proper seating options and some solutions for monkey invasions while students are snacking in this place.

Responses like ‘I'm not even asking for strict seating facilities because this is a naturalistic area’, ‘Any alterations or modifications to this place would be felt by students because it's central to our academic, extracurricular, and social lives’, ‘I don't think any initiatives are needed that would alter or destroy the scenic beauty of the university’, ‘I don't think any student would want to change or modify any aspect of this location’, ‘I'm not asking for seating because I understand there's no way to place it’ strongly advocate for students’ aversion to modify this unique green space.

Case 02 – LAB University of Applied Sciences, Finland

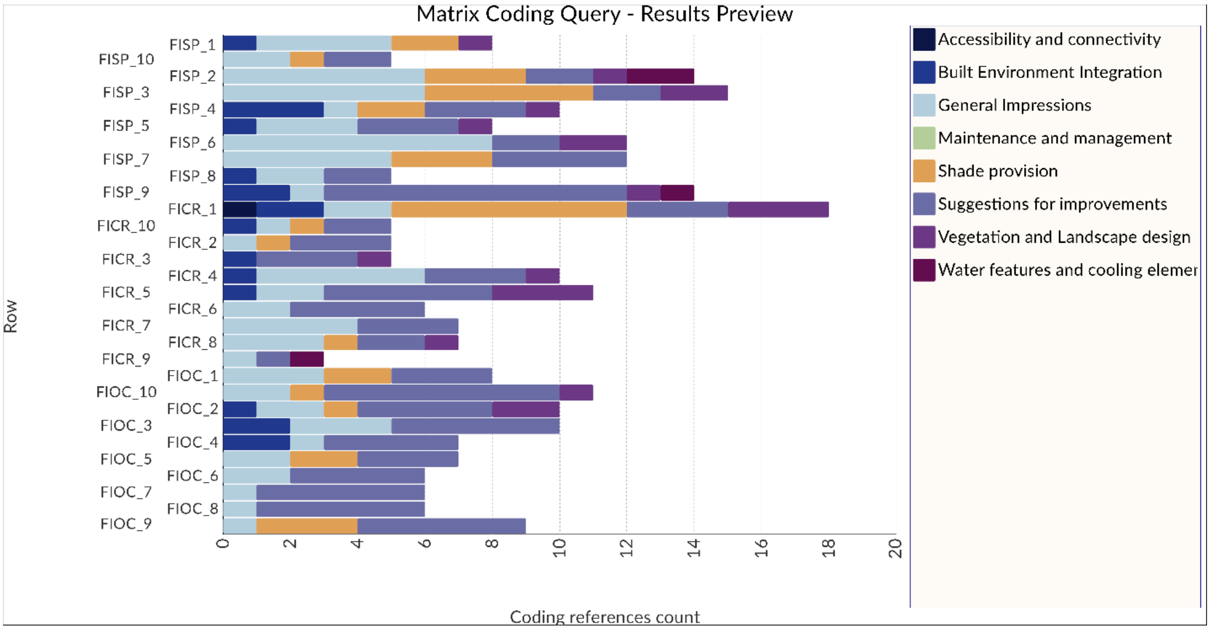


Figure 4.19: Matrix coding query results for 30 interviews in Case – 2

Source: Author's field survey – May - June 2024

As demonstrated in matrix query (figure 4.19), the interviews with Finnish students resulted with a lot of suggestions to improve the outdoor thermal comfort of the selected green spaces. Students provided suggestions while stressing inadequate shading in the green spaces.

<u>Location 01 – Open courtyard</u>

Figure 4.20: Site photographs of AGS 01 - Case 02

Source: Author's field work _May - June 2024

Natural Environment Elements:

The **grassy area and flowering plants** visible in the foreground help in reducing ground temperatures through the process of evapotranspiration. This natural cooling mechanism lowers the ambient temperature in the immediate vicinity, contributing to thermal comfort.

The use of **natural ground cover** instead of concrete or asphalt reduces heat absorption and radiation, helping to maintain a cooler environment.

Built Environment Elements:

The **building's design**, with its glass facades and reflective materials, can help in reducing heat gain. Proper insulation and reflective surfaces contribute to a cooler surrounding environment. The outdoor dining area is shaded by the building shadow. This reduces direct exposure to sunlight, lowering the temperature and creating a more comfortable dining and sitting space. The **partially covered walkways** around the green space offer protection from direct sunlight, enhancing thermal comfort for those walking or sitting nearby.

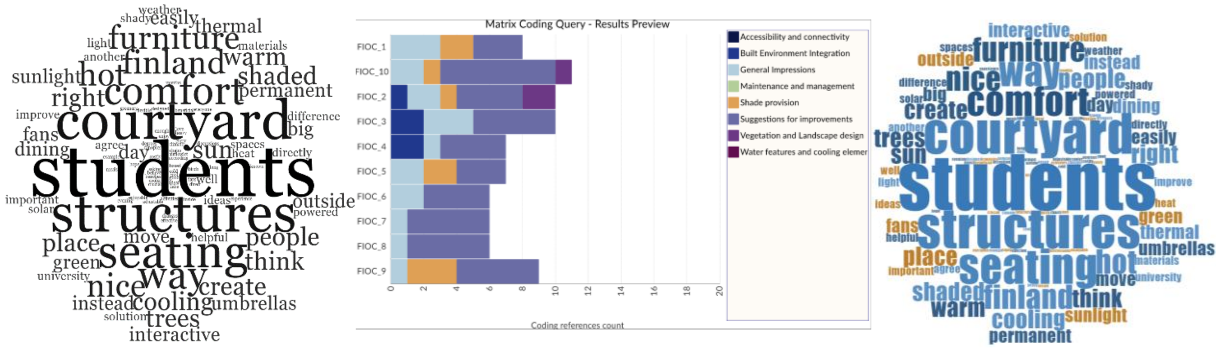


Figure 4.21: Matrix coding query results for 30 interviews in Case – 2

Source: NVivo thematic coding analysis

As denoted above, student respondents provided their general impressions on the courtyard premises with mixed feelings. Many of them were excited to dine outside and appreciated the available seating facilities but they implied the importance of having shading structures, which was one of the many suggestions they made as illustrated in the second word cloud. Their frequent suggestions include having overhead umbrellas or pergolas for shelter, having mobile and lightweight furniture and shading structures, solar powered fans and misting systems in place and creating both shaded and exposed areas in the courtyard to create more inclusive spaces for diverse student needs.

Location 02 – Campus route

Figure 4.22: Site photographs of AGS 02 - Case 02

Source: Author's field work_May - Junel 2024

Natural Environment Elements:

The presence of **trees and shrubs** along the pathway provides shade, reducing direct solar exposure and lowering ambient temperatures in the immediate area. The **ground cover** and wildflowers contribute to cooling through evapotranspiration. This process helps to reduce ground temperatures and cool the air around the pathway. The use of **natural landscaping** with various plant species adds to the aesthetic appeal and psychological comfort, making the space more inviting and relaxing.

Built Environment Elements:

The **paved pathway** ensures a clean and comfortable walking surface, encouraging usage and providing accessibility while being flanked by natural elements for shade and cooling. The presence of **streetlamps** along the pathway enhances safety and usability during evening hours without significantly impacting thermal comfort during the day. The **proximity of the pathway to the building** offers a transitional space that can be used for both leisure and as a corridor between indoor and outdoor environments.

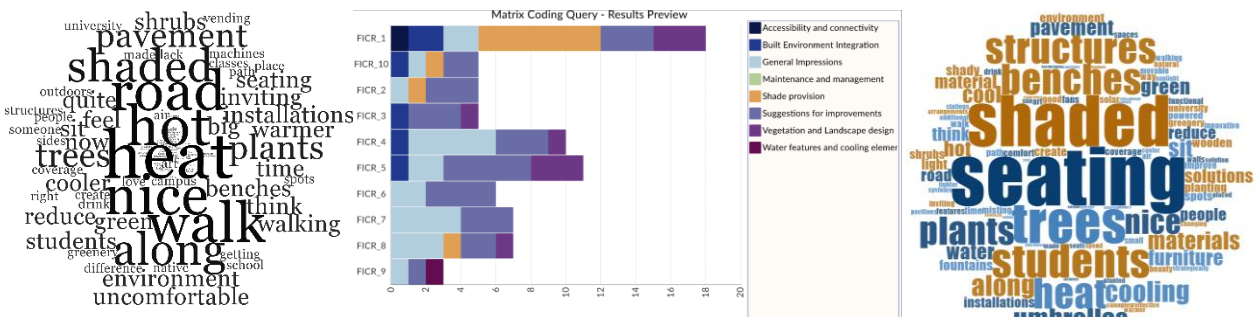


Figure 4.23: Matrix coding query results for 30 interviews in Case – 2

Source: NVivo thematic coding analysis

The students' general impressions of this green space seemed to be quite critical as most of them considered it not comfortable because of no shade provision to escape the heat. Students pinpointed the road being asphalt and having no coverage from trees as main reasons for this. Many of their suggestions to improve thermal comfort included shade provision and making the place more inviting. Students stated the available seating options are rarely in use because of inadequate shade. Respondents' suggestions include planting more trees and diverse species along the road to enhance natural shading, experiment with green walls or trellises in the nearby student accommodation building, inviting students or KOE (student association) to come up their own innovative strategies/ structures for shade provision, creating permeable pavements, and creative placemaking.

Location 03 – Niemi science park




Figure 4.24: Site photographs of AGS 02 - Case 02

Source: Author's field work_May - June 2024

Natural Environment Elements:

The **mature trees with wide canopies** provide shade, reducing direct solar radiation and lowering the temperature in the shaded areas. The canopy cover is dense enough to create substantial shaded areas on the grass, which enhances comfort by lowering the heat experienced by individuals in space. The **grassy ground cover** helps to cool the area by absorbing less heat compared to concrete or asphalt surfaces. The grass also facilitates evapotranspiration, which has a cooling effect on the surrounding air. The **density and arrangement of the trees** contribute to a cooling microclimate by promoting air circulation and natural cooling processes.

Built Environment Elements:

Pathways are designed to meander through the shaded areas, ensuring that users can move comfortably through the space without being exposed to direct sunlight for extended periods. The placement of pathways helps to integrate the movement within the shaded zones provided by the tree canopies. These **seating areas** are designed to blend with the natural environment, providing users with a place to relax while looking through greenery. The **parking area** is positioned adjacent to the green space, and is partially shaded by the building shadow, which helps to keep vehicles cooler and reduces the heat island effect.

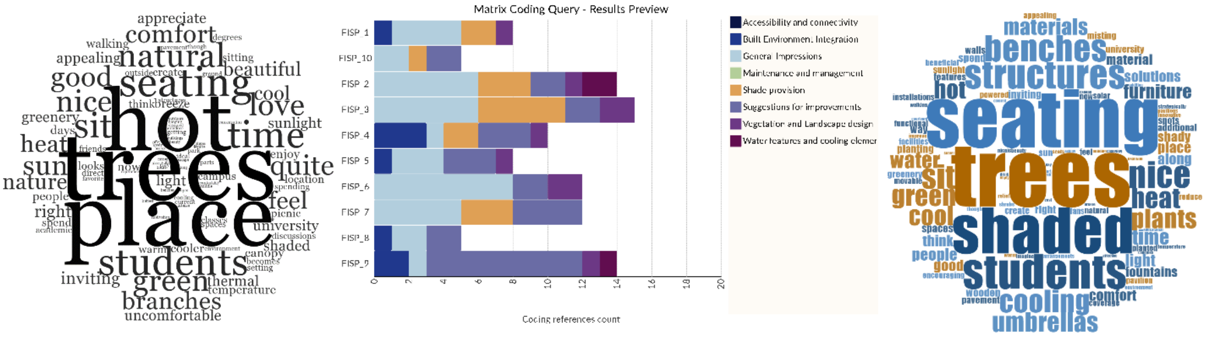


Figure 4.25: Matrix coding query results for 30 interviews in Case – 2

Source: NVivo thematic coding analysis

With reference to figure 4.25, interviewees frequently identified this green space as a hot place with trees according to the word cloud of their general impressions. Even though students greatly appreciated the green scenic value of the space and the shade it has been providing with, a lot of mentions denoted by the matrix coding query results suggested adding more cooling elements and shade structures. Suggestions to improve the thermal comfortability as shown by the second word cloud includes shade structures like pergolas or gazebos, comfortable seating and outdoor working space, cooling features like misting systems and interactive elements to make the place more inviting.

4.4.2. Observational differences in clothing and accessories choices

There are several possible reasons why Sri Lankan university students might not commonly wear sunscreen (SPF 50), sunhats, sunglasses, or use umbrellas during peak temperatures in April whereas Finnish students get dressed more weather appropriately as it was observed during the field survey. Over the phone interviews with selected undergraduate students at the university of Peradeniya resulted in reasons which were rooted in cultural, social, behavioural, and practical factors.

Cultural and Social Norms

- **Cultural Habits**

In many tropical cultures, including Sri Lanka, people are accustomed to high levels of sun exposure from an early age and do not perceive the need for extensive sun protection as strongly as in other regions.

There is a cultural preference for natural methods of dealing with heat, such as seeking shade or wearing loose fitted, light-coloured clothing.

- **Social Influence**

Social norms and peer behaviour usually influence personal habits. If most students do not use sun protection, individuals may be less likely to adopt these measures due to a desire to fit in, which is common in university sub-culture.

Sunhats, sunglasses, and umbrellas may be seen as unnecessary or attention grabbing among peers, influencing students to avoid using them.

Practical Considerations

- **Accessibility and Cost**

High-quality sun protection products like SPF 50 sunscreen, polarized sunglasses, and sturdy sunhats can be expensive and may not be affordable for all students.

The availability of these products in local markets may also be limited or less varied compared to other countries.

- **Convenience and Habit**

Applying sunscreen regularly can be seen as inconvenient or time-consuming. Students may prefer quicker methods of sun protection, such as finding shade.

Carrying an umbrella or wearing a sunhat might be viewed as cumbersome, especially if students have to carry a lot of books, bags, or other items.

Awareness and Education

- **Awareness of Sun Protection**

There may be a lack of awareness about the long-term health benefits of sun protection, including the prevention of skin cancer and premature aging.

Educational campaigns about the importance of sun protection may not be as prevalent or emphasized as in other countries with high UV exposure.

- **Perception of Risk**

Students seem to underestimate the risks associated with UV exposure, especially if they have not experienced sunburns or other immediate effects.

There is a belief that darker skin tones are less susceptible to the harmful effects of UV radiation, although this is a misconception as all skin types can suffer damage from prolonged sun exposure.

Environmental and Behavioural Factors

- **Natural Adaptations**

Many green spaces and campus areas in Sri Lanka are designed with abundant trees and shaded areas, reducing the immediate need for personal sun protection.

Students may naturally seek out shaded areas during peak sun hours, minimizing their direct exposure to the sun.

- **Behavioural Adaptation**

Over time, individuals can develop behavioural adaptations to cope with the heat, such as staying indoors during peak hours, hydrating regularly, and wearing loose, breathable clothing. These adaptive behaviours might reduce the perceived need for additional sun protection measures.

4.4.3. Attitudinal Differences and Cultural Perceptions of Thermal Comfort

Finnish students generally appreciate warm temperatures, which is a welcome change from the typically cold climate they experience for much of the year. However, despite their appreciation for warmth, Finnish students exhibit lower thermal tolerance. This is likely due to their bodies being acclimatized to cooler conditions, making them more sensitive to heat. Consequently, Finnish students are meticulous about their clothing choices, opting for materials like cotton and linen that enhance comfort by being breathable and moisture-wicking. The appreciation for warm temperatures is deeply embedded in Finnish culture, particularly during the summer months when long daylight hours and sunny weather are highly valued. This period is marked by a surge in outdoor activities such as picnics, barbecues, swimming in lakes, hiking, and attending outdoor festivals. These activities are not only a way to enjoy the pleasant weather but also a cultural expression that highlights the importance of warmth and sunshine in Finnish society.

Conversely, **Sri Lankan students, living in a tropical climate, exhibit higher thermal tolerance but prefer shaded environments**. The constant exposure to high temperatures and humidity has conditioned Sri Lankans to endure heat better than their Finnish counterparts. However, despite their tolerance, the preference for shade indicates a desire to mitigate the discomfort caused by prolonged sun exposure. In terms of clothing, Sri Lankans are less concerned about weather-appropriate attire, often wearing what is culturally or personally preferred rather than what is best suited for thermal comfort. This could be attributed to the cultural norms and the relatively constant climate, which reduces the need for seasonal clothing adjustments.

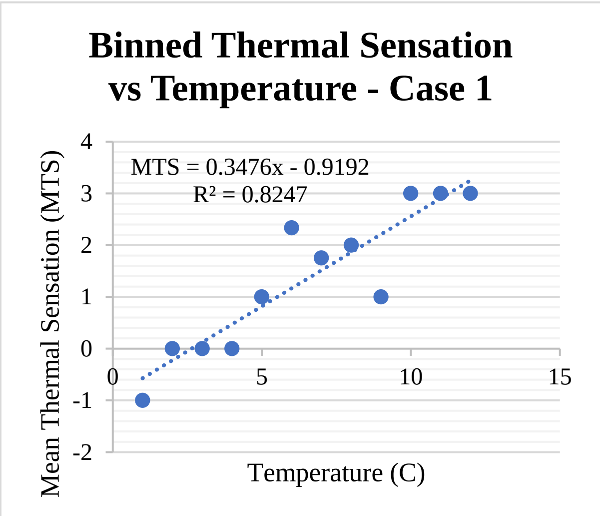
Heat stress poses a significant challenge in Peradeniya, Sri Lanka, due to the combination of high temperatures and humidity. This environmental condition exacerbates discomfort and health risks, making shade, ventilation, and hydration essential for maintaining comfort and well-being. Shaded areas in academic settings become crucial as they provide necessary respite from the intense heat and harmful UV radiation, which are prevalent in tropical climates. In contrast, Lahti, Finland, experiences lower levels of heat stress, as the temperatures rarely reach extremes. Nevertheless, the need for sun exposure is viewed positively in Lahti, providing warmth and enhancing the overall experience of the brief Finnish summer. This cultural difference underscores the varying strategies needed to address thermal comfort in these two distinct environments.

The cultural significance of sun exposure in Finland is evident in the activities that dominate the summer months. The Finnish cultural fabric includes a strong appreciation for the limited period of warm weather, encouraging outdoor social activities that celebrate the sun and warmth. This seasonal behaviour highlights the role of the environment in shaping cultural practices and preferences. On the other hand, the less pronounced seasonality in Sri Lanka means there are fewer cultural activities specifically tied to temperature variations. The preference for shaded areas in Sri Lankan culture reflects a practical adaptation to the climate, focusing on comfort and protection from the intense tropical sun rather than seeking sun exposure for warmth.

4.5. Cross-referencing Objective and Subjective Data

4.5.1. Integration of subjective perceptions with objective measurements

The chart titled "Binned Thermal Sensation vs Temperature " displays two scatter plots with a fitted linear regression line, showcasing the relationship between temperature (in degrees Celsius) and mean thermal sensation (MTS).



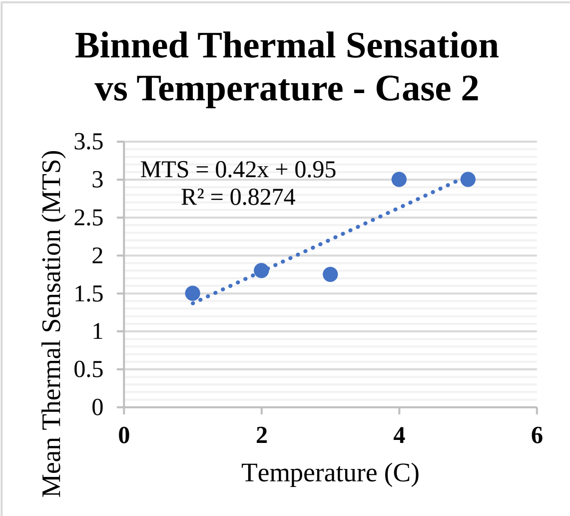


Figure 4.26: Binned thermal sensation vs temperature for case 1 and case 2

Source: Author's field survey_April -May 2024

The positive slope of the regression line in case 1 indicates, as the temperature increases, the mean thermal sensation tends to increase. The high R-squared value suggests that the linear model fits the data well, implying that temperature is a strong predictor of mean thermal sensation in this case. Overall, the chart effectively illustrates the positive correlation between temperature and mean thermal sensation, with a strong linear relationship as indicated by the regression line and high R-squared value.

The second chart for case 2 in figure 4.26 implies a positive slope of the regression line that indicates as the temperature increases, the mean thermal sensation tends to increase. The high R-squared value suggests that the linear model fits the data well, implying that temperature is a strong predictor of mean thermal sensation in this case as well.

In comparison, case 1 has a slope of 0.3476, indicating a smaller increase in MTS per degree Celsius compared to case 2, which has a slope of 0.42. Case 1 has an intercept of -0.9192, meaning the predicted MTS at 0 degrees Celsius is -0.9192, while case 2 has an intercept of 0.95, meaning the predicted MTS at 0 degrees Celsius is 0.95. Both cases have similar R-squared values, with case 1 at 0.8247 and case 2 at 0.8274, indicating a strong linear relationship in both cases. Both cases show a strong positive linear relationship between temperature and mean thermal sensation. However, in case 2, the increase in mean thermal sensation with temperature is more pronounced, and the predicted mean thermal sensation at 0 degrees Celsius is higher compared to case 1.

With reference to the table 4.4 and the calculated OTC indexes, Polonnaruwa area in case 1 Predominantly signifies "Extreme Caution" for HI and "Very Uncomfortable" to "Extremely Uncomfortable" for DI. This indicates significant discomfort and potential heat stress. The Management Faculty seating area similarly shows high discomfort levels with a notable comfortable day on 09.04.2024, with the effect on prevalent winds. Milk Bar shaded tree area consistently shows high discomfort with an "Extreme Caution" for HI, reflecting significant heat stress risks, with a slightly more comfortable day on 12.04.2024.

Table 4.4: Thermal comfort indexes and their interpretation for case 1

AGS Location	Date	Temperature (°C)	Humidity (%)	National Weather Service Heat Index (HI)	Level of Discomfort	Discomfort Index (DI)	Level of Discomfort	Simplified Temperature Humidity Index	Level of Discomfort
Polonnaruwa	06.04.2024	29.5	66	91.3707	Extreme Caution	83.2964	Very Uncomfortable	94.306	Extreme Caution
	07.04.2024	31.1	53	91.8833	Extreme Caution	85.23605	Very Uncomfortable	91.205	Extreme Caution
	08.04.2024	32.2	61	99.7716	Extreme Caution	87.4037	Extremely Uncomfortable	95.204	Extreme Caution
	09.04.2024	32.2	40	90.4294	Extreme Caution	86.4214	Extremely Uncomfortable	87.68	Caution
	10.04.2024	31.9	52	94.3196	Extreme Caution	86.5427	Extremely Uncomfortable	91.798	Extreme Caution
	11.04.2024	30.6	56	91.8870	Extreme Caution	84.6837	Very Uncomfortable	92.13	Extreme Caution
	12.04.2024	32.5	27	87.8037	Caution	86.3582	Extremely Uncomfortable	83.332	Caution
Management Faculty	06.04.2024	31.6	59	96.4586	Extreme Caution	86.4088	Extremely Uncomfortable	93.938	Extreme Caution
	07.04.2024	33.7	47	98.5663	Extreme Caution	89.3724	Extremely Uncomfortable	91.988	Extreme Caution
	08.04.2024	31.1	60	94.8773	Extreme Caution	85.5813	Extremely Uncomfortable	93.768	Extreme Caution
	09.04.2024	25.6	57	79.5206	Comfortabl e	76.31465	Uncomfortable	87.091	Caution
	10.04.2024	32.0	51	94.0993	Extreme Caution	86.63645	Extremely Uncomfortable	91.457	Extreme Caution
	11.04.2024	33.3	51	98.7868	Extreme Caution	88.81965	Extremely Uncomfortable	92.747	Extreme Caution
	12.04.2024	29.2	26	82.0920	Caution	80.90885	Very Uncomfortable	79.731	Comfortable
Milk Bar	06.04.2024	33.2	53	99.5340	Extreme Caution	88.7536	Very Uncomfortable	93.37	Extreme Caution
	07.04.2024	35.3	43	101.7250	Extreme Caution	91.71955	Extremely Uncomfortable	91.985	Extreme Caution
	08.04.2024	31.2	60	95.4311	Extreme Caution	85.7585	Extremely Uncomfortable	94.008	Extreme Caution
	09.04.2024	32.6	38	91.1140	Extreme Caution	87.11345	Extremely Uncomfortable	87.569	Caution
	10.04.2024	31.7	53	93.9434	Extreme Caution	86.21375	Extremely Uncomfortable	91.897	Extreme Caution
	11.04.2024	32.4	53	96.8300	Extreme Caution	87.51345	Extremely Uncomfortable	92.751	Extreme Caution
	12.04.2024	27.9	42	81.9240	Caution	79.5741	Uncomfortable	84.16	Caution

Source: Author's field work – April 2024

The overall trend indicates that all three locations experience significant thermal discomfort, despite being green spaces especially during the first half of the week. The indices collectively show that the students may be at risk of heat-related issues, emphasizing the need for appropriate precautions during high heat and humidity conditions.

Referring to table 4.5, LAB open courtyard area predominantly shows "Caution" for HI and "Uncomfortable" to "Very Uncomfortable" for DI. This indicates slight to significant discomfort. Campus route also shows similar discomfort levels with notable very uncomfortable days. Niemi science park indicates consistent discomfort levels, with some days being more uncomfortable than others.

Table 4.5: Thermal comfort indexes and their interpretation for case 2

AGS Location	Date	Temperature (°C)	Humidity (%)	National Weather Service Heat Index (HI)	Level of Discomfort	Discomfort Index (DI)	Level of Discomfort	Simplified Temperature Humidity	Level of Discomfort
LAB open courtyard	28.05.2024	26.8	39	80.0592	Caution	77.60885	Uncomfortable	82.107	Caution
	29.05.2024	27.1	40	80.5361	Caution	78.14235	Uncomfortable	82.795	Caution
	30.05.2024	28.1	39	81.8323	Caution	79.6673	Uncomfortable	83.454	Caution
	31.05.2024	29.9	38	84.8311	Caution	82.5757	Very Uncomfortable	84.852	Caution
	01.06.2024	29.5	36	83.7919	Caution	81.9	Very Uncomfortable	83.68	Caution
	02.06.2024	26.6	48	80.4616	Caution	77.5729	Uncomfortable	85.102	Caution
	03.06.2024	27.2	46	81.2210	Caution	78.53755	Uncomfortable	84.891	Caution
Campus route	28.05.2024	27.2	41	80.6671	Caution	78.2391	Uncomfortable	83.152	Caution
	29.05.2024	29.6	29	82.9624	Caution	81.65935	Very Uncomfortable	81.313	Caution
	30.05.2024	26.6	45	80.2142	Caution	77.447	Uncomfortable	83.998	Caution
	31.05.2024	28.8	38	82.9055	Caution	80.85335	Very Uncomfortable	83.775	Caution
	01.06.2024	29.9	38	84.8481	Caution	82.6564	Very Uncomfortable	84.702	Caution
	02.06.2024	28.1	46	82.8050	Caution	80.0671	Very Uncomfortable	85.818	Caution
	03.06.2024	25.7	47	79.2665	Comfortable	76.13405	Uncomfortable	83.799	Caution
Niemi science park	28.05.2024	26.9	42	80.3254	Caution	77.77865	Uncomfortable	83.105	Caution
	29.05.2024	28.8	30	81.8726	Caution	80.42505	Very Uncomfortable	80.797	Caution
	30.05.2024	26.4	43	79.7913	Comfortable	77.04925	Uncomfortable	82.895	Caution
	31.05.2024	28.1	39	81.7901	Caution	79.6551	Uncomfortable	83.314	Caution
	01.06.2024	28.4	39	82.3674	Caution	80.21675	Very Uncomfortable	83.787	Caution
	02.06.2024	25.7	50	79.4303	Comfortable	76.27505	Uncomfortable	84.879	Caution
	03.06.2024	27.4	46	81.6209	Caution	78.904	Uncomfortable	85.312	Caution

Source: Author's field work_May - June 2024

Overall, indexes show that all three locations experience varying levels of thermal discomfort, with most days falling under the "Caution" category for HI and ranging from "Uncomfortable" to "Very Uncomfortable" for DI. This suggests a need for caution and potential measures to mitigate heat stress.

While comparing the general temperature and humidity variations in both cases, it is evident that the University of Peradeniya experienced higher temperatures overall compared to LAB University. The highest recorded temperature in Sri Lanka was 35.2°C, while in Finland, the highest was 29.9°C. Sri Lanka had higher humidity levels, contributing to higher discomfort indices. The highest humidity was 65 %, while in Finland, it was 49%.

National Weather Service Heat Index (HI) for Sri Lanka frequently indicated "Extreme Caution" due to high temperatures and humidity, with values peaking at 101.73. For Finland, the HI mostly ranged from "Caution" to "Comfortable," reflecting the lower temperatures and moderate humidity, with values peaking at 84.85.

Discomfort Index (DI) values for Sri Lanka indicated "Very Uncomfortable" to "Extremely Uncomfortable" conditions, reflecting higher discomfort due to heat and humidity. Same index for Finland ranged from "Uncomfortable" to "Very Uncomfortable," but generally lower than those in Sri Lanka.

Simplified Temperature Humidity Index (THI) values showed mostly "Extreme Caution" levels of discomfort, correlating with high humidity for the Sri Lankan case, whereas THI values indicated "Caution" levels, with occasional "Comfortable" ratings, showing less severe discomfort for Finland compared to Sri Lanka.

This thermal comfort analysis reveals that the AGS in University of Peradeniya, Sri Lanka experienced higher levels of discomfort compared to LAB University of Applied Sciences in Finland. The combination of higher temperatures and humidity in Sri Lanka contributed to more extreme heat index and discomfort index values, resulting in "Extreme Caution" levels more frequently. Conversely, Finland's cooler temperatures and moderate humidity levels resulted in "Caution" and "Comfortable" conditions, indicating a more favourable thermal comfort environment.

4.5. Factors affecting thermal comfort perception

The study identified several factors influencing thermal comfort perception through surveys, interviews and environmental monitoring. Through the survey questionnaires, it was clear that past activity levels and thermal history had a profound impact on thermal comfort even though those two factors were not correlated.

Analysed **objective parameters** such as temperature and humidity showed a huge impact on thermal comfort perception since temperature along could make huge change to thermal comfort indexes such as discomfort index (refer table 4.3 and 4.4). Simplified thermal heat index showed changes being sensitive to both temperature and, relative humidity which is another environmental factor significantly impacts outdoor thermal comfort by influencing how humans perceive temperature and how effectively the body can regulate its internal temperature. Higher humidity levels above 60% could reduce the body's ability to cool itself via evaporation, leading to increased perception of heat discomfort, overheating, and increased risk of heat-related illnesses such as heat exhaustion or heat stroke. Even though it was not measured, field notes indicated the influence of wind towards thermal comfort perception since it could significantly reduce temperature in AGS location 2 in Peradeniya (refer figure 4.1). Moreover, solar radiation which affects the intensity of heat, and the duration of daylight hours has a massive impact on thermal comfort perception in these two contexts where sun's overhead position provides midday intense heat for Sri Lankans and long daylight hours result in midnight sun giving adequate time for Finns to enjoy warm sunlight.

The interviews assisted in identifying **environmental and design factors** contributing to thermal comfort which can be modified or altered to enhance the comfortability of the academic green spaces when and where necessary. One main factor was shade and vegetation where in Lahti, Finland trees and vegetation provided essential shade during warmer days even though it was insufficient in the selected locations. Yet, it is noteworthy that deciduous trees offer seasonal shading, which is beneficial in late spring/early summer. In Peradeniya, Sri Lanka, dense, evergreen trees offered constant shade, crucial for reducing heat stress in tropical climates. Canopies are vital for creating comfortable outdoor spaces, which was much appreciated in all three AGS locations. Another important factor was the use of surface materials that do not retain too much heat (lighter-coloured surfaces) can enhance comfort. Grass and natural ground cover help in keeping areas cooler which was observed in both contexts. Water Features were also highlighted in the interviews as a much-requested feature in Lahti AGS locations despite having a lot of lakes surrounding. Peradeniya, Sri Lanka case also emphasized the need for having more water features in the middle of the AGS, already having ponds, fountains, and streams surrounding them for visual and auditory comfort.

Identified **social and cultural factors** include usage patterns, as to how much spaces are actively used for studying, socializing, and recreation. Longer daylight hours encourage prolonged outdoor activities, but the typical summer vacation time indicates less utilization of academic green spaces by the students, which needs to be taken into consideration for the Finnish case. On the contrary, Sri Lankan AGS are used for relaxation, social gatherings, and study, with a preference for shaded areas during the peak hours of the day all around the year, especially in the hottest months like April. Clothing choice is another factor observed and as previously discussed Finns wear light, breathable clothing during this period, adapting to the increasing temperatures. Even though Sri Lankans should be wearing breathable clothing year-round due to consistently warm temperatures, weather appropriateness was rarely noticeable in their attire. Cultural Preferences also plays a role in thermal comfort perception, where in Lahti, Finland there is a cultural appreciation for outdoor activities during the brief warm period, leading to active use of green spaces in general. There is not specific cultural importance of greenery and shaded areas reflected in Sri Lanka though the spaces are frequently used for relaxation and social interaction.

Behavioural and Psychological Factors identified in field observations and interviews stressed acclimatization where students are acclimatizing to the warmer temperatures after a long winter, appreciating the increase in warmth in Lahti. Student are accustomed to high temperatures and humidity in Peradeniya, making them more tolerant of heat but reliant on shade and ventilation. Expectations and adaptation also affect the comfort perception as the expectation of making the most of the warm weather leads to increased outdoor activity and the use of adaptive measures like sun protection. In contrast to Lahti, consistent adaptation strategies including seeking shade and staying hydrated encourage Sri Lankan university students to avoid sun exposure as much as possible. Psychological Comfort plays a major role is shaping thermal comfort perception which is context dependent. For the Finnish respondents, psychological comfort came from the enjoyment of rare warm weather and extended daylight hours, while Sri Lankan university students derived the same comfort from the familiar environment of lush greenery and the sensory experience it provides.

4.6. Summary

This chapter attempted to present and discuss the qualitative and quantitative primary data collected from the field work during April – June 2024 in the University of Peradeniya, Sri Lanka and LAB University of Applied Sciences in Lahti, Finland, altogether with the secondary data collected from the weather stations in both cities. The analysis on subjective thermal comfort perception in both cases generated insights on how university students perceive thermal comfort differently in climatically and culturally diverse contexts given similar temperature and humidity levels and vice versa. It also highlighted how different context specific factors like social norms also affect clothing choices and preference towards thermal conditions. Objective analysis of environmental parameters and the past five-year trend reveals how much the climatic patterns have changed and the need for accurate climate predictions for taking anticipatory actions for mitigation and adaptation measures. Integrating subjective perceptions with objective measurements uncovers the intricate bond between different factors in determining the outdoor thermal comfort and how much different indexes assist in interpreting the complex phenomenon of thermal comfort. The identified factors affecting thermal comfort perceptions of these two distinctive climate and cultural contexts demonstrate the complexity of thermal comfort phenomenon and the need of diverse methodologies to capture and understand its nuances.

The next chapter will uncover the implications of this study to propose measures for designing and managing thermally comfortable green spaces in academic institutions. Consequently, the main findings from this analysis will be narrowed down to reach conclusions, limitations and avenues for future research.

CHAPTER 5: IMPLICATIONS

5.1. Implications for AGS Design and Management

This research into the thermal comfort perceptions and conditions at universities in Finland and Sri Lanka offers several valuable implications for the design and management of academic green spaces. The distinct climatic and cultural contexts of Lahti, Finland, and Peradeniya, Sri Lanka, necessitate tailored approaches to enhance thermal comfort and usability of these outdoor areas.

5.1.1. Climate-Specific Design Strategies

Research findings highlight the need for climate-specific design strategies. For instance, Finland needs maximizing the short warm season, therefore design elements should focus on flexible shading solutions, breathable surface materials, and features that enhance sunlight exposure during the brief summer months. This approach can help extend the usability of green spaces, making them attractive for outdoor activities since recent summers have been marked by an increase in hot days where summer 2021 been Finland's hottest over 80 years with a total of 50 heatwave days (YLE News, 2021) along with a 15-day heatwave record in May 2024 (Presse, 2024).

On the contrary, the constant high temperatures and humidity levels require a focus on shade and ventilation in Sri Lanka. Dense, evergreen trees and permanent canopies are essential and natural cooling elements like water features can also significantly improve comfort. These design choices help reduce heat stress and create comfortable spaces for relaxation, study, and social interaction throughout the year.

5.1.2. Cultural Sensitivity and Behavioural Adaptations

The research underscores the importance of cultural sensitivity in designing academic green spaces. Finnish students' appreciation for outdoor activities in summer can be incorporated into versatile green spaces which can host social and recreational activities. Organizing student centred events and programs in AGS can enhance the overall student usage of these spaces even during the vacation period.

Conversely, recognizing the cultural and behavioural tendency to seek shade and avoid midday sun exposure can assist in deciding the placement and design of shaded areas in Sri Lanka. Understanding that these spaces are frequently used for social interactions and relaxation suggests the need for ample seating, cooling features, and accessible hydration stations as proved by research findings. This approach ensures that the AGS are not only thermally comfortable but also practically relevant and user-friendly.

5.1.3. Health and Well-being Considerations

Research implications for student health and well-being further supports the existing literature (table 2.2) on delivering both physical and mental health benefits. High quality AGS have the potential to reduce the risk of heat-related illnesses which are prominent in hotter climates. Ensuring that students have access to cool, shaded, and well-ventilated outdoor green spaces can support physical health by preventing overheating and dehydration. Moreover, comfortable outdoor environments can enhance mental well-being, providing spaces for relaxation, stress relief, and social interaction that are essential for a well-balanced academic life.

5.1.4. Educational and Policy Recommendations

Educational institutions can benefit from these insights by integrating thermal comfort considerations into university planning and policy. Developing guidelines for the design and maintenance of green spaces that prioritize thermal comfort can help create academically stimulating and liveable campus environments. Design collaborations with landscape architects, environmental psychologists, and sustainability experts can lead to innovative solutions that balance aesthetic, functional, and environmental goals.

5.2. Case Specific Design analysis for enhancing Thermal Comfort

The thematic analysis of face-to-face direct interviews with student respondents of both cases uncovered their own opinions and suggestions to redesign the same locations to enhance their thermal comfortability. One of their common concerns was to enhance the shade/ canopy cover and seating provision which can be considered as a minimum requirement to enhance thermal comfortability along with its 'place' values which was frequently cited by students. The following figure shows their responses on 'canopy' in a nutshell.

Figure 5.1 indicates three simplified reasons why students demand canopies in academic green spaces.

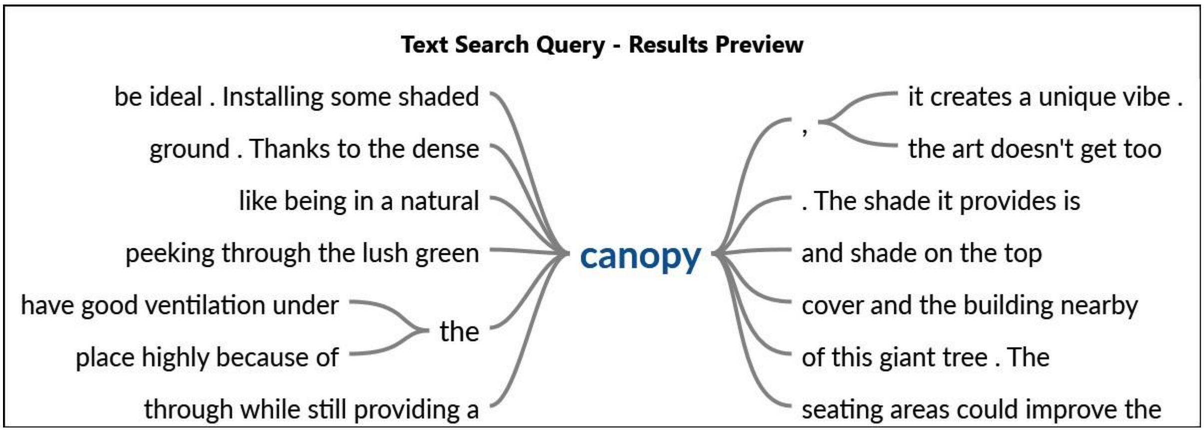


Figure 5.1: NVivo text search query result for canopy for interviews in case 1 and case 2

Source: Author's filed interviews_April - June 2024

Shade Provision - Students emphasize the need for shaded areas to protect from direct sunlight, creating a cooler environment.

Natural Aesthetic - Dense greenery and canopies enhance the visual appeal and provide a natural ambiance.

Ventilation - Good ventilation under canopies is crucial for maintaining a comfortable microclimate.

Similarly, figure 5.2 represents how students explained the integration of better seating to enhance the place value of AGS locations, that leads to three features to be considered while designing better seating.

Comfortable and Abundant Seating - There is a demand for more structured and comfortable seating options, such as benches, to accommodate various activities like studying, socializing, and relaxation.

Integration with Natural Elements - The seating should be integrated with natural features like tree branches and shaded areas to enhance comfort.

Functional Design - Seating arrangements should consider the intrinsic place value, consistent maintenance, and the practical needs of students, ensuring usability throughout the year.

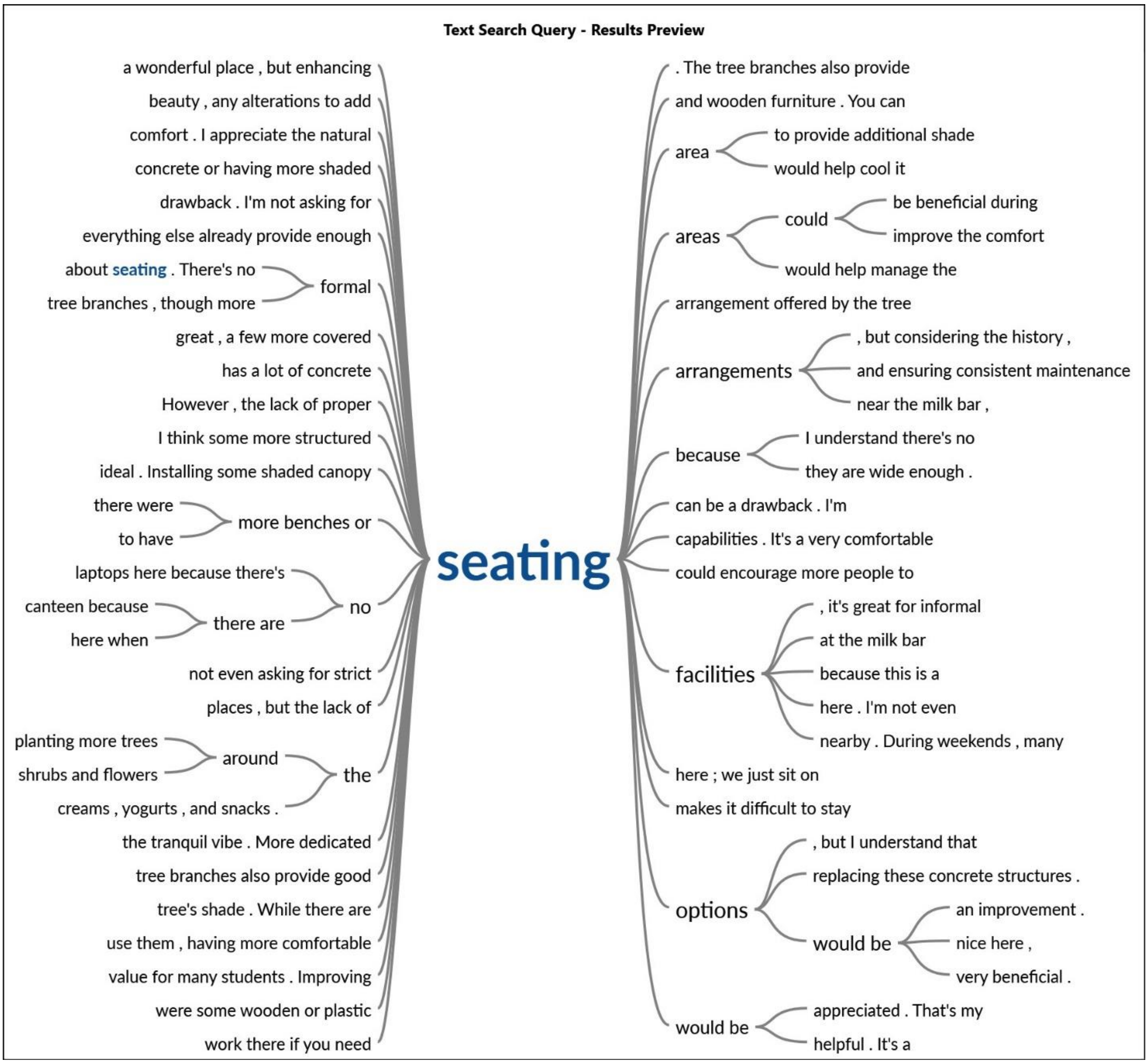


Figure 5.2: NVivo text search query result for seating for case 1 and case 2

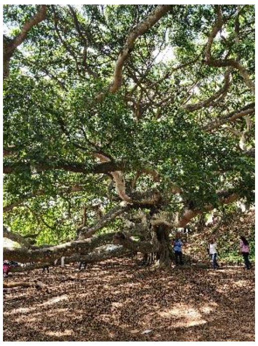
Source: Author's filed interviews_April - June 2024

The study identifies these elements to be critical in designing and managing academic green spaces to ensure they are both thermally comfortable and conducive to student activities. Hence, the following location specific design analysis considers shade and seating provision as essential components to address OTC and placemaking for the targeted AGS locations. The following tables 5.1 and 5.2 provide strategies for two selected AGS locations with highest recorded temperature in each case on how to enhance comfortability and its place value.

Table 5.1: University of Peradeniya, Sri Lanka - AGS location 03

Enhancements	Current State	Proposed strategies
Increasing Shade Coverage	The existing large tree provides substantial shade, but coverage may be inconsistent, especially during peak sun hours.	Additional Tree Planting: Plant more trees around the perimeter to extend the shaded area. Select fast-growing, native species with broad canopies to complement the existing tree as shading structures were not welcomed by students as it could ruin the naturalistic value of the place.
Improving Airflow and Ventilation	The area benefits from some natural airflow due to its open nature but may still experience stagnant air pockets, particularly on hot days.	Wind Corridors: Design the layout to maximize natural ventilation by maintaining open spaces around the central tree area. Avoid dense plantings or structures that could obstruct airflow. Raised Seating Platforms: Consider elevated seating that allows air to flow underneath, providing a cooling effect for those seated.
Cooling Elements	The area is closer to Ma-Oya stream, but the cooling breeze is not enough to counteract the heat generated by concrete seating of the milk bar and adjacent tarred main road.	Reflective Ground Materials: Use light-coloured, reflective materials for any pathways or seating areas to reduce heat absorption.
Comfortable and Functional Furniture	Natural seating provided by the tree branches is unique and engaging but may not be sufficient or comfortable for all users.	Ergonomic Seating: Install ergonomic seating options such as benches and chairs with breathable materials. Ensure that these are placed in shaded areas to maximize comfort. Modular Furniture: Use modular, movable pieces that can be rearranged to fit different group activities. This flexibility makes the

		space more versatile and useful for various purposes.
Material Selection	The ground is covered with natural mulch, which is good for retaining soil moisture even though it is not a comfortable surface for extended periods.	Permeable Pavers: Use permeable pavers for pathways and seating areas. They reduce heat buildup and improve drainage, making them particularly beneficial during rainy periods. Natural Ground Cover: Maintain areas of grass or other natural ground cover that are soft underfoot and cooler than paved surfaces.
Environmental Design and Vegetation	The existing tree is a significant asset, providing shade, a pleasant microclimate and a vibrant gathering spot.	Multi-layer planting: Enhance the cooling effect and biodiversity by incorporating plant layers such, as shrubs and ground cover. Select native plants that require low maintenance.
Behavioural and Psychological Comfort	The area is already a popular gathering spot, indicating its success in providing psychological comfort and a sense of community.	Interactive Elements: Add elements such as educational signage about the local flora and fauna, encouraging users to engage with and appreciate the environment. Event Spaces: Designate areas for specific activities such as study groups, small performances, or outdoor classes. Provide amenities such as power outlets, Wi-Fi, and seating arrangements that cater to these activities
Maintenance and Management	The natural setting requires regular maintenance to ensure cleanliness and usability. Monkey invasion should be addressed to ensure the safety of the students who occupy this place.	Maintenance Plan: Craft a maintenance schedule that encompasses cleaning, trimming and regular inspection of all existing elements. This could be done as a student society led initiative.

		User Engagement: Involve the users (students and staff) in the upkeep of the area through volunteer programs or feedback mechanisms. This can foster a sense of ownership and responsibility towards the space. Secure Waste Bins: Use monkey-proof trash bins with secure lids to prevent monkeys from scavenging for food. Restrict Food Availability: Ensure that no food is left unattended and create strict policies against feeding monkeys. Capture and Relocate: In severe cases, coordinate with wildlife authorities to capture and relocate monkeys to more suitable habitats
Visual representation	 Author's field photograph – May 2024.	 AI generated image using Canva.

Source: Author Interpretation based on face-to-face direct interviews for case 1 AGS location 03

Table 5.2: LAB University of Applied Sciences, Finland - AGS location 02

Enhancements	Current State	Proposed strategies
Increase Vegetation and Shade	The current trees are young and do not provide extensive shade. Limited variety in vegetation types; primarily small trees and sparse greenery.	Plant Mature Trees: Introduce a variety of larger, mature trees to provide immediate shade. Trees such as oaks, maples, or local shade-providing species should be considered. Multi-layer planting: Enhancing the landscape by adding shrubs, bushes and ground cover to develop different layers that can reduce temperatures by releasing moisture into the air. Green Walls and Trellises: Integrate vertical gardens or climbing plants, on walls and trellises near walkways and seating spots, for shade and cooling effects.
Pathway Modifications	Mix of gravel and paved pathways. Paths are relatively exposed to direct sunlight, increasing heat absorption.	Shade Structures: Install pergolas or arbours along pathways to provide shaded walking areas. Cooling Materials: Use light-coloured, reflective paving materials that reduce heat absorption. Permeable materials can also help with heat reduction and manage rainwater runoff.
Seating and Activity Areas	Ample seating available but rarely used because of lack of shade. The area appears to be a transitional space rather than a destination.	Comfortable Seating: Introduce benches and seating areas made of materials that stay cool in the sun. Ensure these areas are placed under shade-providing structures or trees. Picnic and Rest Zones: Designate specific areas for picnics and relaxation, complete with tables,

		chairs, and perhaps hammocks or swings under shaded areas.
Microclimate Factors	Open space with limited shade results in higher temperatures. Lack of water features except the creek behind the students' dormitory which could have help in cooling the environment.	Fountains and Misting Systems: Incorporate small fountains or misting systems along pathways and near seating areas to cool the air and create a more pleasant atmosphere. Reflective Water Elements: Shallow pools (by transforming the existing creek) or water channels can reflect light and further cool the environment.
Additional Elements for Comfort	No specific elements instead of seating, landscaping and wordings drawn on the road.	Wind Catchers and Ventilation: Incorporating design features that improve airflow like carefully positioned openings that help channelling refreshing breezes throughout the space. Interactive and Aesthetic Elements: Integrating sculptures, artistic displays and informative signs highlighting flora and fauna to create a captivating and visually attractive environment.
Sustainable Practices		Rain Gardens and Bioswales: Implement these to manage stormwater especially during the transition to spring, reduce runoff, and enhance the natural cooling effect. Solar-Powered Lighting: Use energy-efficient lighting solutions powered by solar panels to light up the pathways and seating areas during the evening.

Visual representation	 Author's field photograph – June 2024	 AI generated image using Canva.

Source: Author Interpretation based on face-to-face direct interviews for case 2 AGS location 02

5.3. Country specific suggestions for design and management of academic green spaces

Based on the previous two site specific analysis, common suggestions can be drawn for managing AGS in these two countries as presented in table 5.3.

Table 5.3: Country specific suggestions for design and management of AGS

Finland	**Sri Lanka**
Incorporate movable shading solutions such as umbrellas and pergolas in open spaces. These structures should provide adjustable coverage to cater to the varying needs for sun exposure and shade.	Enhance the availability of permanent shaded areas using natural elements like trees and artificial structures like canopies. These should be strategically placed to maximize shade during peak sun hours.
Utilize natural ventilation through design elements that promote airflow. Solar-powered fans and misting systems can be added to areas with limited natural shade.	Focus on enhancing natural ventilation in green spaces and consider installing cooling devices such as misting systems to reduce ambient temperatures and humidity levels.
Both locations should have easily accessible hydration stations to ensure students can stay hydrated, which is crucial for thermal comfort in hot conditions.	
Provide seating that can be moved and adjusted to benefit from either sun or shade, depending on the weather and students' preferences.	Ensure seating areas are predominantly in shaded zones and made from materials that do not retain heat.
Design green spaces that support outdoor activities such as picnics and barbecues, integrating areas for social gatherings that can benefit from sun exposure.	Focus on creating tranquil, shaded environments that allow for comfortable relaxation and study, acknowledging the preference for cooler spaces.

Source: Author Interpretation based on the synopsis of face-to-face direct interviews for case 1 and case 2

5.4. Summary

This chapter focused on the implications of the research and how they should be incorporated into the design and management of AGS in Finland and Sri Lanka. The first part of the chapter outlined different types of implications, followed up by a detailed architectural analysis of two locations to demonstrate how the suggestions proposed by the interviewees can be incorporated into the empirical redesigning of the location in both cases. It was complemented by country specific suggestions for designing comfortable outdoor spaces. By addressing these specific needs and preferences, universities in both regions can create more comfortable and functional outdoor spaces that enhance the well-being and productivity of their students.

CHAPTER 6: FINDINGS, CONCLUSION AND WAY FORWARD

6.1. Findings

This study intended to analyse and compare objective thermal conditions, assess and compare the subjective perception of OTC among university students, identify factors affecting OTC perception, and recommend design and management strategies for AGS in tow selected universities in Finland and Sri Lanka.

6.1.1. Subjective Perception of thermal comfort

The data from both universities indicated that most students perceived the thermal conditions as warm or hot. In Peradeniya, Sri Lanka (Case 1), many students reported feeling hot, with significant preference for cooler conditions. In Lahti, Finland (Case 2), students also felt warm but had a slightly higher acceptance of current conditions. This indicates a generally high perception of warmth in both climates, though more pronounced in Sri Lanka.

6.1.2. Objective thermal conditions

Objective measurements revealed significant differences in temperature and humidity between the two locations. Sri Lanka experienced higher temperatures and humidity levels, leading to higher Heat Index (HI) and Discomfort Index (DI) values. Finland's comparably lower temperatures and moderate humidity resulted in less severe discomfort levels. The highest recorded temperature in Sri Lanka was 35.2°C compared to 29.9°C in Finland. Humidity levels also peaked higher in Sri Lanka at 65% versus 49% in Finland.

6.1.3. Factors affecting thermal comfort perception

The study identified several factors affecting thermal comfort perception, including past activity levels and thermal history, which despite not being correlated, significantly influenced comfort. Environmental parameters such as temperature, humidity, wind, and solar radiation also played critical roles. Surface materials, water features, social and cultural factors, and usage patterns were also important, with notable differences between the Finnish and Sri Lankan settings. Behavioural and psychological factors, such as acclimatization and adaptation strategies, further shaped comfort perceptions, highlighting the complex interplay of physical, environmental, and cultural influences on thermal comfort.

6.1.4. Strategies for designing and managing thermally comfortable academic green spaces

The research implies climate-specific design strategies as essential, with flexible shading and breathable materials needed in Finland, and constant shade and ventilation in Sri Lanka. Cultural sensitivity is crucial, with Finnish spaces supporting versatile outdoor activities and Sri Lankan spaces offering shaded, cool areas for social gatherings. Health and well-being considerations emphasize the importance of reducing heat-related illnesses and promoting mental well-being through well-designed outdoor environments. Educational institutions are encouraged to integrate these insights into campus planning and policy to create sustainable and liveable campuses. Country specific design suggestions are vital for consideration while placemaking along with enhancing thermal comfortability which is very much context dependent.

6.2. Conclusion

The comparative analysis of thermal comfort perceptions and objective thermal conditions among university students in Finland and Sri Lanka reveals significant insights into the factors influencing thermal comfort and the implications for designing academic green spaces. The study highlights that both Finnish and Sri Lankan students generally perceive their thermal environments as warm or hot, with Sri Lankans expressing a stronger preference for cooler conditions. Objective measurements confirm that University of Peradeniya experiences higher temperatures and humidity levels compared to LAB University of Applied Sciences, contributing to greater discomfort levels. Past year trends anticipate increasing temperatures in future which calls for thermally comfortable outdoor green spaces.

Key factors affecting thermal comfort perception include temperature, humidity, wind, and solar radiation, with cultural and behavioural elements also playing crucial roles. Finnish students benefit from adaptive clothing choices and appreciate the warmth and long daylight hours of their brief summer, which fosters active use of green spaces for social and recreational activities. Yet, their usage of academic green spaces is limited due to summer vacation which declines the utility value of such places in the university. In contrast, Sri Lankan students, while more thermally tolerant, prefer shaded areas to mitigate the intense heat and UV radiation, often relying on constant shade and ventilation. They tend to appreciate the existing green spaces and extensive tree canopies but demand more shade provision to combat the repercussions of increasing heat.

The findings underscore the importance of incorporating climate-sensitive design elements in academic green spaces. Recommendations for improving thermal comfort include enhancing shaded areas with trees and canopies, using surface materials that minimize heat retention, integrating water features, and ensuring proper ventilation. Additionally, cultural preferences and usage patterns should be considered to create spaces that not only provide thermal comfort but also align with the social and psychological needs of the students.

Overall, this research provides a comprehensive understanding of thermal comfort dynamics in different climatic and cultural contexts, offering valuable insights for the design and management of academic green spaces to enhance student well-being and comfort.

6.3. Limitations of the research

The study acknowledges that data collection only spans across one week, which may not fully represent the seasonal variations (four distinctive seasons for Lahti and wet/ dry seasons for Peradeniya) and long-term trends in temperature and thermal comfort. The research focuses on specific locations within Peradeniya and Lahti, which may not capture the diversity of microclimates and thermal conditions in other parts of these regions. The temperatures recorded are snapshots at specific times during peak hours (12.00 – 15.00), lacking continuous monitoring that could provide a more comprehensive understanding of daily temperature fluctuations and peak heat times. The research primarily measures temperature and relative humidity without considering other critical environmental factors like wind speed, and solar radiation, which significantly affect thermal comfort. The study does not account for human metabolic rates due to methodological inconvenience which influence individual thermal comfort.

The findings from Peradeniya and Lahti may not be generalizable to other geographic regions with different climates, topography, and urban designs. The research does not evaluate the effectiveness of various thermal comfort improvement strategies, leaving uncertainty about the practical implications and benefits of suggested interventions. The study's short-term focus does not account for the long-term effects of climate change and urbanization on thermal comfort, which could significantly alter future conditions.

Addressing these limitations in future research could provide a more holistic understanding of thermal comfort and inform more effective strategies for enhancing it in diverse environments.

6.4. Suggestions for future research based on the analysis outcomes

The research opens avenues for further exploration into the relationship between thermal comfort and student performance, engagement, and overall satisfaction with campus environments. Longitudinal studies could provide deeper insights into how seasonal changes and climate variations impact thermal comfort perceptions over time. Additionally, exploring the role of emerging technologies in enhancing thermal comfort, such as smart shading systems and adaptive cooling solutions, could offer new possibilities for academic green space design. In conclusion, this research emphasizes the critical role of thermal comfort in shaping the usability and appeal of academic green spaces. By adopting climate-specific, culturally sensitive, and health-oriented design strategies, universities can create outdoor environments that support student well-being, foster community, and enhance the overall educational experience. The reflections from this study provide a foundation for developing more resilient, comfortable, and inclusive university environments across diverse climatic regions.

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APPENDIX I: SURVEY QUESTIONNAIRE

AGS Location: No:

Survey Questionnaire assessing the Outdoor Thermal Comfort in Academic Green Spaces
Case 1: University of Peradeniya, Sri Lanka

This survey is a part of the MSc thesis work to complete the Erasmus Mundus Joint master's degree in urban Climate and Sustainability (MUrCS). All the personal information and responses collected are only utilized to generate academic insights and will be kept strictly confidential.
Your time and effort in participating in this survey is highly appreciated!

Section 1 - Background Information

1. Date:
2. Time:
3. Location:
4. Age:
5. Gender:
6. Weight (approx.):
7. Height (approx.):
8. Ethnic orientation:
9. Hometown:

10. Please tick your dress code from the below choices.

Top		**Bottom**		**Outer layer**	
Short sleeve shirt		Short		Jacket	
Long sleeve shirt		Long trouser (linen)		Jersey	
Short sleeve t short		Long trouser (denim)		Cardigan	
Long sleeve t shirt		Short skirt		Cap	
Long sleeve blouse		Long skirt		Hat	
Short sleeve blouse		Short frock		Scarf	
Crop top		Long frock		Gloves	
Body suit/ jumpsuit		Abaya/ Burqa		Religious headwear	

Section 2 – Thermal History and Past Activity

1. Where were you before coming to this green space?

....

2. What were you doing at that place?

Reclining	
Seated quiet	
Standing relaxed	
Light activity standing	
Medium activity, standing	
High Activity	

3. How long did you stay there (in minutes)?

Less than 30		30 to 60		60 to 120		120 <	

4. Did you feel a difference after arriving at the current green space?

Yes		No	

4.1. If yes, what was the difference like?

....

Section 3 – Current Thermal Comfort Perception

1. Did temperature influence your choice of staying at this specific location?

Yes		No	

1.1. If yes, why did you stop here?

....

2. How long have you been to this place?

....

3. How often do you come to this place?

Few times a day		Everyday		Few times a week		Every week		Occasionally	

4. What is your current thermal comfort (TCV according to Bedford, 1936 7-point scale)?

Cold	
Cool	
Comfortably cool	
Comfortable	
Comfortably warm	
Warm	
Hot	

5. What is your current thermal sensation (TSV according to ASHRAE, 1966 7-point scale)?

Cold	
Cool	
Slightly cool	
Neutral	
Slightly warm	
Warm	
Hot	

6. What is your current thermal preference (TPV according to McIntyre, 1978 3-point scale)?

Cooler		No change		Hotter	

7. How do you experience the air movement (windiness)?

Very High	
High	
Slightly High	
Neither high nor low	
Slightly low	
Low	
Very low	

8. How do you prefer to have the air movement?

Much more	
A bit more	
No change	
A bit less	
Much less	

9. How do you experience the humidity?

Very Humid	
Humid	
Slightly Humid	
Neither humid nor dry	
Slightly dry	
Dry	
Very dry	

10. How do you prefer the humidity to be?

Much drier	
A bit drier	
No change	
A bit more humid	
Much more humid	

11. Do you feel the need to take other comfort measures while staying at this place (eg: open umbrella, wear hat, drink more, move away etc.)

Yes		No	

11.1. If yes, what are they?

....

APPENDIX II: INTERVIEW QUESTIONS

Interview Questions assessing the Outdoor Thermal Comfort in Academic Green Spaces

Case 2: LAB University of Applied Sciences, Lahti, Finland

These interview questions are a part of the MSc thesis work to complete the Erasmus Mundus Joint master's degree in Urban Climate and Sustainability (MUrCS). All the responses collected are only utilized to generate academic insights and will be kept strictly confidential. These questions are intended to provide an assessment of the outdoor thermal comfort (OTC) in academic green spaces (AGS) by gathering perception data from student users. Answers to these survey questions will direct informed recommendations for design and management of AGS to provide a continual comfortable environment for all users.
Questions are divided into eight sections.

Section 1 - General Impressions

1. How would you rate the overall design of the green spaces within the LAB University of Applied Sciences in terms of thermal comfort?
2. What aspects of the design contribute most to your perception of thermal comfort in this AGS location?
   Eg: vegetation and landscape design, shade provision, water features

Section 2 - Vegetation and Landscape Design

1. Do you think the type and distribution of vegetation within green spaces effectively contribute to thermal comfort? Why or why not?
2. Are there any specific types of trees or plants that you believe enhance thermal comfort in outdoor areas?
3. How important do you consider the presence of greenery for providing shade and cooling effects in the university's outdoor spaces?

Section 3 - Shade Provision

1. Do you feel that there is <u>adequate shading available</u> in the green spaces to provide relief from the sun's heat? Why or why not?
2. How do you perceive the <u>effectiveness of existing structures</u> (e.g., pergolas, awnings) in providing shade?

Section 4 - Built Environment Integration

1. How well do you think the <u>design of buildings and outdoor structures integrates with the surrounding green spaces</u> to enhance thermal comfort?
2. Are there any <u>architectural features</u> or <u>materials used in the buildings</u> that contribute positively or negatively to outdoor thermal comfort?

Section 5 - Water Features and Cooling Elements

1. Do you believe that the <u>presence of water features</u> (e.g., fountains, ponds) enhances the thermal comfort of outdoor areas in the university?
2. Have you noticed <u>any other cooling elements</u> (e.g., misting systems, fans) integrated into the green spaces? If yes, how effective do you find them?

Section 6 - Accessibility and Connectivity

1. <u>How accessible</u> do you find the green spaces within the university campus? Are there <u>any barriers</u> that hinder your access to these areas?
2. Do you think there are <u>sufficient pathways and connections</u> between different green spaces to encourage movement and exploration?

Section 7 - Maintenance and Management

1. <u>How well-maintained</u> do you think the green spaces are in terms of <u>cleanliness, upkeep of vegetation, and repair of amenities</u>?
2. Have you noticed <u>any efforts by the university administration</u> to manage thermal comfort in the outdoor spaces (e.g., trimming trees for better shading, installing heat-absorbing materials)? If yes, please describe.

Section 8 - Suggestions for Improvement

1. Based on your experiences, what improvements would you recommend enhancing the thermal comfort of green spaces within the university campus?
2. Are there any specific design or management strategies that you believe could be implemented to better meet the thermal comfort needs of students, faculty, and visitors?