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Assessing Local Climate Functions of Urban Green Open Spaces

A Case Study on Public and Institutional Open Spaces in Glasgow

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Title

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Abstract

Urban Green Open Spaces are one of the essential elements that narrate a city's liveability and life-stream. Due to the emergence impact of global climate change and increasing urbanization, 21st century is at a critical state in terms of UGOS adequacy and future consequences. The outdoor environment has fallen into an alarming threat for the habitants during the summer of 2022, with frequent heat wave events exceeding 40°C across Europe and the UK. The concern rises towards the local green spaces' functions if extreme warm days occur more frequently. A mono-functional UGOS with poor performance dominated by a built environment often discourages usability and amenity values. This research paper aims to construct upon improving UGOS- categorized as neighbourhood scale green open space in Glasgow as a case study and explore the opportunities of valued UGOS.

To serve the SDG goal of open space and to meet the climate change adoption goals, it is essential to foresee the potential support with integrated biodiversity and the socio-ecological benefits of UGOS. The gap between policy development and on-ground action weakens these facilities that a local UGOS are meant to provide. Experts' administrative opinions and the desired expectation from communities get lost in translation due to the high housing demand, economic hub, and business district. A relationship needs to be investigated regarding the landuse of UGOS and its importance to local and broader communities.

The research methodology is reinforced by the thermal comfort simulation analysis, spatial configuration analysis, and interview of experts' opinions. An institutional open space and a typical functioning public open space are assessed as investigation sites. A relevant empirical study and the policies and strategies associated with UGOS in Glasgow give an overview of the current trend of UGOS functions in this paper. Based on the findings and experts' opinions, attempted thermal comfort indices analysis (MRT, PET, UTCI) and linking them with open space quality indicators combinedly illustrates the broader influences of UGOS as a resilient device for tackling heat stress, bio-diversity loss, health risks etc.

The scientific evidence and high degree of stakeholders' collaborative insights link the standard variables for future growth and design consideration of UGOS with a climate-focused planning and design approach. Existing scenarios, larger green cover scenarios, ongoing development scenarios, and proposed scenarios from the detailed ENVI-met climatic analysis highlights the key findings and suitability of UGOS. Based on the analysis result, the concept of this research work can initiate holistic and multidisciplinary planning steps and solutions for future UGOS development.

Keywords

Urban Green Open Space, Public Open Space, Institutional Open Space, Key Performance Indicator, Micro-climate Indices, ENVI-Met, UTCI, PET, Comparative Analysis, Festival Park, QEUH Campus, NHS, Glasgow

Originality statement. I hereby declare that this Master's dissertation is my own original work, does not contain other people's work without this being stated, cited and referenced, has not been submitted elsewhere in fulfilment of the requirements of this or any other award.	**Signature**

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CHAPTER 1 INTRODUCTION

1.1 RATIONALE

In the long course of industrialization and modernization, cites growth leads to dysfunctional environments, a sense of scale, and feeling lost in between or ignored in experience (Gehl & Svarre, 2013). Between 2015 and 2020, urban populations globally have grown by more than 397 million people (UNDESA, 2019). Climate change can directly impact the functioning of urban systems, but the elements in urban systems play a significant role in adapting to the effects of climate change (Dodman et al., 2022). More consumption means more investments and production, resulting in less space and fewer resources. Insensitive growth in every urban area sector builds up a city's future events. One of the most affected elements of this growth is Urban Green Open Space (UGOS) which is often portrayed as only a physical space by urban designers, landscape architects, architects, and planners; without acknowledging its integrated part such as environment, liveability, socio-cultural engagement and the rights of individuals and groups (Mehta, 2014). Due to high housing demand, office buildings, roadways, and infrastructures within urban areas, neighbourhood-scale UGOS is blatantly under threat. It is not being revised unless urban hazards and climate change phenomena such as heat stress, Urban Heat Islands (UHI), urban flooding, and urban pollution occur.

While density dominates the UGOS, it is necessary to revisit the balance of a city in terms of future growth. Thompson's question regarding the need for urban open space in the 21st century contextualizes the situation. The question is about understanding interaction through nature and a broader ecological structure with the social and cultural values that create the forms of UGOS. Should it be a more flexible and productive landscape to incorporate loose-fit landscapes with innovative urban networks (Thompson, 2002)? This research aims to identify the attributes of UGOS retrofitted by growing urban trends with an adoptable climate-resilient planning framework through socio-environmental benefits. Small or big, breathing space is vital as the capacity to withhold the population. There is a wealth of existing research, but the context has changed significantly in UGOS design and planning; it should be centred around climate change impact mitigation with spatial equity for the people.

Open spaces significantly impact the city's ecology and biodiversity from different scales in the neighbourhood to the regional level. The tendency to develop densified areas and city centres is exceptionally insensitive and often impossible to connect with natural components. Every open space, like a green park, promenade, plaza, or street, is the source of these same components. However, it is too expensive to leave one unit of space because of the economic benefits of the built environment, and it does not qualify for the basic need of shelter. Therefore, small to medium-scale open spaces have a significant role to play in sound-microclimate solutions in growing city neighbourhoods. There are insufficient holistic guidelines for creating UGOS in terms of ecological benefit and social

elements with an integrated and qualitative approach at a neighbourhood scale. It is essential to review the existing works of literature by urban planner activists over the climate change period days; to connect the dots from the isolated development index in terms of climate and integrated social diversity.

1.2 AIM AND OBJECTIVES

The research aims to identify and evaluate Urban Green Open Space (UGOS) through case studies in Glasgow with spatial elements and microclimate analysis in growing urban areas. It further recommends UGOS quality indicators for climate change mitigation-focused UGOS planning. The following objectives complete the overall purpose of this research work.

1. Identifying dimensions and criteria of UGOS strategies with their associated environmental benefits from existing planning and policy. Including the influence of different actors in the planning, construction, and governance of UGOS.
2. Understanding UGOS spatial and ecological features on a neighbourhood scale.

3. Assessing Key Performance indicators of UGOS by integrating expert's and stakeholder's opinions and climate change adoption-led design approach.
4. Analyzing microclimate indices and thermal comfort through case studies in previous, present and post-design contexts with the integration of Key Performance Indicator for UGOS
5. Giving recommendations for future UGOS quality assessment, design and planning development.

1.3 METHODOLOGY OUTLINE

The research methodology followed a “Research for Design” approach with comparative and simulation research strategies. It is divided into four main themes, (1) spatial and ecological relations, (2) administrative expert opinion integration, (3) Key Performance Indicators of UGOS and (4) micro-climate indices comfort range. Initially, It followed a qualitative approach through existing literature study, interviews and questionnaires for expert's opinions. The qualitative findings aided the quantitative data derivation, which are traverse survey, micro-climate simulation of UGOS, comparative analysis of the result, and integration of quality matrix. The analysis and result of existing and proposed scenarios finalized the recommendation and design guidelines of UGOS. The software employed for research, analysis and results includes Microsoft Word, Excel, Google Earth Pro, Arc GIS Pro, Sketch UP 2020, Tinytag explorer, Kestrel, 2D photographs, ENVI-met 5.0.3, Leonardo 5.0.3, BIO-met 5.0.3, Adobe Photoshop, and Adobe Illustrator.

1.4 DISSERTATION STRUCTURE

Chapter one **introduces** the **rationale** and aims of conducting this research paper. It describes the aim and objectives, rationale, and research gap of the chosen topic

Chapter two, the **literature review,** explores the current wealth of research on UGOS and associated factors in three selected themes. This chapter looms on the question and purpose of the research paper in the current emergency of climate change and its associated relation with UGOS in the growing urban context. Beginning with the planning division, it ends with supporting the research gap and objectives.

Chapter three describes the **background of** Glasgow city open space context and two **UGOS case studies** where the research has been conducted.

Chapter four, the **methodology** chapter, illustrates the outline of the research methodology, work approach and dissertation process. It mentions the time and specification of the methods.

Chapter five follows the outline of the previous chapter with the **analysis and result**. It explores the outcomes of the survey and traverse study. Integration of expert opinions and spatial and ecological analysis created the KPI for UGOS in this chapter and reflected it in the micro-climatic model scenarios through ENVI-met simulation.

Chapter six summarizes the objectives of the dissertation from the result, literature review and current context. It reflects the author's insight through the proposal, recommendation and **discussion** on UGOS provision and planning.

Chapter seven **concludes** the research paper with the orientation of the future study.

CHAPTER 2 LITERATURE REVIEW

2.1 BACKGROUND

This chapter explores the background and the importance of climate-resilient Urban Green Open Space (UGOS), which is recognized as urban park-type spaces and can redeem the climate change effects (such as surface runoff, heat waves, and thermal stress) in the concentrated urban areas. The performance of the urban morphology with climate change impacts, it is necessary to visualize the demand of park type UGOS in a city considering different environmental aspects (Carter et al., 2015). It is a juxtaposition of socioenvironmental, ecological, and microclimatic benefits to represent the holistic functions of UGOS in the urban realm. UGOS are vital elements to conquer such demands in ecological and cultural dimensions. Even with the consensual need for the act, there is an insufficient knowledge gap on conducting adaptation acts to improve the experience and comfort of users in outdoor environments such as UGOS locally (Nouri, 2017). Lewis Mumford, a prominent American historian, predicted the mechanical thinking of a metropolis and opposed the method of setting an ideal environmental condition because it is not an "ideal condition"; it should be addressed as a "varies condition" (Correa, 1989). A certain degree of temperature, humidity or square meter cannot define a static condition as an ideal method. Therefore, having a symbiotic relationship with people, space and nature to its users is one of the primary challenges in the era of Anthropocene (Norman, 2016). Identifying existing park type UGOS on a local scale can bring out the solutions of dynamic environmental factors that rejuvenate a suitable living condition in expanding neighbourhoods of a city. Radical changes to UGOS after the industrial revolution happened in both developed and developing countries (Khalid, 2019). Accordingly, a post-industrialized city like Glasgow, the fourth-most populous city in the United Kingdom (Largest European City 2020 Statista), has been chosen to review the existing park-type space strategies and current trends of UGOS development. This chapter illustrates active design solutions and planning applied in neighbourhood scale green space and the background of Glasgow open space context as a case study. It further explores the quality indicators initiated by the Glasgow city planners for the instrumental development in the design, management, and climate change adoption aspects of UGOS.

2.2 STRATEGIES AND PLANNING ACT

The consequences of the increased urbanization make developed countries mandate open space strategies more seriously than ever. According to UN-Habitat, 15-20% of urban land should be preserved for public open spaces, with 30-35% for the streets and roads of a city ("Atlas of Urban Expansion - Cities," n.d.). Which also set aligns with the main aim of Sustainable Development Goal (SDG) 11 and target 11.7, which is to provide universal access to safe, inclusive, and accessible, green, and public spaces, especially for women and children, older persons, and persons with disabilities by 2030 (UN, 2015). A city-wide public space strategy depends on the land, governance, legislation, financing,

policy, and inclusion; still, the implementation can be interpreted by economic and political factors (CWPSS UN-Habitat, 2019).

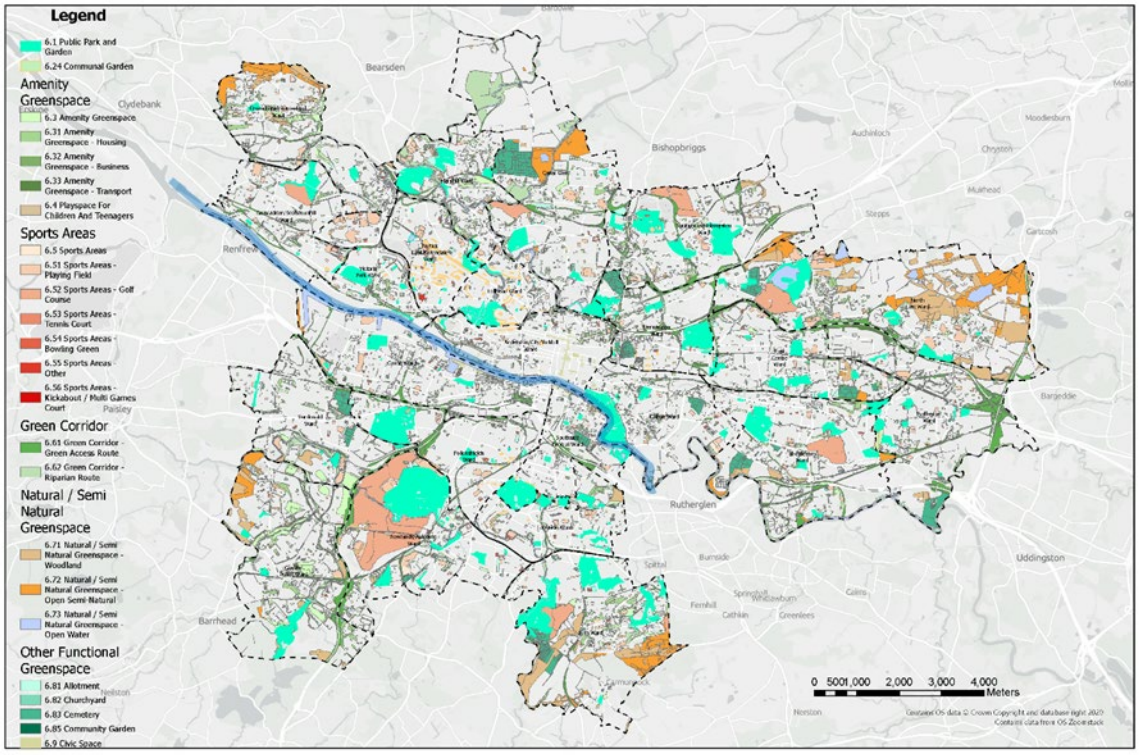

Figure 1: Glasgow Open Space map, the typologies derived by Scottish Government PAN 65 (Scottish Government, 2008)

Funded by the European Union's Horizon 2020, Glasgow City Council (GCC) has adopted the Glasgow Open Space Strategy (GOSS), a document that will help to plan and formally address open spaces integrated with climate change impact solutions and the upgrade of health, liveability, and resiliency of the city. The GOSS has categorised the types of open spaces in an open space map (figure 1) and intends to find out the current and future needs of open spaces and provide those requirements through the GOSS delivery plan. However, the focus of this strategy is city-wide. In terms of the local level, it depends on the site-specific context and users' reflections on the current amenities regarding UGOS. For example, Edinburgh's Open Space Strategy plan has already benefited its people as a post-survey shows 82% satisfactory results from the users of different UGOS(CWPSS UN-Habitat, 2019). Also, the open spaces strategy considerations are primarily based on a city's prior needs. The goals of Copenhagen's Green Structure Plan integrated neighbourhood scale with innovative green Infrastructure in UGOS. It already has an evaluation report of exiting POS inventory for the entire built-up and undeveloped urban area to experience nature in the city (Mengel, 2020). In terms of Glasgow, previous researchers have depicted that the initial discursive and policy practices adopted by the city and urban park developer were a mere collaboration with inclusive urban park development but ultimately benefitted a more comprehensive image and attractiveness for potential buyers (Inroy, 2000). In any terms, provisioning of UGOS demands a common goal of mitigating the

challenge of microclimate deterioration as well as socio-environmental and cultural upgrades encircling from city to local scale.

2.3 NEIGHBOURHOOD UGOS AND GROWING URBAN AREA

The whole COVID pandemic portrayed the loss of not having qualitative open spaces in urban areas. The inaccessibility and closed public realm converted the occupancy into streets, neighbourhoods, private lawns, rooftops, etc. This adoption of embracing any available space for social activities reminds us of the dependency on open space in daily life. A journal about the COVID pandemic situation, "2020 A Year without Public Space", has brought up different concerns from the urban scholar regarding the crisis in the urban planning framework for UGOS (Bravo *et al.*, 2020). The observation of the street as a public space showed the behavioural dynamics of people at COVID times established. Table 1 below identifies the adoptive usage of areas in the limited situation. The World

	Personal activities	Group activities	Different ages	Mixed use	Effective area used	Street features
Before Covid-19						
During Covid-19						

Table 1: Street as public place during COVID times (source: 2020 A Year without Public Space)

Health Organization (WHO) has recommended that every city target a minimum of 9 square meters of open space per capita, which must be accessible, safe, and functional and up to 50 square meters in terms of generous standards. The Open Space Map within the Glasgow city boundary has been created based on the audit and advised by PAN65 (Scottish Government, 2008) regarding space quality and categories (figure 1). Public parks and gardens type means the land area that is designed, constructed, managed, and maintained as a public park or has accessibility by public but private ownership. In terms of open space consideration mentioned in figure 1, it is often easy to identify them in regional-scale parks. However, intermediate to small scale UGOS has immediate ease of access for the nearby habitats. Often, a park close to home is a highly valued green area with substantial restorative value (Kaplan et al., 1998). A neighbourhood park defines a place with diverse needs at a comfortable distance, has basic recreational amenities for all users, and is located within the centre of development (Chapman, 1999). According to GCC, the walking distance from a usable open space should be 400m from the user's home. However, 60% of people in Glasgow live within 500m of derelict land that has the opportunity to be a viable UGOS (GCC, 2020). In this context, considered UGOS is addressed at a medium scale (area<3ha) that is situated within a growing neighbourhood, residential area and institutional area that directly improves the micro-climate situations with green infrastructure and offers leisure and recreational functions

for local or immediate users. The scale is based on the limitation of pragmatic climate analysis with a broader perspective in the planning process through KPI and recommendations for this research paper.

2.4 CLIMATE CHANGE ADOPTION AND HEAT STRESS

The 2015 Paris Agreement aims to limit temperature rise to well below 2°C above pre-industrial levels and pursue efforts to limit it to 1.5°C. According to IPCC, the time is now to reduce emissions by 2030 (IPCC, 2022). Changes in radiation and wind patterns due to climate change impact Urban Heat Island (UHI), amplifying urban city cores (Emmanuel et al., 2007) and causing heat wave incidents. Also, the UHI effect depicts a high risk for pandemic events within the city. Due to this fact, the environmental

City	Winter (DJF)	Spring (MAM)	Summer (JJA)	Autumn (SON)	Annual
New castle upon-Tyne	1.8	1.9	2.0	1.8	1.9
Portsmouth	1.3	1.73	2.0	2.0	1.8
Central London	1.3	1.7	1.9	1.6	1.6
Liverpool	1.1	1.4	1.7	1.5	1.4
Glasgow	1.0	1.5	1.5	1.2	1.3
Edinburgh	1.1	1.4	1.4	1.3	1.3
London Suburbs	0.9	1.2	1.4	1.1	1.1
Plymouth	0.9	1.2	1.2	1.1	1.1
Sheffield	0.9	0.9	1.1	0.9	1.0
Manchester	0.8	1.1	1.2	0.8	0.9
Bristol	0.6	1.0	1.2	0.9	0.9
Middlesbrough	0.8	1.0	0.9	0.8	0.9
York	0.8	0.8	1.0	0.9	0.9
Cardiff	0.5	0.9	1.1	0.6	0.8
Leeds-Bradford	0.6	0.7	0.8	0.8	0.7
Nottingham	0.5	0.7	0.9	0.6	0.7
Bournemouth	0.6	0.8	0.8	0.5	0.7
Birmingham	0.4	0.5	0.7	0.6	0.6
Coventry	0.4	0.5	0.7	0.4	0.5
Belfast	0.4	0.5	0.3	0.3	0.4
Leicester	0.0	0.2	0.1	0.1	0.1

Figure 2: Seasonal and yearly average of UHI in various cities in UK Source:(Kershaw et al.*, 2010).*

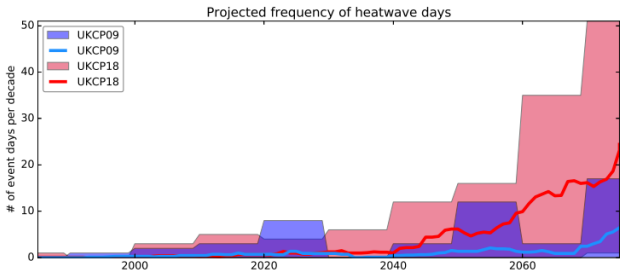

Figure 3 Projected heatwave frequency in Scotland under new UK climate projections

protection of ecologically valuable areas such as riverbanks, wetlands, and biodiversity by following environmental regulations should be developed in UGOS (Martinez et al., 2016). Researchers showed an estimation of the heat island effect in populated urban centres in the UK that reveals the seasonal and yearly average of UHI in various cities (Kershaw *et al.*, 2010). According to UK Met Office data, UK Climate Projections (UKCP) model 18, a spatial mapping system, projected increased heatwave frequency for Scotland in the upcoming future(O'Neill et al, 2019). In recent times, the >28 °C band can be seen very often in the dry spell of summer (June to August), increasing to 40°C across Europe and the UK. The UK met office declared an emergency of the true heatwave is only met when there is constant record heat for three consecutive days by meeting maximum or exceeding. The adaptation strategy and action plan "Climate Ready Clyde" has identified higher average temperatures, with more frequent and extreme heatwaves in on Glasgow City Region (Climate Ready Clyde, 2021b). The mitigation steps adopted in the strategies prioritize carbon emission reduction than deal with the change via land use or land cover manipulations (Emmanuel et al, 2015). However, the impact of heat stress is crucial, and it will be too late to repair the natural state when outdoor spaces seem unhabitable. The most affected sector in this area is the health service and the effect on built, social and institutional infrastructures supporting health care operation. The health care system is facing a change in service demand for the impact on human health (Curtis et al., 2017), such as level 3 heat-health alerts due to heatwave. The National Health Service (NHS), the owner of the most significant portion of open space in Glasgow, has

adopted different climate challenge mitigation plans as the administrative body. Greater Glasgow and Clyde board working as a stakeholder with GCC for reviving the derelict land and unsuccessful open space in institutional and hospital compound. By incorporating functions like the therapeutic garden, art and creative zone, and woodand garden, the community hospital garden's result is recognised through awards and appreciation. Such notable awards are the Green Flag award(Greenspace Scotland) and Building with Nature Award, following the official standards set and recognised in the United Kingdom or the European Union. Acknowledging different types of UGOS through awards is positive reinforcement for producing more good quality UGOS.

2.4 MICRO-CLIMATIC COMFORT AND UGOS CONTRAST

The role of urban climate change is a significant part of human experience, and it is being recognised increasingly (Emmanuel et al, 2012). UGOS creates an environment with specific microclimatic qualities due to complex surface structures (Mahmoud, 2011). The definition of thermal comfort is "the condition of mind that expresses satisfaction with the thermal environment", which requires subjective evaluation beyond physical or

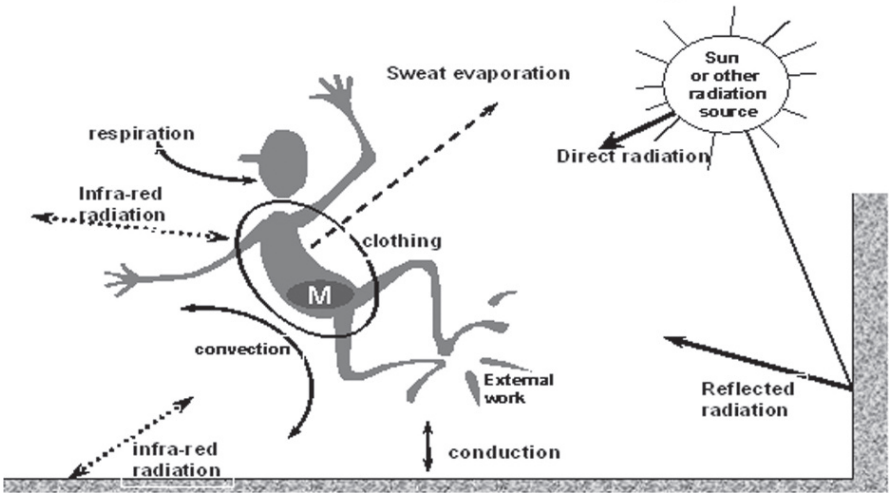

Figure 4 The heat exchange between the human body and the thermal environment, an illustration of heat exchange by Havenith, 2001

Thermal perception	UTCI	PMV	PET
Very cold[1] (Extreme cold stress[1,2])	< -40	-3	<4
(very strong cold stress[2])	-40 to -27		
Cold[1] (Strong cold stress[1,2])	-27 to -13	-2.5	4-8
Cool[1,3] (Moderate cold stress[1,2]/ Moderate Hazard[3])	-13 to 0	-1.5	8-13
Slightly cool[1] (Slight cold stress[1,2])	0 to +9	-0.5	13-18
Comfortable[1,3] (No thermal stress[1,2]/ No Danger[3,4])	+9 to +26	0	18-23
Slightly warm[1] (Slight heat stress[1])		0.5	23-29
Warm[1, 3,4] (Moderate heat stress[1,2]/ Caution[3,4])	+26 to +32	1.5	29-35
Hot[1, 3,4] (Strong heat stress[1,2]/ Extreme caution[3,4])	+32 to +38	2.5	35-41
(very strong heat stress[2])	+38 to +46		
Very hot[1, 3,4] (Extreme heat stress[1,2]/ Danger[3,4])	> +46	3	>41
Sweltering[4] (extreme danger[4])			

[1] PET and PMV [2]UTCI

Figure 5: Combined indexes of thermal indices source (Zare et al., 2018)

psychological factors (ASHRAE, 2009). A comfortable thermal environment is significant in the outdoor spaces as UGOS due to frequent exposure to the weather while spending recreational and leisure time of its users (Mahmoud, 2011). To assess thermal comfort conditions, the researchers use several thermal indices to understand the effect of comfort levels on people's use of outdoor spaces (Thorsson, et al, 2004; Oertel, et al, 2015). Some commonly used indices are Predicted Mean Vote (PMV), Physiologically Equivalent temperature (PET), and Universal Thermal Index (UTCI). For analysing these indices, meteorological input variables such as air temperature, air humidity, wind velocity, and Mean Radiant Temperature (MRT), including short and long wave radiation fluxes, metabolic rate, and clothing insulation, is required (Jendritzky et al, 2009). These models represent people's exposure to the ambient climatic environment over time in numerical index and solution through the energy balance equations by thermoregulation (Nagano et al, 2011).

Regarding thermal extremes, tolerance depends on different characteristics such as age, fitness, gender, morphology, and body mass (Havenith, 2001). The thermal perception index (figure 5) for these indices shows that considering thermal comfort and human wellbeing assessment, PET and UTCI index is mostly suitable for UGOS. However, a study based in Glasgow showed that the 'optimal' PET comfort range is 9°C to 18°C, which is visibly below the suggested thermal comfort range from 18°C to 23°C (Oertel, et al, 2015). Nonetheless, various research has done assessments using these climate indices (table 1); outdoor climate data influences the urban micro-climate situation, and the effects can be enhanced in proper planning and design decision. Outdoor thermal models are created by using ENVI-met modelling software, which allows the determination of outdoor thermal comfort with basic and possible proposed scenario variables (Yilmaz et al, 2018). Bruse and Fleer created this software in 1998.

Predicted Mean Vote (PMV)	• Aims to predict the mean value of votes of a group of occupants on a seven-point thermal sensation scale. Also interpreted by the Predicted Percentage Dissatisfied Index (PPD) • Developed as an indoor thermal comfort index, it considers cloth and activity • Commonly adopted in outdoor thermal comfort studies in which large groups of people are being surveyed (Matzarakis, et al, 1999)	Study Example: Place: Cambridge, UK Features: Temperate climate Study area: Open spaces Season: Spring, summer, winter (Nikolopoulou, et al, 2001)
Physiologically Equivalent temperature (PET)	• The evaluation of a complex outdoor climatic environment to a simple indoor scenario on a physiologically equivalent basis can be easily understood and interpreted. • Suitable for outdoor thermal comfort analysis (Höppe, 1999)	Study Example: Place: Kassel, Germany Features: Temperate climate Study area: Open space Season: Spring, summer (Katzschner, 2006)

Universal Thermal Climate Index (UTCI) (°C)	• Aims to assess the outdoor thermal conditions in the major fields of human biometeorology by a one-dimensional quantity summarising the interaction of environmental temperature, wind speed, humidity, and long-wave and short-wave radiant fluxes. • Uses "UTCI-Fiala", an advanced clothing model	Study Example: Place: Melbourne, Australia Features: Oceanic climate Study area: Urban Park Season: Summer (Motazedian, et al, 2020)

Table 2: Definition of thermal indices by creators and authors

A case study conducted in Erzurum, Turkey, showed the comparison of several urban settings of relative humidity (%), air temperature (°C), MRT, and PMV, reflecting that the microclimate parameters are directly affected by the urban geometry and vegetation (figure 6). In cities, green spaces are a regulatory role and establish positive microcirculatory effects in different seasons with positive environmental aesthetics and economics (Nouri, 2017). The study reflected that urban areas with trees have better thermal comfort than the simulated model without trees in both summer and winter. The

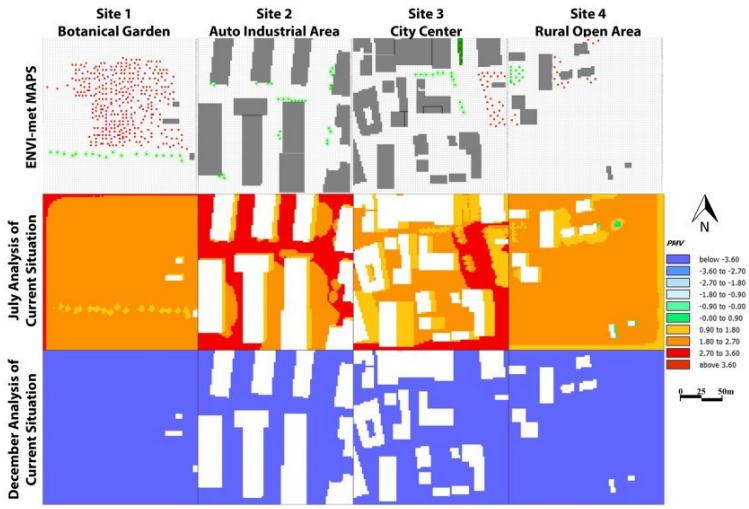

Figure 6: The PMV maps of four different areas studied (Yilmaz et al, 2018)

planned model of UGOS can generate healthy urbanization. Pilot and comparison studies done by researchers in Hongkong and Singapore address optimization of microclimate conditions such as shading, cross-ventilation, and thermal comfort to facilitate longer stays and use of therapeutic functions as indicators and questioner surveys (Xue et al, 2017). The Singapore participants addressed visit preference in the early morning, while Hong Kong participants preferred to visit in the afternoon. Due to the divergence of daily temperature, the duration of stay of participants from Hong Kong is significantly longer than those from Singapore. Therefore, the preference for outdoor activities in UGOS is relevant to microclimate conditions.

2.5 SOCIAL ENVIRONMENTAL AND ECOLOGICAL WELLBEING

Different series of outcomes, such as exposure to environmental risks, health and wellbeing, lifestyle and behavioural aspects, social equity, and quality of life, in general,

can be significantly affected by UGOS interventions (WHO, 2017). Similarly, it is important to design well for green public open spaces, but often the ambitions are not met by reality (CABE, 2004). Nonetheless, a high-quality open space can offer extensive economic, social and environmental benefits to the local communities (Khalid, 2019). Different built environment components such as surface covering, evapotranspiration of vegetation, and shading by artificial objects and trees extensively affect the outdoor thermal environment (Mahmoud, 2011). A well-designed UGOS reduces the heat-absorbing surface, brings solar protection, and increases cooling by shading and evapotranspiration. It mitigates air pollution microclimate issues, filtrates air pollutants, and enhances species diversity and composition and cultural and educational values

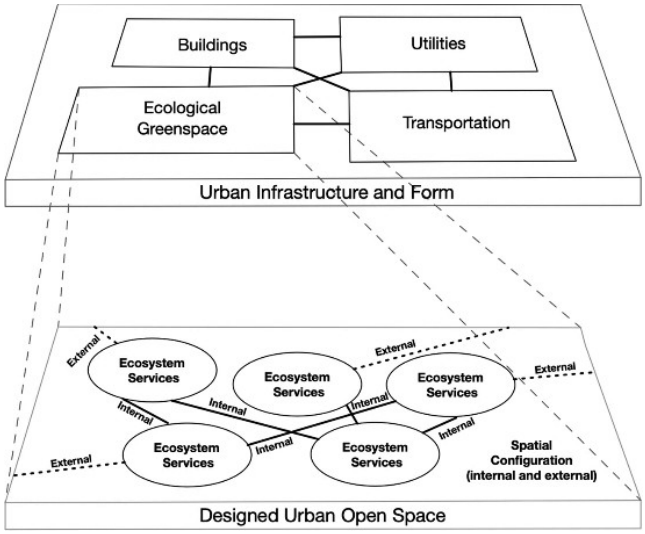

Figure 7: conceptual system of UGOS comprising two main objects (i.e., ecosystem services and spatial configuration (internal linkages and external linkages) (Wang and Foley, 2021)

(Semeraro et al., 2021). A pilot study conducted in Dublin, Ireland, assessing the performance of UGOS, the study indicated the integrated The Economics of Ecosystems and Biodiversity (TEEB) services of two urban parks (figure 7) (Wang et al., 2021)and the Hierarchical index system (HIS) concept was derived from the Socio-ecological system (SES) theory which defines "resilience as a product of (1) the amount of perturbation a system can endure without losing its key functions or changing states, (2) the system's ability to self-organize, and (3) the system's capacity for adaptation and learning" (Meerow et al, 2019).

Similarly, a resilient UGOS can be evaluated to align with this definition and social contexts. Table 3 represents the ecosystem services directly linked with a good quality UGOS. Different ecological benefits, such as shading, air cooling effect, and airborne particulate matter filtering, reduce energy use and improve cities' environmental quality. Walking and green pathways also reduce global CO2 emissions due to active travelling. Reviewing microclimate factors and revealing ecological dimensions of compared case studies can extend the existing evaluation method and enhance resilient thinking in UGOS design guidelines under diverse scenarios.

Types of services in TEEB		Ecosystem Services
Provisioning Services	*2*	*Water (e.g. for drinking, irrigation, cooling)*
	6	*Ornamental resources (e.g. artisan work, décorative plants, pet animals, fashion)*
Regulating Services	*7*	*Air quality regulation (e.g. capturing (fine)dust, chemicals, etc)*
	8	*Climate regulation (incl. C-sequestration, influence of vegetation on rainfall, etc.)*
	9	*Moderation of extreme events (eg. storm protection and flood prevention)*
	10	*Regulation of water flows (e.g. natural drainage, irrigation and drought prevention)*
	11	*Waste treatment (especially water purification)*
Cultural and Amenity Services	*18*	*Aesthetic information*
	19	*Opportunities for recreation & tourism*
	20	*Inspiration for culture, art and design*
	21	*Spiritual experience*
	22	*Information for cognitive development*

Table 3: Directly linked ecosystem services provided by UGOS

2.6 CLIMATE-FOCUSED KEY PERFORMANCE INDICATORS FOR URBAN GREEN OPEN SPACES

Different evaluations attempted by the researcher for UGOS through scoring, weightings, assigning variables and measuring criteria are often reflected as an open space index. The researcher creates these indexes to find out the optimality of POS and UGOS. An indicator provides a clue to a matter of larger significance or makes a trend or phenomenon perceptible that is not immediately detectable. It reveals and gives evidence, and its significance extends beyond what is measured to a larger phenomenon of interest (IJC; Indicators for Evaluation Task Force, 1996). Inclusiveness, meaningfulness, safety, comfort, and pleasurability these five fundamental attributes of open space were identified by Jan Gehl (GEHL, 1987). A researcher applied the framework for creating an

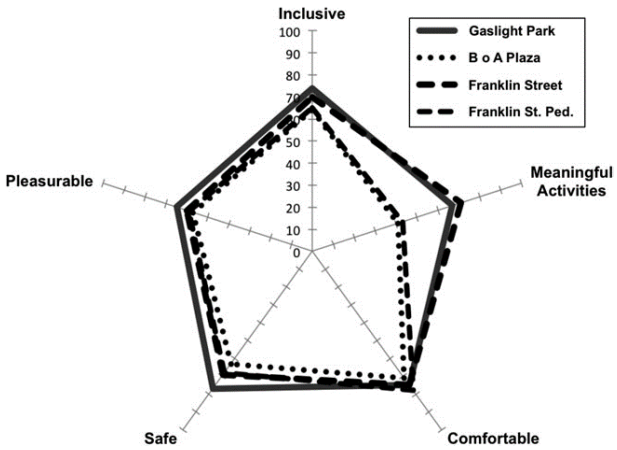

Figure 8: A comparative visual display of the results of the public space index for four spaces in downtown Tampa, Florida adopted from framework suggested by Jan Gehl (Mehta, 2013)

open space index in chosen case study areas (Mehta, 2013). The author evaluated the public spaces with the public space index through observance and data entries with these five dimensions. Around forty-five variables were used in this index; among these, thirty-two variables are observable, and thirteen are perceptual, which depends on the selected space types. From scale zero to three, the evaluation of the variables is weighted, and the process is based on the empirical work of public spaces directed by the author.

On the other hand, the research mentioned in the previous chapter used a Hierarchical index system (HIS) to evaluate the performance of urban parks. It demonstrates the applicability of ecological and socio-environmental attributes to the evaluation model (Wang et al., 2021). Placemaking is also another way to measure the qualities of public UGOS with a sustainable design approach. (Nouri, 2017). However, aiming on climate resiliency with existing qualitative research on user experience with socio-environmental quality still lacks the true contribution of UGOS in the era of climate change emergency. Different city strategies have started auditing and evaluating the UGOS and POS at the city level, but the local scale commitment is often missed out, which results in the abduction of UGOS in the trend of urbanization. A climate-focused quality matrix or key performance indicator for UGOS can seek to capture quantifiable measures and subjective dimensions of sustainability. Furthermore, a set of standard benchmarks (KPIs) can develop the reflective principles of sustainability and climate resiliency. It can be contextualised from the individual perspective of an eco-engineering project through stakeholder consultation or engagement (Nouri, 2017).

2.7 RESEARCH GAP

Firstly, the risk of insensitive urban growth and retrofitting major infrastructure and landuse change underlines the limitation of UGOS planning and design practice consideration. The UGOS adequacy is often expressed in standard by the book (9 square meters per person by WHO) rather than site-specific requirements and inter-relationships with socio-environmental criteria. Moreover, at the local scale, the study of UGOS is insufficient to provide and link the wider variables of climatic perspective and spatial and ecological configuration.

Secondly, the UGOS integration in the planning process is not adequately utilised as it does not provide immediate service and is left to be the end bit of elements in the design and construction process. More evidential proof of the importance and benefits of integral sustainable UGOS needs to be spread at the policy and ground levels by prioritising human well-being and nature conservation to tackle future risks and management costs.

Thirdly, different research work emphasizes the user's reflection and experiential qualities of UGOS. The thermal comfort and microclimatic performance analysis of UGOS are based on existing green parks and open spaces. However, the contribution of green

infrastructure, spatial configuration and green space must be linked with the evidential micro-climatic performance of UGOS, especially on the neighbourhood scale, for future planning consideration of new UGOS. It can also advocate for preserving more green coverage in increasing urban areas.

In recent years COVID-19 and climate change facts resulted in paranoia and prejudice against restriction and inadequate UGOS for social health and inequality of access as a third place (UN-Habitat, 2020). The impact is being considered Therefore, more standards and applicability of different types of UGOS and their functions can come forth through scientific evidence and research analysis to highlight equal accessibility for all users, especially vulnerable ones. Furthermore, heat wave events are a primary concern, and how outdoor thermal comfort and activities during such events should be measured with high priority.

CHAPTER 3 CASE STUDY

3.1 GLASGOW CASE STUDY SELECTION

The research involves outcomes and deficiencies of established strategies related to open space provision in site-based scenarios. A detailed literature review has shown the contextual interest in evaluating UGOS quality aligned with the uprising concerns of the climate change impacts in Glasgow city. The case studies are substantial to see the applicability of climate resiliency and an overview of the resurgent general topic of UGOS

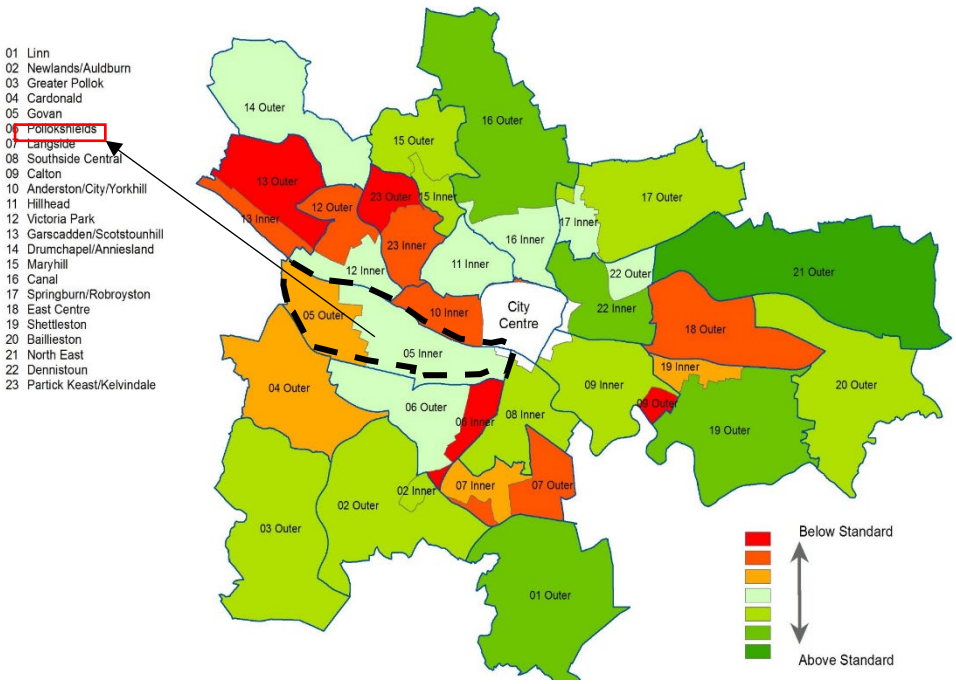

Figure 9: Quantity Standard by Ward and Part of Ward by GOSS 2020 (Source: GCC)

planning. Neighbourhood scale UGOS often risk abduction by increasing land cover conversions. Two UGOSs have been found to carry out the research, and both are in a similar administrative area, Govan, the 5TH ward among 23 wards of the Glasgow municipality area. The Govan area is located at the southwestern bank of the Clyde River, where the city's industrial revolution emerged. It has been undergoing through multiple post-industrial urban regeneration projects for the last few decades. According to GOSS 2020, the outer part of the Govan ward is marked as near below standard level for publicly usable open space. In contrast, the inner part shows a moderate standard level. This combination enables the two types of case studies in two different quality levels within a similar statistical configuration and administrative boundary. The scope of research broadens by choosing this area as it facilitates insight into the current growth of city development and the impact on the existing and future UGOSs of the Govan area.

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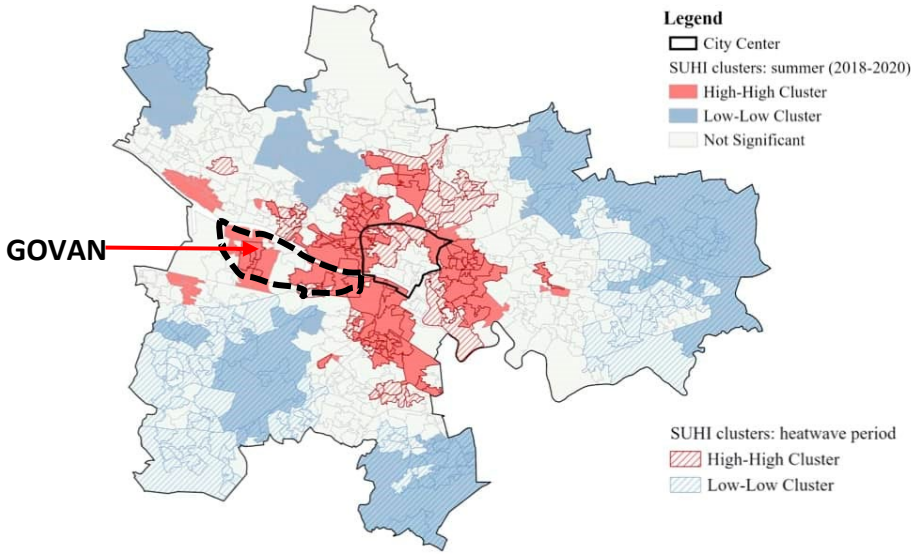


Figure 10: Surface urban heat island (SUHI) map of Glasgow during a heatwave (25.6.20180). High-high cluster represents the zone of high land surface temperature (Source: Emmanuel, 2021)

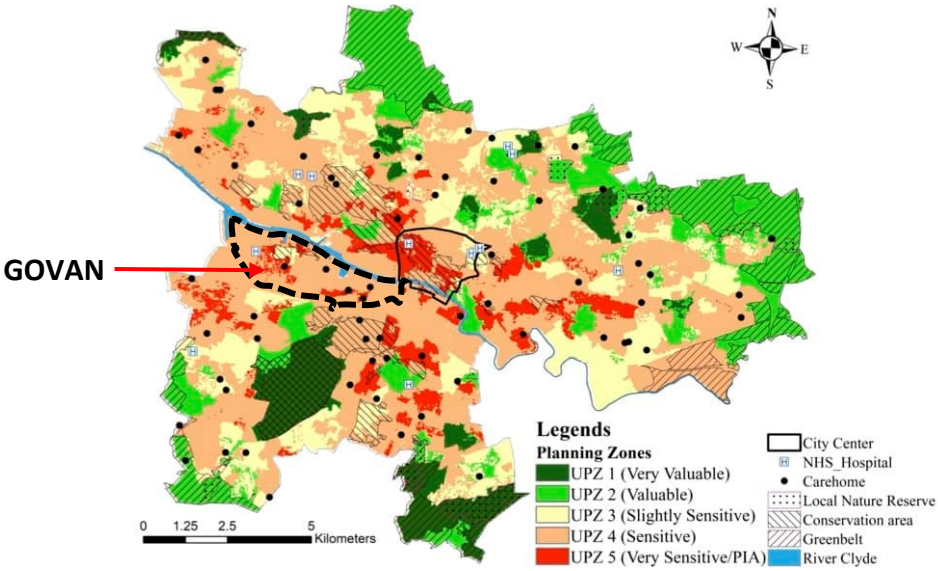


Figure 11: Urban climate action recommendation map for Glasgow (Source: Emmanuel, 2021)

To adapt to climate change impact, the microclimate, which is influenced by local surroundings and climate context, the assessment in this location will portray the contribution of UGOS, which also meets the research objective. Furthermore, the selection of case studies has the relevance of measuring the micro-climate resiliency and environmental impact due to the placement in heatwave prone zone and sensitive zone according to the Surface urban heat island (SUHI) map (Figure 10) of Glasgow during a heatwave (28th June 2018) and the Urban climate action recommendation map (Figure 11) (Emmanuel, 2021). The intention was to compare an existing typical UGOS park (The Festival Park) and an ongoing institutional UGOS park (Queen Elizabeth University Hospital Central Park) on a similar scale with nearer built environment features within a common administrative boundary. The two-case study meets the required urban setting

for the research purpose. The detail history and background of the two sites are given below.

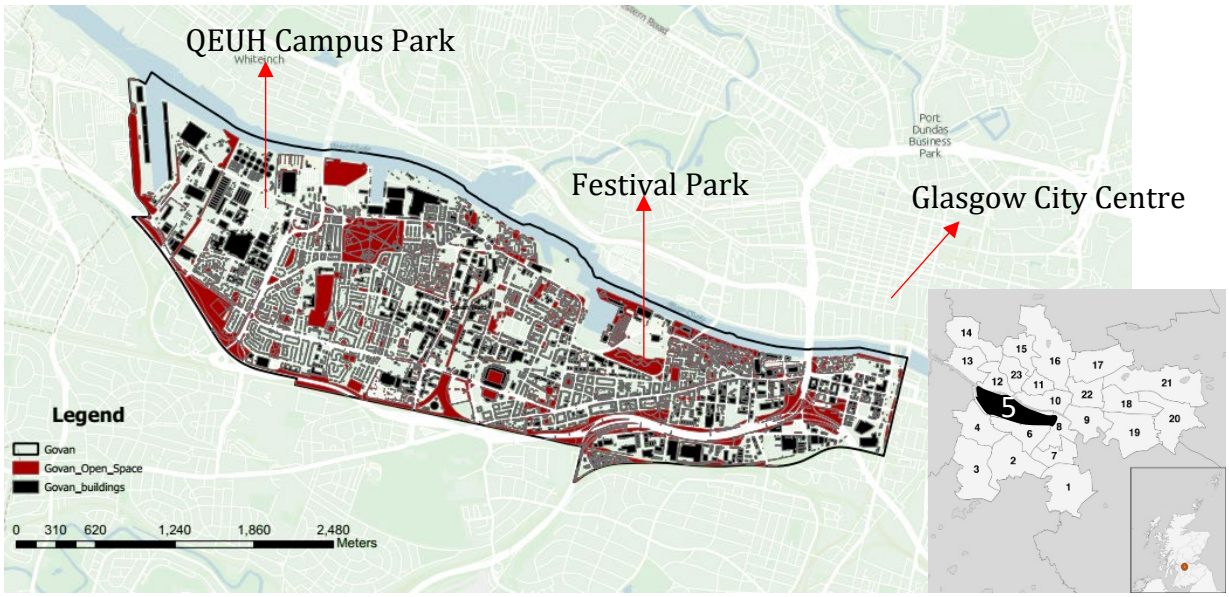


Figure 12: Location of Govan ward and the two selected sites (by author)

3.2 UGOS BACKGROUND AND HISTORY

3.2.1 FESTIVAL PARK AS A PUBLIC OPEN SPACE

The site has a unique history of a grand international event, "Glasgow Garden Festival" held in 1988, including the Princess Dock basin, Clyde southern bank and Govan area for improving its image and economic development (National Audit Office, 1988). The concept derived from Germany's first garden festival in 1937, which was applied to repair post-war damage and derelict green land to develop something permanent afterwards (John Heeley, 1988). The Glasgow event covered 120 acres, including 17 of the waterbody, and it took place for 152 days by attracting 4.3 million visitors led by the Scottish Development Agency (Glasgow City Council , 2007). It accommodated a 60-acre area of horticultural retreat allocating 112 gardens containing thousands of shrubs, trees and plants cultivated from Scotland and other recreational arrangements. The site was meant to be developed as a commerce and leisure area and was renamed, Pacific Quay. The city council kept around 11 hectares of remaining green bodies designated as public amenity parks. Whatsoever Glasgow claims to have more numerous parks and open spaces than other neighbouring cities. It appears that it was difficult to sustain the vast coverage of the area by keeping it with festival garden functions (Diamond, 1996). Besides the park area, it was a vacant, derelict grass land for a long time due to ownership challenges, except around the 2000s, the Pacific quay master plan was developed (Varna, 2014). A few decades later, the overall area was planned to convert the park to residential and economic development zones. Today the remaining Festival Park area is around 4 ha

(Source: Pan65 Open Space). The former part of the festival park is under the regeneration project, which is the Creative Clyde public amenity development and industries under the Clyde Waterfront project. The new development has housing, a service area, a hotel, retail, restaurants with a connection and new access points to the park and greenspaces around the new residential development (Clyde Waterfront, 2022).

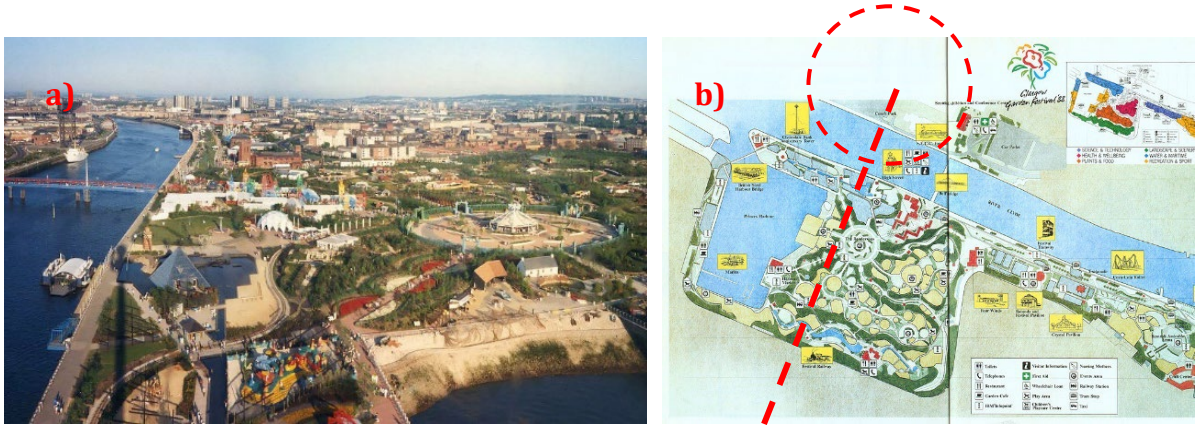


Figure 13: a) Garden Festival Event Masterplan and b) Event Aerial Image in 1988 (Source Internet)

Figure 14:Festival part in year 2002 b) Festival Park in year 2020 (source: Google earth)

Associated Developers	Functions and features	Materials/Specifications	link
Village Hotel (Completed 2015)	a. Hotel b. Restaurant c. parking	a. 1.28 ha area (approx.)	
Stewart Milne Homes, Overseen by Haus Architects (Ongoing), (Planning application January 2018)	d. A residential scheme of 203 dwellings: a mix of townhouses, colony-style housing flats, e. Seating, avenues of trees, blocks of ornamental planting, f. Core space area for amenities	b. 2.5 ha area (approx.) c. red, grey, and dark brick, metal panels and stone	https://www.haus-collective.com/design/pacific-quay/
Surplus Property Solution, overseen by Ryder Architecture Ltd (Ongoing) (Planning application April 2022)	a. 43 dwellings, b. units for retail, offices, and cafes c. 50 parking spaces d. Open spaces/park spaces	a. 0.48 ha area b. Not built yet	

Table 4: Detail associated housings development and undergoing projects on previous area of Festival Park

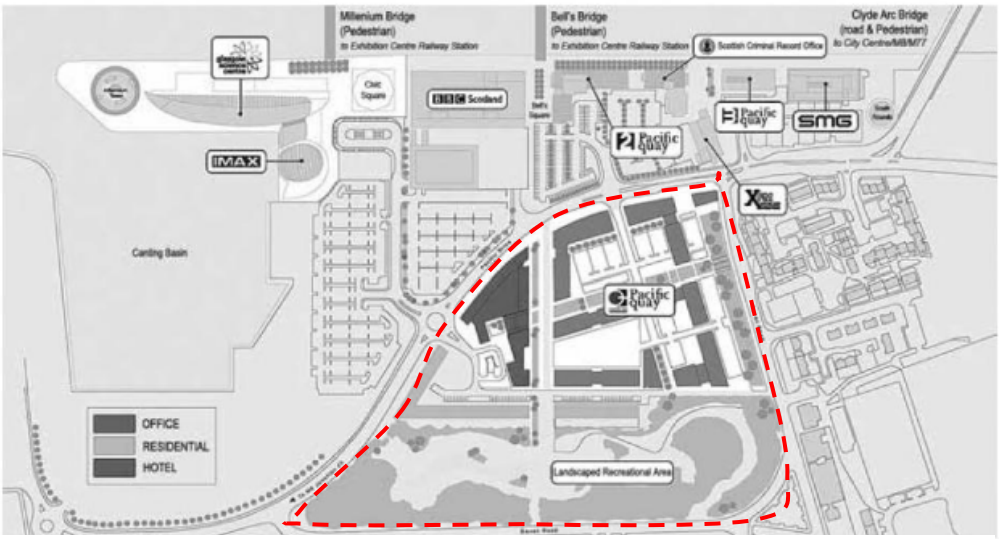


Figure 15: Master plan of Pacific Quay project in Old Festival Park (Source: Pacific Quay Project)

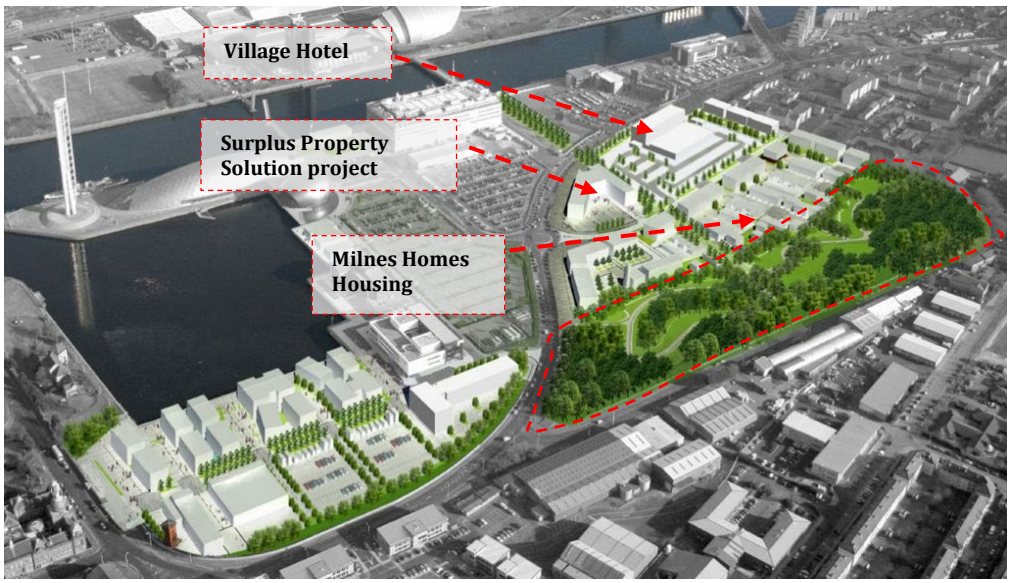


Figure 16: Aerial view of housing projects in Old Festival Park (Source: Pacific Quay Project)

3.2.2 QEUH CAMPUS AS INSTITUTIONAL URBAN GREEN OPEN SPACE

The Queen Elizabeth University Hospital (QEUH) premises holds a rich historical background, known as Govan Combination Poorhouse, built-in 1872 with a poorhouse, asylum, and hospital. Most of these functions were relocated before 1905s new additions and over 250 years of timeframe. The old Victorian approach of agrarian landscape setting was rooted in the landscape for users' food, exercise, and therapeutic functions. After industrial growth, rail, and road infrastructure development, the site got landlocked and lost its visual relation to the river Clyde.

Currently, the hospital is named after Queen Elizabeth the second, and it was developed by a large publicly funded grant in 2016. Multiple new functions had been added, such as children's hospital, university campus, emergency department etc. It became operational with a 1677-bed capacity and more than 10,000 working employees. The only civic space on the campus is the "Lollipop Lane" adjacent to the children's hospital, and the remaining open space area has been acted as an unplanned space on the premises until recently. The administrative body has integrated landscape planning to bring proper outdoor space for the users' well-being and reduce the built-environment impact. NHS Greater Glasgow & Clyde has intended to develop Queen Elizabeth University Hospital's (QEUH) existing open spaces into quality UGOS by integrating landscape design. This transition enables the key objectives of this research to compare the existing and proposed landscape improvement features with an existing UGOS, the festival park and reflect the driving factors of planning management and socio-environmental performance of UGOS.

The proposed landscape design concentrated on active travel, biodiversity, wayfinding and navigability, and creative functions/public art for the staff, patients, visitors, and nearby habitats. However, the new design approach is limited to the open space only and refurbishing the existing SUDS pond and greening parking area. The ratio between open space and built environment is quite the same as before, but the landscape design will logically enhance the socio-environmental quality of the campus. Generally, the standard of healthcare facilities is high as other NHS hospital sites, such as the royal Edinburgh Hospital, which was recently awarded the Green Flag Award (discussed in chapter 2) in 2021 because of its mission of mainstreaming green infrastructure in the placemaking principle of the UK. Also, Forth Valley Royal Hospital and Larbert Woods in Falkirk were awarded the Building with Nature National award because of their high-quality green infrastructure and landscape planning.

Therefore, QEUH strongly aids the thesis objectives as the whole process can be evaluated in retrospect of exiting UGOS and the impactful contribution to finding potential indicators of developing a resilient UGOS in relation to the uprising-built environment and climate change risk in Glasgow city context.

Figure 17: Satellite view of QEUH in 2002 (source: Google earth)

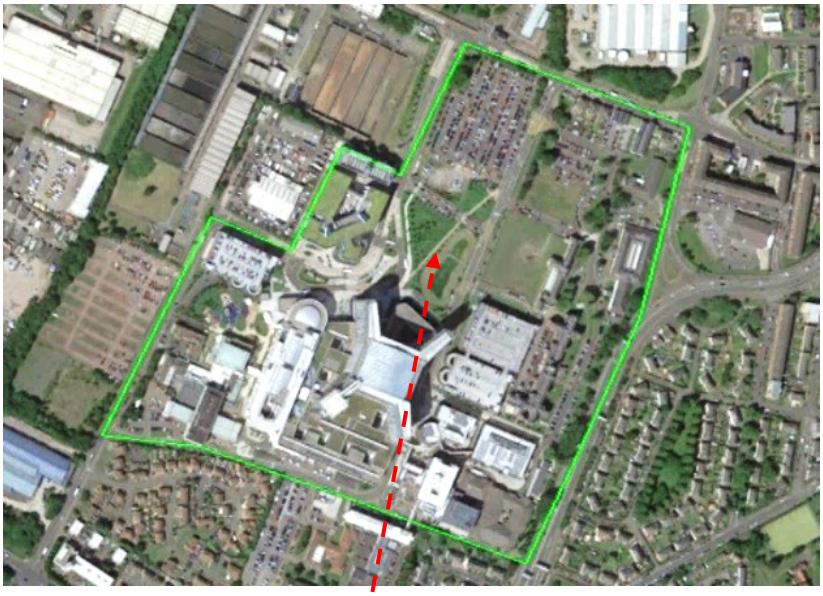


Figure 18: Satellite view of QEUH in 2022(source: Google earth)

Figure 19: Hospital Building and existing scenario of QEUH open space (photo by author)

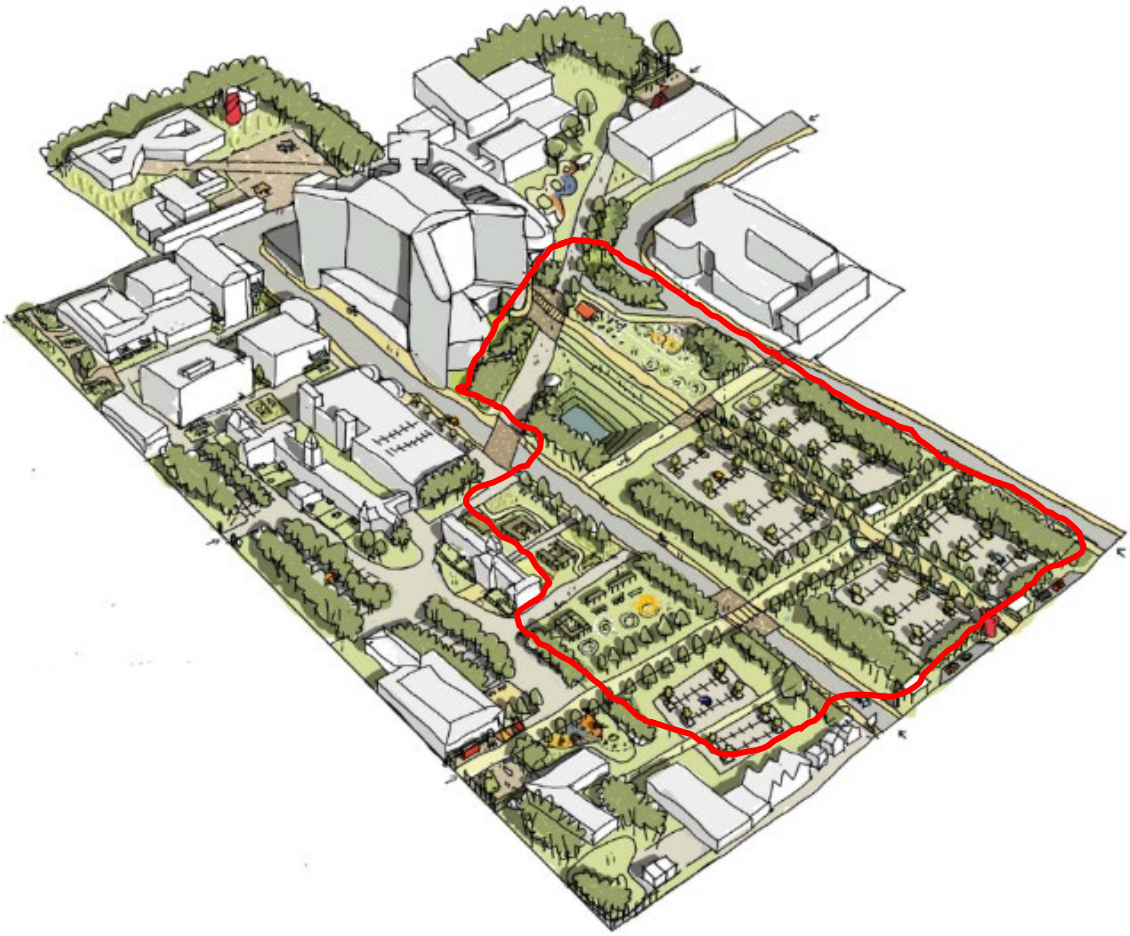


Figure 20: Proposed and landscape design by NHS Greater Glasgow and Clyed (NHSGGC) (source: NHS & ERZ studio)

Figure 21: Ongoing construction of greenspace development in the QEUH campus park (photo taken by author 2022)

CHAPTER 4 METHODOLOGY

4.1 RESEARCH FRAMEWORK

This chapter focuses on the outline and framework of the research. The indicators related to enhancing the quality of UGOS will finally assess the optimality of selected case studies. The research question is as follows: How to achieve the integral framework concept derived from comparing two influential UGOS in terms of climate resiliency and Socio-environmental quality? Can an optimal UGOS mitigate the climate risk in increasing urban areas? How can we use UGOS to improve our environment?

The research is based on case studies because UGOS depends on the specific geographic condition, urban morphology, culture, and spatial distribution. However, it aims to find out a general contribution of quality-urban-green spaces which are publicly accessible. Selected case studies are relevant to analyse as they show both phases of vacant open space and a designed open space that can transform into an influential public park. The current situation questions the common interest in contributing to holistic design development nature. Through an abductive approach, the research topic finds the scope of work in different groups and criteria that are fundamentally entwined with UGOS division and design decisions. Such criteria include collaborative stakeholders, nature-based planning, biodiversity restoration in the city, users' mental health and thermal comfort, sustainable urban growth, etc.

The applicable criteria follow suitable case study selection to serve the research purpose. The deductive approach finds out the microclimate situation of parks and key performance indicators integrated with socio-environmental and ecological factors. The base case simulation creates the comparative analysis in terms of climate resiliency effectivity during the hottest day using ENVI-met.

Secondly, the comparative analysis with extensive field study creates the ideal conditions and performance of selected indicators through sound microclimate simulated situations and finds the common theme of developing the UGOS in general. It is comparison research with the proposed simulation. Re-thinking the indicators and creating the quality microclimate simulation results in the holistic quality features of UGOS.

Both quantitative and qualitative methods are conducted throughout the research. Experts' opinion, traverse survey on two hottest days, city profile from the weather station, represents the quantitative method. Ultimately it asses the performance out of comparison of two cases which answers the research questions. Finding sustainable KPI indicators and ecosystem services has consisted of both methods.

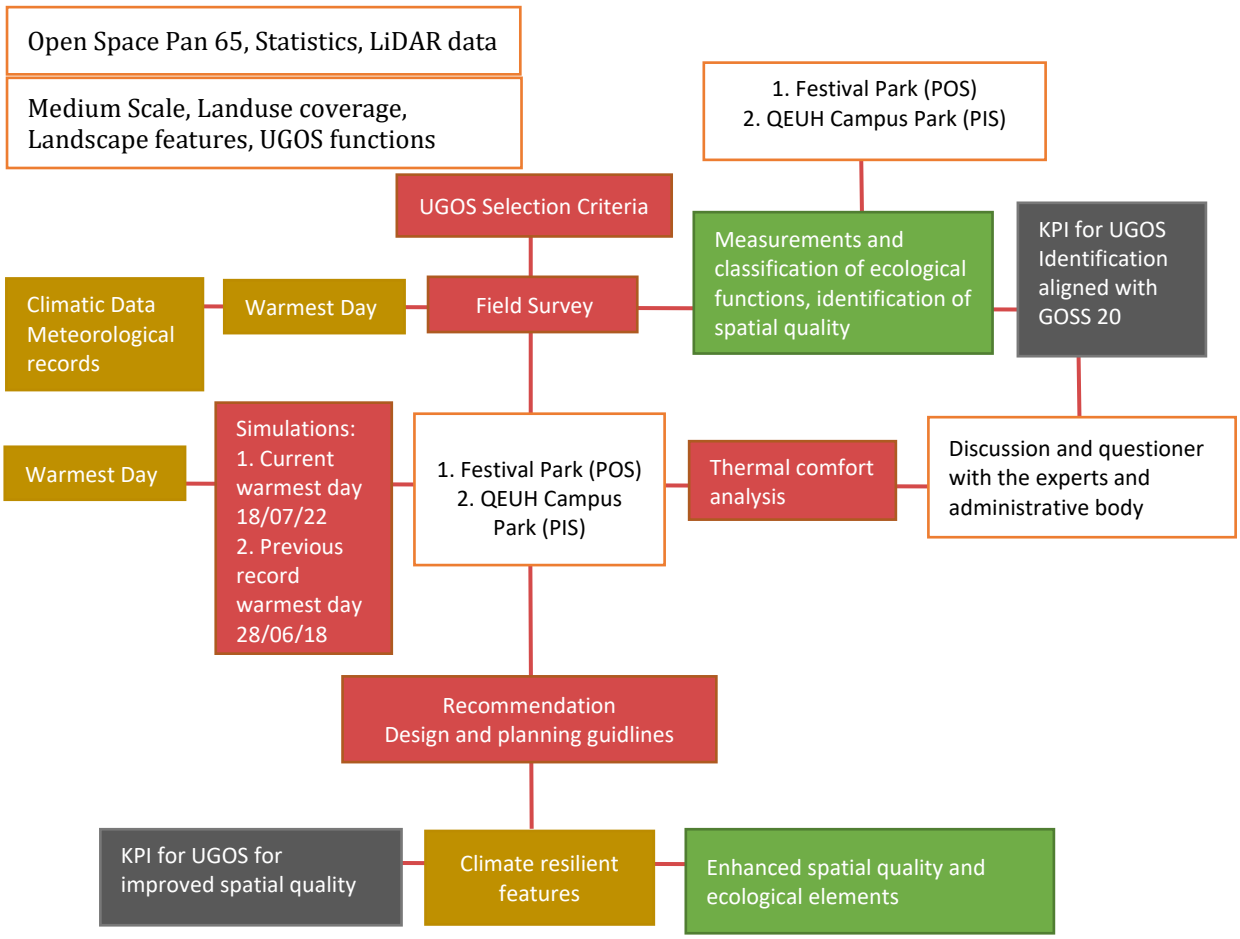


Figure 22: Design Diagram table of Research Framework (by author)

4.2 DATA SOURCES

Due to site-based analysis, most of the data are derived from the Traverse survey and site observation. However, base findings are conducted by holistic analysis of existing data sets. Part of the data initiated the Selection of Site and statistical information for literature review. Table 5 represents the collected data from open source and by application to the administrative service and associated people with ongoing development in the case study area. British National Grid (BNG) has been used as a coordinate system for raster and vector files.

Data Type	Data	Information	Source	Format
Climate	Meteorological Data: Met Office Hourly Observation Data 2018-2021	Temperature, Humidity, Wind Speed, Cloud Cover	Met Office Uk (Haduk Grid)	Excel (.csv)

	Traverse Survey, Micro-Climate Measurements	Measurements	Google Earth, Self-visit	Photos, (Kestrel, Tinytag)
Socio-environmental	Ward boundary GIS	Glasgow Ward Demarcation	Glasgow City Council	(.shp)
	Master Map GIS	Building footprint and building height	EDINA Digimap Ordinance Survey Service	Cad(.dwg) Vector (.shp)
	Open Space Pan 65 GIS File	Open Space and Open Space Categories	Pan 65, Open Source	(.shp)
	Built-Environment, SIMD	Historical Data, Statistical Data	Urban Big Data center (UBDC)	(.shp) Excel (.csv)
Ecological	Proposed Landscape Plan (QEUH)	Masterplan, Site Analysis, Functions	Erz Landscape Studio, NHS,	Cad (.dwg) (.pdf)
	DSM, LiDAR	Topographic elevation, Point cloud data	Urban Big Data center (UBDC)	Shape file, LAS file

Table 5: Data Source and Collection for climatic, socioenvironmental, and ecological analysis (by author)

4.2.1 Meteorological features study

The meteorological background of Glasgow was obtained from the Glasgow International Airport weather station located in (55.87 °N, 4.43 °W) western part of the city (Renfrewshire) and by accessing UK Meteorological Office hourly weather records (January 2018 – July 2022). The weather data analysis portrays the temperature variation over time due to climate change, the instability of temperature, and past extreme climate events. It aids the objective which is to find required thermal comforts and the performance of urban parks with green cover in the city.

The primary intention of conducting the survey during summer is based on the past and forthcoming scenario of heatwave days in Glasgow, and the thesis time frame was a relevant period in that context. Concern rises as the heatwave threshold temperatures scenario 'exceeding 28 °C and not decreasing below 15°C' will often be happening in the future period of the city (Shane O'neill, 2019). The fluctuating temperatures can impact a large population and many healthcare-related issues, including vulnerable groups of people, society, and the environment; therefore, it will be necessary for this research. Thus, past and current warmest day microclimatic condition surveys became part of the research area.

4.2.2 SPATIAL STRUCTURE, SURFACES AND VEGETATION STUDY

The scope of the research topic is extensive due to open space being combined with both thermal comfort and ecological benefits for its users. To assess and identify the best outcome, key data such as shading, tree elevation, waterbodies, and physical elements are essential in the case studies. Digimap's Ordnance Survey data from Glasgow City Council were used to identify the current Landuse cover of the two case studies. Urban Big Data Centre (UBDC) from the University of Glasgow provided the required data with Light detection and ranging (LiDAR), and it has been used for shading and vegetation analysis and built structure modelling. The binary format or LAS was extracted from the airborne LiDAR data, and Digital Surface Model (DSM) for both cases studies were created. This part of the methodology is limited to existing data and site-specific features.

4.3 ADMINISTRATIVE EXPERTS' OPINION

Jan Gehl assessed public open space into different criteria which are divided into three groups: protection, comfort, and enjoyment with associated environmental elements (Gehl, 2010). Consequently, to act as a catalyst for the redevelopment of a neighbourhood or a city, the selected UGOS should be accessed regarding their spatial configuration and ecological performances. This research methodology includes semi-structured interviews with associated administrative body or stakeholders to identify the KPI for UGOS. Discussing possible quality enhancement for future planning and distribution UGOS in a sustainable and climate-focused design is essential. The discussion explains the general scenario of UGOS in the 21st century. The site-specific reflections from this questionnaire method can identify the common risk and inadequacy of a transitioning institutional UGOS such as QEUH site and remain historical and park type UGOS such as Festival Park.

4.4 IDENTIFICATION OF KEY PERFORMANCE INDICATORS FOR UGOS

European Environment Agency (EEA) defined Indicators as a tool of quantitative measure that is used for demonstrating and communicating complex phenomena through trends and progress over time (EEA, 2005)[1]. Integrating Key Performance Indicator (KPI) is a suitable method to find a direct link with Ecosystem Services (ES), SDG goals and Glasgow Open Space Strategy (GOSS) for site-based UGOS case studies and in general observation of UGOS quality. However, the indicators are based on verifiable data and are effective for measuring, monitoring, and communicating, which have no pre-defined sets of universally applicability (Martin Rutzinger, 2019). The focus and objectives of identifying KPI will derive the key objectives of this research in Festival Park and QEUH campus greenspace management. The KPI for UGOS in this research is rooted in the given Quality Assessment Matrix by the GCC strategy audit indicators in the GOSS

[1] *"An indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. An indicator is a sign or symptom that makes something known with a reasonable degree of certainty. An indicator reveals, gives evidence, and its significance extends beyond what is measured to a larger phenomenon of interest" (Donnelly et al., 2007)'*

2020 (GCC, 2020) report (shown in table 6) and the relevance of the selected case studies. The need for re-evaluating mentioned auditory indicators in GOSS 2020 does not entirely reflect the holistic driving factors of a climate-resilient park or urban green cover yet, due to the gap between policy level ambition and on-site development

Indicators	*Key Definitions*
A) Size	*Area Coverage> 0.3 ha*
B) Configuration	*The usable shape of area for all groups of users; less deformed space (e.g., long, thin, irregularly, or steeply sloping spaces); exceptions can be incorporated for key roles*
C) Surveillance	*Visibility of Key area from surroundings; potential secluded area for biodiversity.*
D) Accessibility	*Wider connection; DDA compliant access; easy direct maintenance access; key entrances benefited from lighting on external road/path.*
E) Aspect	*Direct sunlight; planting shade.*
F) Place Quality	*User's wellbeing through space with plantation and landscaping; wider contribution and amenity value to the neighbouring space.*
G) Use	*A range of active and non-active uses, including (Gi to Gvii)*
Gi) Informal sport/recreation	*Balance of flat or gently sloping well-drained space*
Gii) Children's play	*Children's play area; natural and imaginative play*
Giii) Relaxation	*Quieter area away from sports area but closer to children play area with possible surveillance, relaxation and meeting place, seating, and bins in proximity.*
Giv) Biodiversity	*A variety of connected habitats, and different plant and animal species.*
Gv) Maintenance and Condition	*Routine maintenance (grass cutting, litter clearing etc.); well-maintenance and usable condition.*
Gvi) Water Management	*Requirement for natural flood water management.*
Gvii) Community growing/ allotment space	*Space for allotments/community growing where applicable.*

Table 6: Quality assessment matrix and key descriptions of GOSS 2020 (by GCC)

The two case studies have a similar status regarding ongoing built environment development projects, and the impacts concern the future of the selected UGOS. A pragmatic approach will be followed for KPI identification based on UGOS relevant indicators with integrated climatic, ecosystem-service provision, ecological factors and associated interviewed administrative expert's views. This approach has been adopted from standard and best evaluation guidelines without passing a judgment on whether the project is breaching the limited resources because it would be an example of a case such as strong sustainability definition as ecological footprint (C. Raudsepp-Hearnea, 2010).

4.5 TRAVERSE SURVEY IN PARK TYPE AND CAMPUS TYPE UGOS

The study was conducted to assess the microclimate effect on a neighbourhood scale in selected case studies and to compare different aspects and, eventually, climatic KPI for assessment and comparative analysis. The survey method will determine the

temperature and relative humidity in summer weather conditions and the calibration of the ENVI-met model. The weather forecast observation selected three dates to capture the maximum heat on those dates. The climate data was collected on the 5th of June at Festival Park during the hottest hour of the day, 15:30, using the Kestrel 3000

Festival Park

5 Points
20 points

Walk path 1120m

Figure 23: Survey map of Festival Park (source: Google Earth)

QEUH Campus Park Area

5 Points
20 points

Walk path 987m

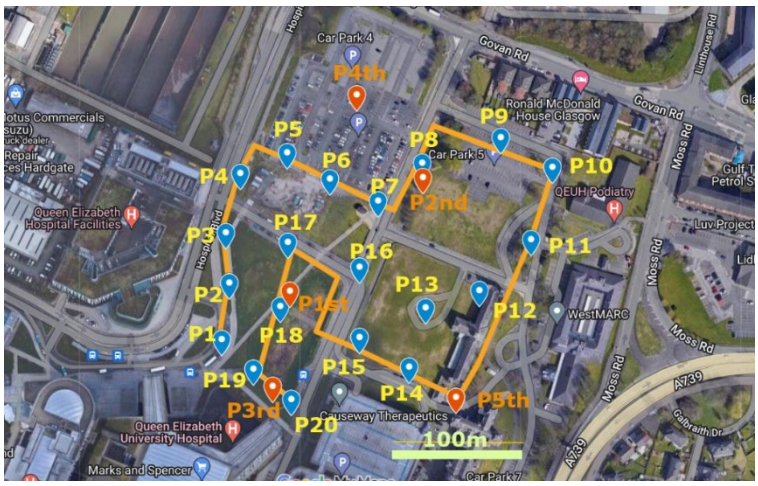


Figure 24: Survey Map of QEUH campus park (source: Google Earth)

Environmental Meter tool; The following day, 6th June, was scheduled for the QEUH site around a similar time and specifications. A walking route was mapped for both sites, which consisted of 20 points to cover different parts of each site and their vegetation cover. Another hot day was selected for additional five points at different times of the day, which determined the variables in terms of the park's inner and outer climatic influence. Among the five points, 3 points are inside the park, and the other 2 points are in the peripheral area of the park. Afterwards, July 18th, 2022, was used to confirm the ENVI-met model performance on the hottest day in the summer season and was considered the peak hour. Temporal correction of data was collected from the fixed station and nearby Paisley (Renfrewshire) weather - Met Office weather station to access the observation at a similar time. A walking route of 110m for festival park and 987m for

SENSOR	ACCURACY (+/-)	RESOLUTION	SPECIFICATION RANGE
Wind Speed |Air Speed	Larger of 3% of reading, least significant digit or 20 ft/min	0.1 m/s 1 ft/min 0.1 km/h 0.1 mph 0.1 knots 1 B*	0.6 to 40.0 m/s 118 to 7,874 ft/min 2.2 to 144.0 km/h 1.3 to 89.5 mph 1.2 to 77.8 knots 0 to 12 B*
Ambient Temperature	0.9 °F 0.5 °C	0.1 °F 0.1 °C	-20.0 to 158.0 °F -29.0 to 70.0 °C
Relative Humidity	3%RH	0.1 %RH	5 to 95% 25°C non-condensing

Figure 25: Kestrel tool 3000 specification (source: kestrel meter webpage)

QEUH park for 20 points measurement was mapped before the survey was completed in an hour. It was done within an hour and peak hour to avoid significant weather changes. However, the other five points were measured in terms of convenience of accessing as the data were taken during various times. During the survey, the Kestrel tool was held around 2.5m over the ground level and noted down the readings in the notebook. For additional five points, the data was taken during morning, noon, afternoon and evening, and after sunset to see the differences in individual settings.

Figure 26: The tiny tag tool and the fixed station near a visual distance and in a quiet, area near eastern part of Glasgow (by author)

The temperatures and relative humidity readings taken from the traverse survey were corrected using the fixed station to get the temperature difference due to any sudden change of weather that might occur during the survey. It was created with Tinytag and a weather shield probe on a vertical post within an observable distance. Tinytag is a temperature data logger which was calibrated to take data every minute. The Linear Regression method was used in Microsoft Excel for the correction method.

4.6 MODELLING AND SIMULATION

For finding climate indicators and analysing the impact of urban green space, ENVI-met software was used to generate a three-dimensional microclimate model and simulate the park environment in different scenarios. The existing built environment and park setting were developed in 3D modelling Sketchup software, and 2D modelling Autodesk AutoCAD software was used. The building heights were taken from open-source 3D model data from Glasgow City Council. Different measurements of buildings, pavement, and plantation types were replicated in the 3D modelling from field survey observation and raw data collection from administrative sectors. Extension programs ENVI-met INX has been used in SketchUp Modelling that worked as a link (plug-in) with the ENVI-met model. Eventually, through Leonardo 4.4.5, 2D simulated maps were visualized and extracted from ENVI-met binary result files. The limitations chapter discusses the relevancy and accuracy of the data.

4.7 COMPARISON RESULTS AND INTEGRATION OF KPI FOR UGOS

Various scenarios were created to calibrate the final KPI for the high-quality performance of the QEUH site. Base case simulation and proposed landscape planning setting in the QEUH site were compared with the Festival Park setting through the KPI framework and the traverse survey data. Also, the proposed simulation from ENVI-met modelling and KPI assessment derived the future performance of the site.

4.8 DISCUSSION AND RECOMMENDATION

Validation of KPI for UGOS, based on microclimate comfort and spatial and ecological analysis, is this paper's end result. It validates the importance of climate-focused open space planning on a neighbourhood scale through the relevancy of microclimate influence, spatial integration with the built environment and collaboration of stakeholders and users for designing and planning for park type and campus type UGOS. Microclimate model simulation in both case studies and comparative analysis methods summarized the recommendation for future UGOS provisioning.

CHAPTER 5 ANALYSIS AND RESULT

The analysis chapter reflects collected data from the survey and multiple methods discussed in chapter four, the methodology part. Mentioned data source in the previous chapter has been used for the self-elaboration of two case studies with a comparative approach. The focus of this analysis is to relate different aspects of public open spaces placed in similar urban morphology but has different priorities, such as a hospital campus case study and a more generic park case study. Climate analysis majorly contributes to this whole chapter and to the result of validating key performance indicators for UGOS and the importance of holistic planning and division for UGOS. After comparing and finding the relevant data, this chapter focuses on the future micro-climate situation of ongoing landscape design, which eventually constructs the recommendation of the existing implemented design and planning approach of UGOS in general. Proposed greenspace development in the QEUH campus case study led by NHS climate adoption planning contributes to the final part of this chapter through different scenarios of climate simulation. Eventually, expert's opinion, socio-environmental analysis projects the important quality indicators for optimal performance of discussed open space types for the recommendation in the following result chapter six.

5.1 OVERVIEW AND COMPARATIVE ANALYSIS OF TWO UGOS

The profile of the two case studies has been derived from multiple research techniques of data collection, such as fieldwork, satellite image classification, proposed landscape planning identification, and ordinance survey map analysis. Table 7 to table 9 provide an overview of QEUH campus open space in terms of overall boundary area and festival park pre- and post-condition. The time era is categorized under the importance of the research topic. Festival Park's green cover impacts growing urbanization, and the park's scale is concise in the present situation. Whereas QEUH campus area open space was unsuccessful in terms of its usability, and at present, it is being developed. These four categories show the action and journey related to the maintenance and planning of these two case studies. The case study part in the methodology chapter shows an understanding of the appearances. The comparative analysis in this chapter establishes the research objectives, which focus on the current development trend of UGOS planning and management.

Fig 27: Festival Park Older Version (Up to 2002)

Fig 28: Festival Park (At present)

Fig 29: QEUH Open Space (At Present)

Fig 30 Proposed QEUH Campus Park by NHS

Criteria	Older version (Up to 2002)	Festival Park (At present)	QEUH Open Space (At present)	ProUGOSed QEUH Cam Open Space (Under construction)
Status	Established in1988 and opened with a historical Glasgow Garden Festival held in the city in 50 years	After 2010 redeveloped by the river Pacific Quay project	Establishment integrated with Hospital and University in 2015	Proposed as Public Park, Ongoing Landscape project
Size and Shape	Before, the total area was around **10.8 ha**	**4 h**a after the new urban development adjacent to the river Clyde bank	**2.6 ha**	**2.6 ha with additional** integrated Landscape area with built infrastructure
Topography type		Flat ground, sloped ground, Shallow waterbody with rocks and plants	Flat ground, sloped ground, ditch/waterbody	Topography type Flat ground, sloped ground, suds pond/waterbody

Table 7 Approximate land surface cover in two case studies based on collected data (by author)

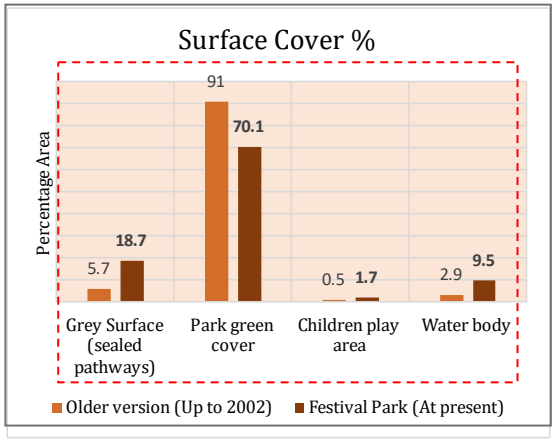


Table 8: Overview of Festival Park area (by author)

Figure 31: a) Grey surface b) Green cover c) Children play, d) Water body at Festival Park (2022) (photos taken by author)

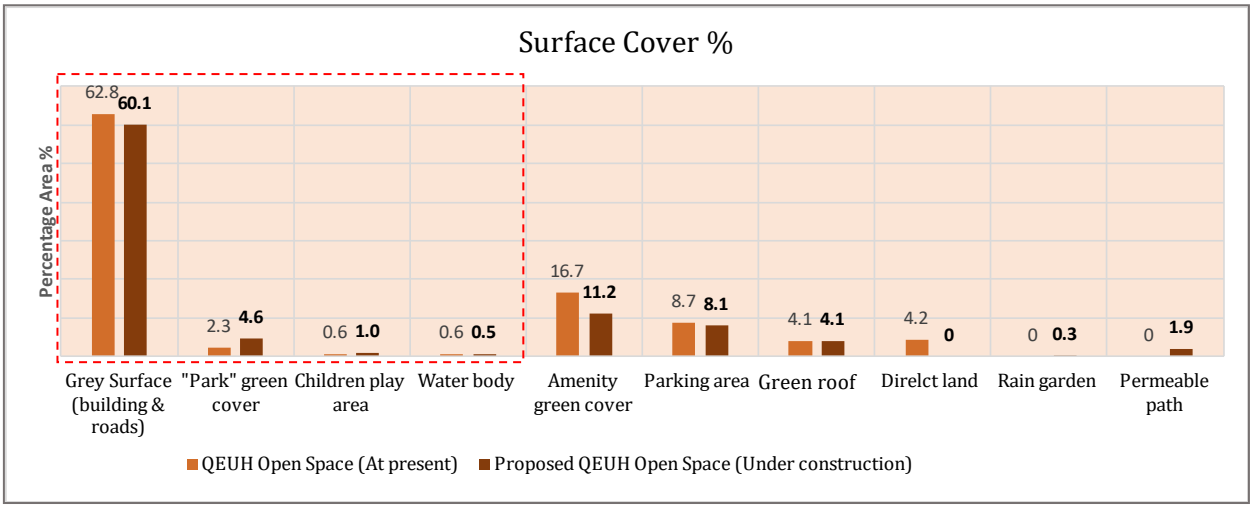


Table 9: Overview of QEUH campus area (by author)

Figure 32: a) Grey surface b) Green cover c) Children play, d) Water body at QEUH campus area (2022) (photos taken by author)

According to Glasgow Open Space Strategy 2020 report, the future use of open space is divided into four categories which are 1) Retained open space, 2) New open space, 3) Redefined open space, and 4) Redundant open space. The definition of categories is shown in table 9 below. Remaining Festival Park lacks the previous green cover and associated ecological benefits from a large natural element as it was before in 2010. For example, previously, the whole area with park amenities could be counted as a large public park like Elder Park in the east. After conducting the survey, the remaining festival park is identified as Retained Open Space as well as Re-defined Open Space. On the other hand, the analysis shows that a campus-led development in the QEUH area statistically lacks an eligible green space for the campus and surrounding neighbourhood in every term. Despite high budget development in the hospital campus, the "central park" open space area did not deliver any valuable contribution to the microclimate and biodiversity found as derelict land on the campus in this research. Existing landscape elements such as planted trees and suds pond have been identified as unsuccessful due to poor soil quality and poor planning. However, it falls into all four categories because the park area is being developed as a new open space with ongoing landscape proposal and development. Secondly, it is also a Re-defined Open Space because existing functions will

1) Retained open space • *More multifunctional to some degree* • *To meet the accessibility standard* • *To retain the existing public open space function but may require an enhancement in their quality* • *Additional planting to deliver enhanced biodiversity* • *Minimizing maintenance* **Applicable for Festival Park and QEUH Campus Park**	***2) New open space*** • *Accessibility and Quantity Standards* • *Growing or outdoor sport* • *To create new habitat links* • *To create active travel links* • *To manage flood risk* • *Appropriately located areas of vacant and derelict land as new open space* **Applicable QEUH Campus Park**
3) Re-defined Open Space, • *To be used differently to meet current and future needs,* • *e.g., former playing pitch is no longer required for outdoor sport but is well located to meet the accessibility standard* • *e.g., an area of amenity grassland could be planted, or left to naturalise, to provide enhanced habitat connectivity and/or carbon sequestration* **Applicable for Festival Park and QEUH Campus Park**	***4) Redundant Open Space,*** • *Capital receipts for sale of space that will not have a role in meeting current or future need* • *To reduce maintenance burdens, to compensate the loss of open space, to free up resources* • *To be invested in the City's remaining open spaces with possible "land-swaps" – using a development site to fill a gap in planning process* **Applicable QEUH Campus Park**

Table 10: GOSS 2020 definition of Retained Open Space and New Open Space (Source: GCC and author)

be redefined as a therapeutic garden and creative platform for the users etc. Thirdly, it is a retained space due to expected maintenance and management for restoring the quality within the campus and connected areas. New sustainable elements are proposed to be added, such as previous covers such as Resin Bound surface, which allows water to permeate through the surface and improved existing SUDS (Sustainable Urban Drainage Systems) in the parking area with an adjacent rain garden. Eventually, some spaces can be treated as Redundant Open Spaces for important hospital functions in the near future. Thus, combining different priorities makes spatial distribution more logical in this context. This comparative overview depicts the performance and characteristics of two case studies and the current condition of open space development.

5.2 CLIMATE CONDITION ANALYSIS

Glasgow is generally cloudy and windy most of the year and is classified as an oceanic climate. The summer is usually cool, and winters are cold long and primarily wet. The temperature typically varies from 1°C to 19°C and is rarely below -6°C or above 23°C, and the annual precipitation is 1,245 mm on average. It has a high amount of rain compared

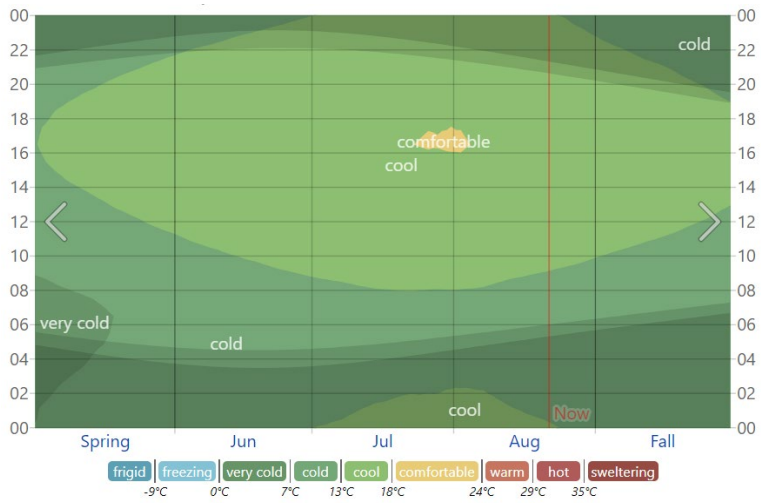


Figure 33: Average hourly temperature in Glasgow (Source: Weather Spark)

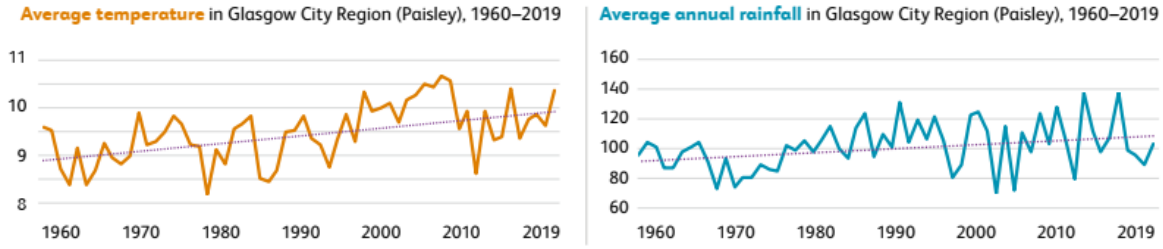
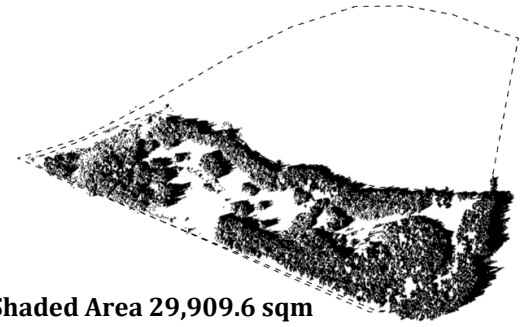


Figure 34 Glasgow City Region's temperatures (left) and rainfall (right)(Climate Ready Clyde, 2021)

to the other part of the UK. During the summer season, the average high temperature is >20 °C, and with occasional heat waves, it reaches up to 27°C to 30°C. For this research purpose, the summer season (June to August) has been analysed thoroughly to see the heat stress events and climate change impact during this season on the city. The average hourly wind speed is around 4.6m/s to 4.9m/s, and the wind can be strong. During the summer season in Glasgow, it impacted the traverse study due to its impact on air temperature. The temperature usually increases from 15:00 to 16:00 hours on summer days. Even though the solar noon period is around 13:30 hours, the research aimed to record the maximum temperature of the current warmest hour.

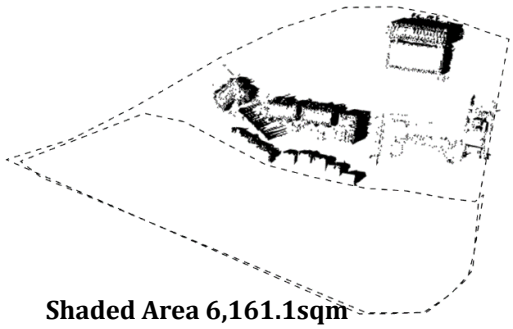
5.3 SPATIAL STRUCTURE, SURFACES AND VEGETATION

Infrequent extreme temperature events during the summer season in Glasgow affect the outdoor activity and it is important to identify an effective ecological component for UGOS design guidelines. Both case studies analysis of environmental components presents their association with mitigating such events through natural elements such as shading and vegetation. After conducting the analysis on the surface cover and built



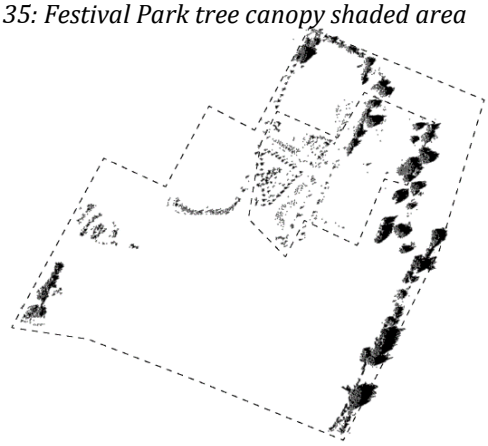
Shaded Area 29,909.6 sqm

Figure 35: Festival Park tree canopy shaded area



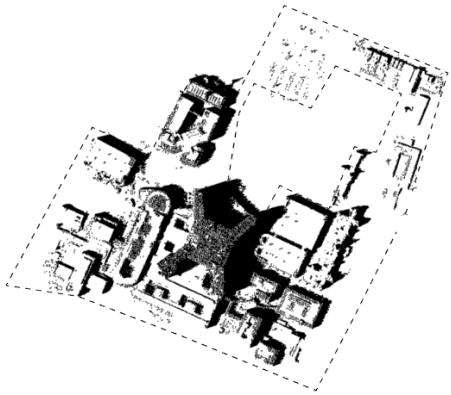
Shaded Area 6,161.1sqm

Figure 36: Festival Park extended building shadow area



Shaded Area 15,081 sqm

Figure 37: The QEUH campus tree canopy shaded area



Shaded Area 59,875 sqm

Figure 38: The QEUH campus building shadow area

environment scenarios (previous chapter), Digital Surface Model (DSM) point data predicted the vegetation cover and shading cover in Festival Park because large tree canopy coverage or shading from buildings are effective design strategies against urban heat stress (Kantor et al., 2018). Festival Park with the extended area (housing and Pacific Quay) shows almost 30,000 sqm shaded space by tree canopy. 6,161 sqm from the building area. The Infrequent extreme temperature events during the summer season in Glasgow affect outdoor activity, and it is essential to identify the ecological component that is effective for UGOS design guidelines. Both case studies analysis of environmental components presents their association with mitigating such events through natural elements such as shading and vegetation.

Around the park area, there are mature trees and spreadable canopy coverage. Thus, it is identical in figures 35 and 38 above that the park area contains natural shading only. On the contrary, the QEUH campus area has a 59,875 sqm building shadow than tree canopy coverage of 15,080 sqm. The natural shading aspects are clearly insufficient in the hospital campus area because of the poor soil quality and less mature trees. It was important to see the presence of natural shading because 25% to 55% of park visitors tend to go under shade during warm weather conditions (Thorsson et al. 2004). Due to the negligible presence of tree coverage and large areas of mown lawns in the focused area (central park) of the QEUH campus, the following vegetation profile assessment was done only for Festival Park. Light detection and ranging (LiDaR) and Digital Surface Model (DSM) point data depict the three-dimensional elements of vegetation cover of the site to understand the three-dimensional aspects of the park. The tree elevation profile (Figure 40) represents above 10-meter-tall trees, and it is located mostly in the high vegetation area from south to north cut elevation (AB) (Figure 39).

Figure 39: Elevation line on topographic view of Festival Park for reference

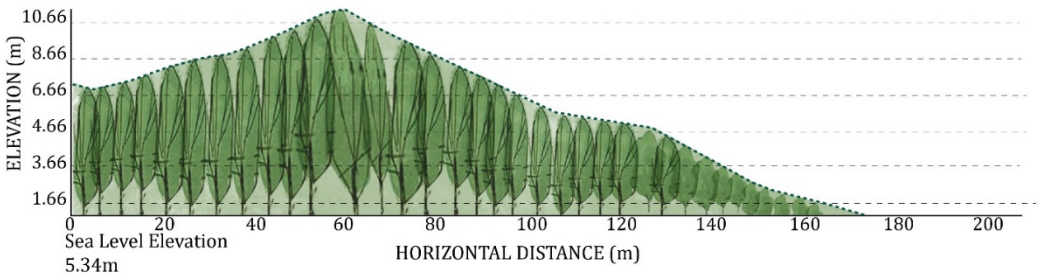


Figure 40 North-south vegetation elevation (AB) profile of Festival Park (by author)

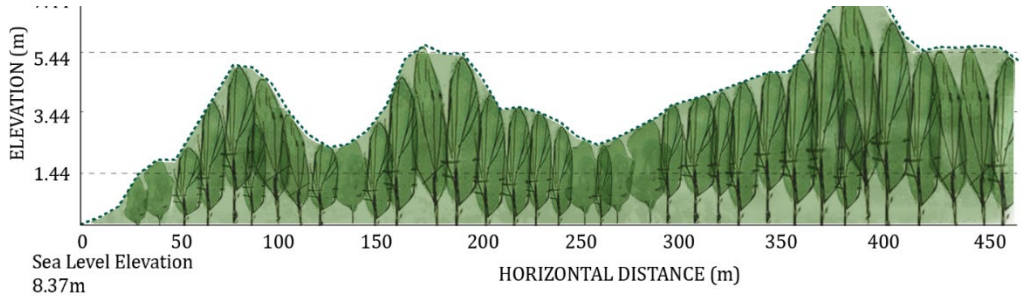


Figure 41: West-east vegetation elevation (CD) profile of Festival Park (by author)

Another influential ecological element, such as a tailored water body, is common in both case studies. The site survey identifies the natural waterbody as a linear retention pond in Festival Park. However, the water flow was not noticeable due to the warm season. The wetland is integrated with natural elements such as stone, wet plants, and shrubs, and it has a shallow depth from the ground level. As an ecological component, the SUDS pond In the QEUH campus park area has been identified as a design flaw and an inactive landscape element for the UGOS case study. However, it was designed to manage stormwater events for up to 1000 years with climate mitigation benefits following the Scottish Water Sewers for Scotland 2 (SFS2) format (ERZ; NHS, 2021).

Figure 42: Retention wetland in Festival Park (Photo taken by author)

Figure 43: The SUDS Pond in QEUH Campus Park (Photo taken by author)

5.4 ADMINISTRATIVE EXPERTS' OPINIONS INTEGRATION

A mixed questionnaire method was abducted for the integrated administrative body of the QEUH campus green space development. The ongoing landscape planning led by a collaborative stakeholder initiated by NHS Greater Glasgow and Clyde is an example of the current state of UGOS development focused on climate change adoption. Online discussion, written question and suggestion form has been used to extract valuable perspective on setting the frameworks for the KPI of UGOS and evaluation (for the detailed questionnaire and response, see Annex 1). The extracted features of the discussion and questionnaires have been narrowed down (table 5) to valuable guidance for the Key Performance Indicators of UGOS planning and assessment.

Climate change approach	**Keynotes of response**
Emphasized factors of UGOS development	• climate change mitigation, connectivity and access to green space Increased levels of active travel management • micro-climate, water management and usage, land use, habitat, biodiversity, holistic designs with blue green networks functioning as one of many layers, networks which combine into the overall landscape system. • trees and vegetation for the heat island effect reduction • amenable space for users with comfortable outdoors such as shelter and shading • High vegetation cover, primarily tree and shrub cover and wildflower planting, rather than mown lawn
Climate change action	• Moderate to Unsatisfactory level • It should be under full consideration • Unsatisfactory level
Climate change policy in the development	• Below Expected level • Should be under full consideration

QEUH greenspace development	**Keynotes of response**
Types of benefits	• Health and wellbeing, better air quality, habitat for birds and pollinators • Meaningful and joyful connection with users with the outdoors through placemaking, innovation and creativity • A system and network based on an established tripartite approach (ecology, economy, and community).
Proposed landscape plan	• A good example of a Sustainable integrated approach based on expected funding, Introducing Sustainable drainage (SUSDS), therapeutic design

	• Wayfinding and active travel facility • Diverse range of user group • Systems-based approach for multifunctional places • A more biodiverse meadow is an Immediate solution for reducing maintenance costs with increasing biodiversity. • Presence of creativity and art
Previous approach	• Difficult and cost-effective due to the lack of interest in green space planning when it was built. • Lack of biodiversity and green space is only with mown amenity • Inadequacy in active travel and greenspace connection • A reminder of the impacts of climate change, which are only set to worsen. Proposals for changing climate and providing for the needs of the diverse range of users • "green desert" "Lipstick on the grill" (key comments)
Stakeholder collaboration	• At current state difficult and cost-effective due to a lack of interest in green space planning when it was built. • Inadequacy in active travel and greenspace connection • A reminder of the impacts of climate change, which are only set to worsen.

UGOS context in Glasgow	**Keynotes of response**
Glasgow heatwave events and greenspace context	• The built environment has a direct impact on neighbourhood scale parks shrinking Inequal greenspace quality, not adequate • direct impact on people's health, and current healthcare provision is stretched • I) damage to building forms, ii) overheated roads and pavements, iii) arising diseases, iii) mental stress, v) hazardous risk • Consequences of flooding because of dry spells followed by heavy downpours. Despite of heat wave emergency of flooding because of dry spells followed by heavy downpours.
Growth/decline of neighbourhood scale park	• Concerns on decline • The built environment has a direct impact on neighbourhood scale parks, shrinking

Table 11: Compilation of key notes abducted from questioner response from the administrative body of a collaborative greenspace development in the QEUH campus case study

5.5 APPLICABLE KPI IDENTIFICATION FOR UGOS

Considering all the variables of discussed case studies, a set of Key Performance Indicators (KPI) for UGOS has been identified, which can be applicable for assessing the quality of public park-type open spaces. Table 12 represents the Quality Assessment Matrix by the GOSS audit indicators (GCC, 2020), which led to the source structure of generated KPI for UGOS in the analysis part. It focuses on climate comfort and ecological, and user benefits from UGOS in a site-specific context. Eventually, it brings out the result and discussion of this research.

Indicators	***Description***
A) Size	*as specified in the accessibility standard, sites should be of 0.3 ha or more to provide enough space for a variety of uses.*
B) Configuration	*the open space should be of a shape that encourages use by all members of the community. Long, thin, irregularly shaped or steeply sloping spaces may be less able to accommodate a variety of uses. Exceptions might include where the space would play a key role in, e.g. water management, that would necessitate a certain configuration.*
C) Surveillance	*wherever possible, the areas of the space that people are likely to use most often ("key areas" – especially areas for quieter relaxation) should be visible from surrounding buildings, encouraging responsible use - secluded corners should be used for appropriate purposes, such as biodiversity.*
D) Accessibility	*the space should be easily accessible from the wider area, should utilise DDA compliant paths and access points and should, where appropriate, incorporate any longer distance routes. Access for maintenance purposes should be easy and direct. Key entrances should benefit from lighting on surrounding roads/paths.*
E) Aspect	*much of the space should, where possible, benefit from direct sunlight (planting should provide some shade from the sun)*
F) Place Quality	*the location of the space, its planting and landscaping should create a sense of wellbeing for users of the space, in addition to complementing surrounding uses and contributing to their amenity.*
G) Use	*the space should provide for a range of active and non-active uses, including*
Gi) Informal sport/recreation	*a good proportion of the space should be flat or gently sloping and would be well-drained to provide for use on dry days.*
Gii) Children's play	*the space should provide for children's play, particularly natural and imaginative play*
Giii) Relaxation	*quieter areas, away from the parts of the space where informal sport/recreation and children's play are likely to take place, should be provided for relaxation and meeting people. Seating and bins should be provided in suitable locations, including to allow surveillance of areas likely to be used by younger children*
Giv) Biodiversity	*spaces should provide for a variety of connected habitats and a variety of different plant and animal species*
Gv) Maintenance and Condition	*over and above routine maintenance (grass cutting, litter clearing etc) the infrastructure required to meet key criteria should be well-maintained and in a usable condition.*

Gvi) Water Management	*spaces should, where appropriate, help meet the requirement for natural flood water management*
Gvii) Community growing/ allotment space	*where appropriate and where a local demand has been established that cannot be easily met elsewhere in the area, spaces should provide for space for allotments/community growing e). this is likely to require a publicly usable open space greater than 0.3 ha in size*

Table 12: Quality assessment matrix by the GOSS 2020

The KPI for UGOS has been generated by analysis exiting quality indicators by an elaborative research study (GEHL, 1987; GROOT, 2010; Mehta, 2013; Lynch, 2008; Nouri et al., 2017) and associated expert's opinions through questioner on site-specific context. Forty performance indicators included in set A to set O (a total of fifteen sets) have been identified from the above definition of the open space quality matrix category. Priority sign individual upwards arrow (↑) has been assigned with each indicator relevant to the case studies and aligned with GOSS 2020 auditory matrix scoring value. The scoring criteria from GOSS 2020 determine the present status of two case studies of UGOS, and the priority arrow is assigned in that manner. For example, high priority (↑↑↑↑↑) is equivalent to a score of 1 as it is in poor condition and needs immediate measures (table 13)

Score by GCC 2020	**Priority**	**Priority Value**
Score 1 - Poor	High priority	(↑↑↑↑↑)
Score 2 - Fair	Mid-high priority	(↑↑↑↑)
Score 3 - Good	Moderate priority	(↑↑↑)
Score 4 - Very Good	Semi-low priority	(↑↑)
Score 5 - Excellent	Low priority	(↑)

Table 13: Priority mark value aligned with GCC scoring value (by author)

The explanatory analysis note indicates assessment and the scope of enhancement for each indicator in the priority area of case studies through research references, existing data, site survey analysis and most importantly, expert's questioner responses. Table 14 describes all these indicators with clear applicability in the planning, design and management division of UGOS. It delivers a set of focused measures for each case study by prioritizing the indicators.

Climate change mitigation indicators are marked as a high priority which is entwined with environmental variables. Enhanced biodiversity, adequate green cover, active travel system (for low carbon emotion), and health and wellbeing of the users and extended community were highly prioritised by all the experts in the interview session (previous chapter). In terms of biodiversity and green cover, these KPI of UGOS identifies the need/presence of natural shading from tree canopies or sustainable shading element, proper plantation placements and use of native or non-native plants, air purifier plants, climate-friendly landscape furniture, multifunctional soil quality, consideration of local flora and fauna, the associated ecological corridor for each case study. Highly prioritising

these indicators can themselves balance the effect of micro-climate change such as heat stress (e.g., tree canopies, sun sail) and high rainfall events (e.g., use of SuDS, reuse of water for irrigation) in QEUH campus park and Festival Park

Increased levels of active travel also highlight less carbon emission and spread awareness among the users. Eventually, the outdoor activities and space quality depends on visual connection and locating its presence in a certain area. Route from point A to Point B and in between the efficient presence of urban Park can deliver a pleasant journey and eagerness to reach the destination daily. With proper room to walk, a wheeled walking facility, protection from vehicular dominance, and active travel is the element to configure a successful park space.

Table 14: Generated KPI for UGOS development and quality assessment

GCC Indicator & Description	**Suggested KPI for UGOS**	**Priority level in Festival Park (POS)**	**Priority level in QEUH Campus (PIS)**	**Analysis Notes & Priority Areas**
A) size *area coverage> 0.3 ha*	A) Eligibility of a public park/green space 1) Area Coverage> 0.3 ha	>2 ha	>2 ha	Eligible to be usable open space, it is more than the minimum requirement of area coverage.
B) configuration *Usable shape of area for all group of users.* *Less deformed space (e.g., long, thin, irregularly, or steeply sloping spaces); exceptions can be incorporated for key roles*	B) Configuration and Imageability 2) Appropriate design 3) Site spatial sequence	(↑↑↑) (B2)	(↑↑↑↑) (B2)	POS can accommodate some functions (Gi to Giv) on a limited scale; less functional space such as natural steps on elevated parts; low maintained dense vegetation area. PIS can only accommodate some functions (Gi to Giv) with difficulty; there is no preconceived thought behind the design for a wider context; the large part is less functional/useful and needs to be prioritised.
		(↑↑) (B3)	(↑↑↑↑) (B3)	
C) surveillance *Visibility of key area from surroundings;* *potential secluded area for biodiversity.*	C) Surveillance 4) Wayfinding of key areas. e.g., sitting, standing etc	(↑↑) (C4)	(↑↑↑↑) (C4)	POS has most of the key spaces that are overlooked by buildings likely to be occupied during daylight hours; dense vegetation is placed in a few corner spaces. PIS has some key spaces that are overlooked by buildings likely to be occupied during daylight hours, except the space is not desirable; dedicated/secluded space for biodiversity demand is in high priority for this case study.
	5) Potential pocket space e.g., sustainable use of corners allocated with the right species	(↑↑) (C5)	(↑↑↑↑) (C5)	

D) accessibility *Wider connection;DDA[2] complaint access; easy direct maintenance access; key entrances benefited from lighting on external road/path*	D) Accessibility 6) Equity and inclusivity 7) Experienced distance 8) Physical distance	(↑↑↑↑) (D6)	(↑↑↑↑↑) (D6)	POS has insufficient DDA-compliant access and poor visual connectivity from the southern neighbourhood; entrances are poorly lit, and it has a slope higher than 5 %, which is not comfortable for wheelchair accessibility (Yılmaz, 2018). PIS needs DDA complaint planning immediately; complex and limited accessibility; experienced distance (GEHL, 1987) is rather dull; physical distance is compromised due to the dominance of roads and vehicles.
		(↑↑) (D7)	(↑↑↑↑) (D7)	
		(↑↑) (D8)	(↑↑↑↑) (D8)	
E) aspect *Direct sunlight; planting shade*	Ei) Climate Aspect 9) Balanced sunlight exposure 10) Landscape shading 11) Regulated air quality 12) Sustainable material for all-season landscape furniture 13) Permeable material for ground cover	(↑↑) (Ei 9)	(↑↑↑↑↑) (Ei 9)	POS has direct sunlight exposure in most usable spaces; adequate natural shading except in some areas; and impervious ground cover. PIS has imbalanced sunlight exposure(Nouri and Costa, 2017); large building shadow at some parts; poor natural shading; few artificial shading spots; air quality might have been affected due to vehicular movement in the adjacent parking; less green infrastructure; mostly impervious ground cover.
		(↑↑) (Ei 10)	(↑↑↑↑↑) (Ei 10)	
		(↑↑) (Ei 11)	(↑↑↑↑↑) (Ei 11)	
		(↑↑↑) (Ei 12)	(↑↑↑↑↑) (Ei 12)	
		(↑↑↑) (Ei 13)	(↑↑↑↑↑) (Ei 13)	

[2] Disability Discrimination Act (DDA) represents the law and policy of accessibility and reasonable steps provided for disabled people in establishments that is open to the public

Eii) natural capital (new addition)	Eii) Natural capital 14) Improved soil quality 15) Natural drainage 16) Heritage tree 17) Natural surface cover	(↑↑) (Eii 14)	(↑↑↑↑↑) (Eii 14)	POS has adequate natural capital except for low maintenance; natural surface cover has a higher ratio than sealed pavement; heritage trees could be prioritised by identification and conservation. PIS has slow growth of vegetation due to poor soil quality; natural drainage is non-functional; heritage trees are present except non-prioritized; inadequate natural surface cover.
		(↑↑) (Eii 15)	(↑↑↑↑) (Eii 15)	
		(↑↑) (Eii 16)	(↑↑↑) (Eii 16)	
		(↑↑) (Eii 17)	(↑↑↑↑) (Eii 17)	
F) place quality *User's wellbeing by through space with plantation and landscaping; wider contribution and amenity value to the neighbouring space.*	F) Place Quality & Pleasantness 18) Touristic 19) Recreational (landscape conversation) 20) Creativity 21) Cultural presence 22) Cognitive development	(↑↑) (F 18)	(↑) (F 18)	POS location, planting, and landscaping provide some amenities for surrounding areas, are not adequately touristic due to less visibility from outside; provide less creativity; possible scope of landscape conversation and cognitive development (GEHL, 1987). PIS location, planting, and landscaping provide few amenities for surrounding areas; other variables are missing due to poor landscape quality.
		(↑) (F 19)	(↑↑↑↑) (F 19)	
		(↑↑) (F 20)	(↑↑↑) (F 20)	
		(↑↑) (F 21)	(↑↑↑) (F 21)	
		(↑↑) (F 22)	(↑↑↑↑) (F 22)	
G) use				
Gi) informal sport/recreation	Gi) Informal sport/recreation 23) Gently sloped grassland 24) Green exercise area	(↑↑) (Gi 23)	(↑↑) (Gi 23)	POS can facilitate informal sports; roughly equivalent in size to a Multi-

Gently sloping, grassed area, *Well drained in terms of surface water runoff*	e.g., therapeutic garden, yoga & meditation area	(↑↑) (Gi 24)	(↑↑↑↑) (Gi 24)	use game area; an adequate green exercise area can be developed. PIS can not facilitate much of informal sports (less applicability in this case study); the green exercise area needs prioritization and special attention.
Gii) children's play *Natural and imaginative play for children*	Gii) Playground 25) Children play area 26) Interactive space for diverse age group	(↑↑↑) (Gii 25)	(↑↑↑↑) (Gii 25)	POS has adequate opportunities for natural play provided by the landscaping, topography and planting from wider context; for only limited children age group. PIS has inadequate opportunities for natural play provided by the landscaping, topography and planting; poor placement/ not integrated children's play area; not interactive.
		(↑↑↑) (Gii 26)	(↑↑↑↑↑) (Gii 26)	
Giii) relaxation *Quieter area away from sports area but closer to children play area with possible surveillance, relaxation and meeting place, seating, and bins in proximity*	Giii) Relaxation 27) Third place and spirituality	(↑↑↑) (Giii 27)	(↑↑↑↑↑) (Gii 27)	POS has quieter areas for relaxation, meeting, picnicking and natural shading; less temporal shading (e.g. sun sailing); some spaces are too detached; not adequate bins; can bring spirituality while visiting. PIS does not have adequate relaxation and meeting area; interrupted sitting due to narrow pavement; can not be called a third place or less sense of spirituality (GEHL, 1987).
Giv) biodiversity *A variety of connected habitats, different plant and animal species*	Giv) Ecological Service 28) Flora and fauna diversity 29) Site-based habitat provision	(↑↑) (Giv 28)	(↑↑↑↑↑) (Giv 28)	POS has enhanced biodiversity through habitat provision; it has a connection, and it facilitates functional connection; the presence of various vegetation with various heights. PIS has little biodiversity and flora fauna diversity.
		(↑↑) (Giv 29)	(↑↑↑↑↑) (Giv 29)	

Gv) maintenance and condition *Routine maintenance (grass cutting, litter clearing etc.); well-maintenance and usable condition.*	Gv) Maintenance of quality state 30) preservation of heritage tree 31) physical elements, objects 32) seasonal volunteer survey 33) Campaign of extreme events & green space solution	(↑↑↑) (Gv 30)	(↑↑↑↑↑) (Gv 30)	POS has some of the infrastructures that contribute to provision for Gi, Gii and Giii; quality is moderate; needs to be prioritised 30, 31, 32 and 33. PIS has no contribution in terms of Gv 30 to Gv 33.
		(↑↑↑) (Gv 30)	(↑↑↑↑) (Gv 30)	
		(↑↑↑) (Gv 30)	(↑↑↑↑) (Gv 30)	
		(↑↑↑) (Gv 30)	(↑↑↑↑) (Gv 30)	
Gvi) water management *Requirement for natural flood water management.*	Gvi) Nature-based water management 34) Natural/Semi Drainage 35) functional waterbody	(↑↑↑) (Gvi 34)	(↑↑↑↑) (Gvi 34)	POS has natural retention linear pond, which minimises the flood risk; safe design with amenity and biodiversity value; low maintenance. PIS has SuDS with little amenity and biodiversity value; unsafe; low maintenance.
		(↑↑↑) (Gvi 35)	(↑↑↑↑) (Gvi 35)	
Gvii) community growing/ allotment space *Space for allotments/community growing where applicable.*	Gvii) Community growing/ allotment space 36) Urban farming 37) Art and creative platform 38) Educational tour 39) Community gathering 40) Individual adaptation	(↑↑↑) (Gvii 36 to Gvii 40)	(↑↑↑) (Gvii 36 to Gvii 40)	POS and PIS have the potential to provide growing community features from (Gvii 36 to Gvii 40) but are not being applied.

(Table 14 continued from previous pages)

5.6 TRAVERSE SURVEY AND MICROCLIMATE MODELLING

5.6.1 TRAVERSE SURVEY 1ST PART JUNE 2022

First part of the survey consisted with two-day observation consecutively on 5th June in Festival Park and 6th June in QEUH campus for an observation of the beginning of the summer season. After conducting the survey in early June, the differences in air temperature (Ta in °C) were visible in the QEUH campus area and the Festival park. Through Linear regression, the corrected temperature for all points at a static moment of 3:30 pm is shown in table 16 and table 18.

According to Glasgow weather station (55.87 °N, 4.43 °W) data, the pick air temperature was 18.4°C, and the lowest was 5.9°C, and the sky was mostly clear on 5th June 2022. The maximum humidity was 87.6%, and the minimum was 53%. During the survey period, the average wind flow was 3.5m/s and in the northeast direction. Despite the UHI effect, fixed station air temperature was constant on average at 17.5°C, whereas on-site measurements showed the highest air temperature at 23°C at point 16 and the lowest at 18.14°C at point 20. A similar air temperature value was seen at points 1, 2, 11 and 1, below 20°C. At points 3, 5 to 9, 12, and 17 were above 20°C. This survey helped to

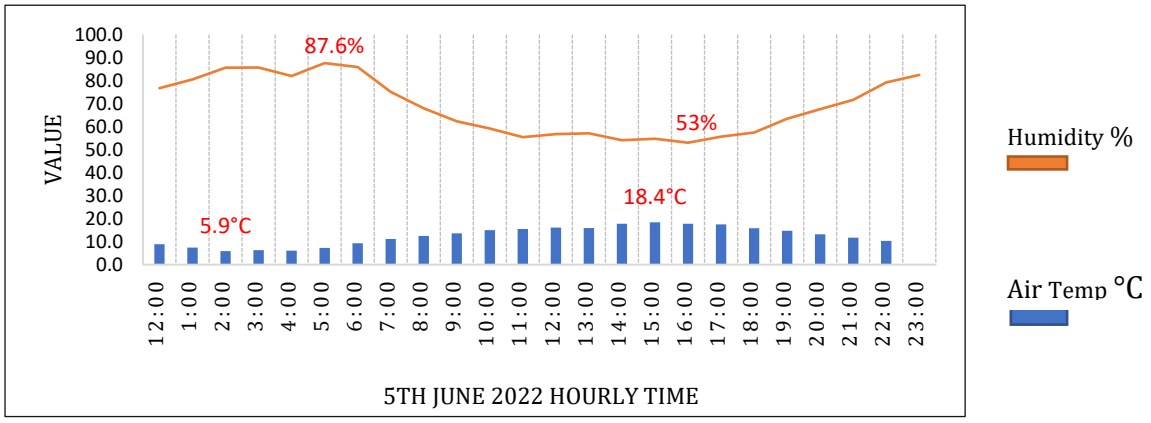
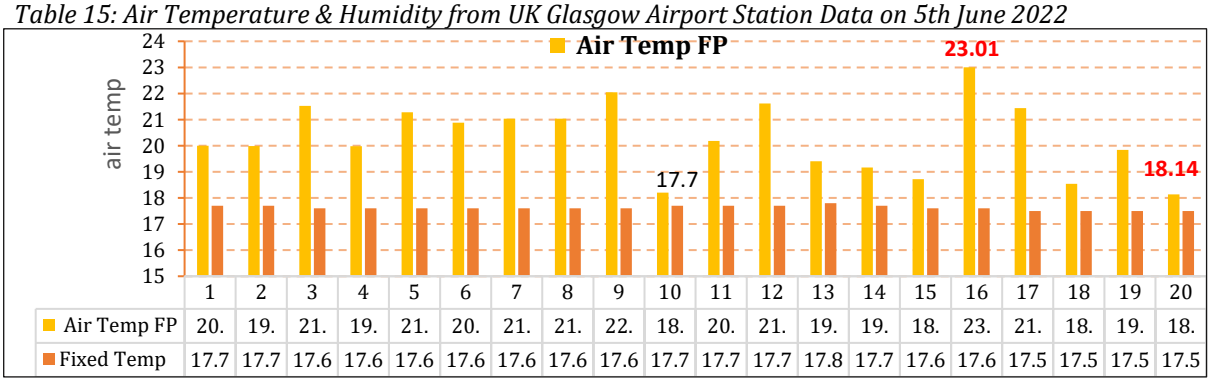


Table 15: Air Temperature & Humidity from UK Glasgow Airport Station Data on 5th June 2022



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Air Temp FP	20.	19.	21.	19.	21.	20.	21.	21.	22.	18.	20.	21.	19.	19.	18.	23.	21.	18.	19.	18.
Fixed Temp	17.7	17.7	17.6	17.6	17.6	17.6	17.6	17.6	17.6	17.7	17.7	17.7	17.8	17.7	17.6	17.6	17.5	17.5	17.5	17.5

Table 16: Festival Park and Fixed Station air temperature data on 20 points at 15:30 on 5th June 2022 (by author)

determine the features of selected points in Festival Park. A similar survey was carried out in the QEUH campus open space area on 6th June. On that day, the pick air temperature was 19,7°C, and the lowest was 5.7°C. The sky was partly cloudy, the relative humidity maximum was 96%, and the minimum was 49.7%. The temperature increased more than

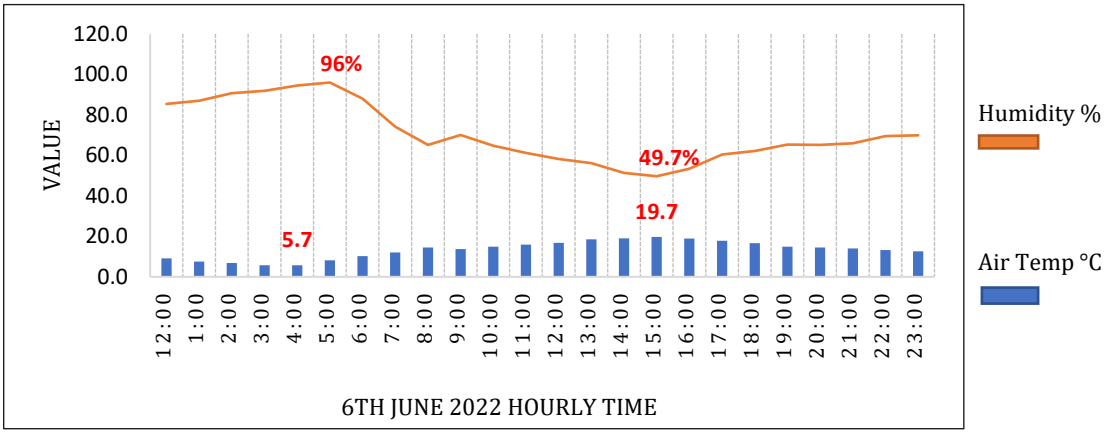
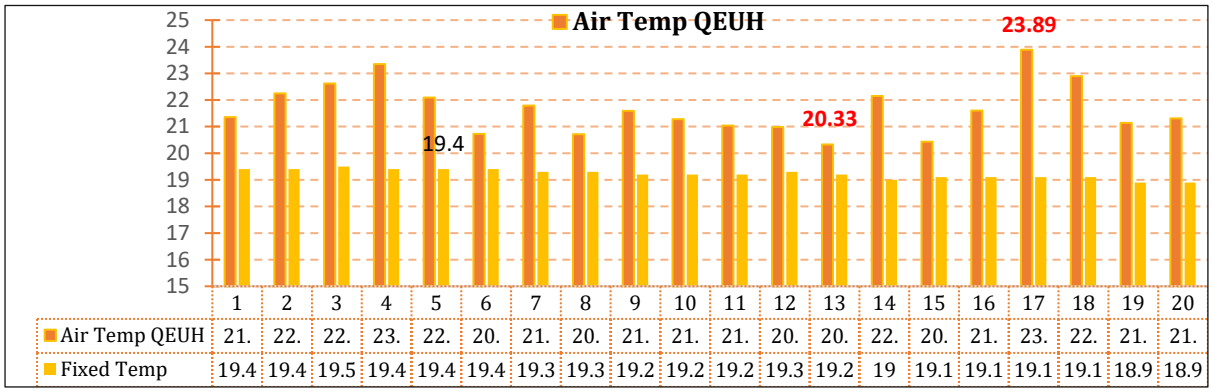


Table 17: Air Temperature & Humidity from UK Glasgow Airport Station Data on 6th June 2022



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Air Temp QEUH	21.	22.	22.	23.	22.	20.	21.	20.	21.	21.	21.	20.	20.	22.	20.	21.	23.	22.	21.	21.
Fixed Temp	19.4	19.4	19.5	19.4	19.4	19.4	19.3	19.3	19.2	19.2	19.2	19.3	19.2	19	19.1	19.1	19.1	19.1	18.9	18.9

Table 18: The QEUH campus and Fixed Station air temperature data on 20 points at 15:30 on 6th June 2022 (by author)

the previous day, and the wind flow was not constant during the survey period. The average wind flow was 2m/s to 3m/s and towards the east direction. Also, the fixed station air temperature was 19.3°C on average. The QEUH site measurements showed the highest air temperature at 23.89°C at point 17 and the lowest at 20.33°C at point 13. Another closest high air temperature value of 23.34°C was at point 4. Otherwise, most points showed air temperature above 21°C except points 8 and 13.

Climate data collection on 15th June 2022 shows air temperature and humidity fluctuation at different periods. The temperature variation in different open space points helped finalize five extra points, which show the different urban sets in each open space. The points were selected based on the urban profile, three are inside the green park area,

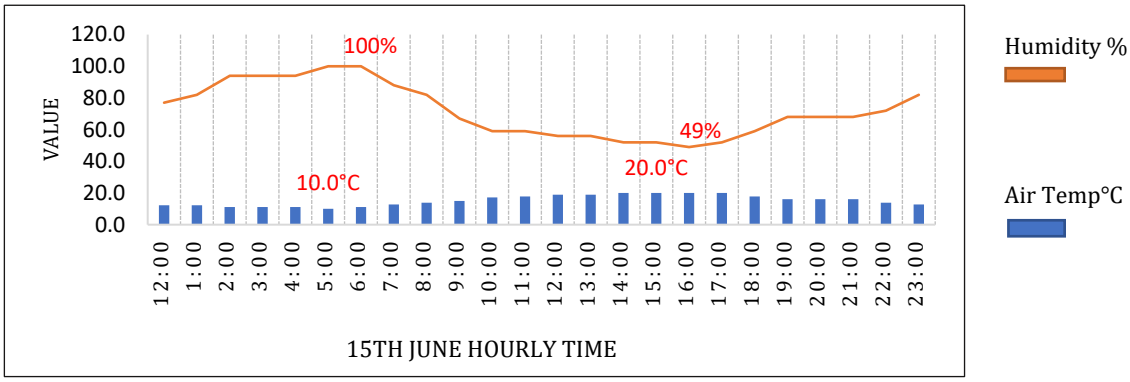


Table 19: Air Temperature & Humidity from UK Glasgow Airport Station Data on 15th June 2022

and two are adjacent built environment areas. The weather station data and site measurements data showed the difference in air temperature (figure 44). 1st point had the highest humidity due to deep vegetation and trapped the heat during the warmest period (2 pm to 5 pm). In the same period 4th point considerably showed the highest air temperature at 24.2°C except after the sunset period at 17.2°C, and it has the lowest humidity at 43.6%. 5th point, the housing area had similar temperatures around 23.2°C around the same time. However, 2nd point fluctuated due to wind flow and more openness than other points. Nonetheless, wind flow and shaded/unshaded areas directly affected the variables of air temperature and relative humidity.

QEUH campus open space area, the air temperature values on the selected key five points were less than in the Festival Park due to the hour difference of measurement and weather variables (see in limitation chapter). During the warmest hour, the air temperature was 23°C, highest at the 2nd point, with a humidity of 54.3%. The relative humidity value was comparatively low due to less vegetation, but at the 2nd point, it was 65.2%, the highest (table 21). Due to wind flow, the air temperature reading did not properly analyse the variance. However, the analysis represents that the microclimate situation of the campus area is not engaged with existing elements in the open space area as there is no particular zoning, and it is acting as a direct land.

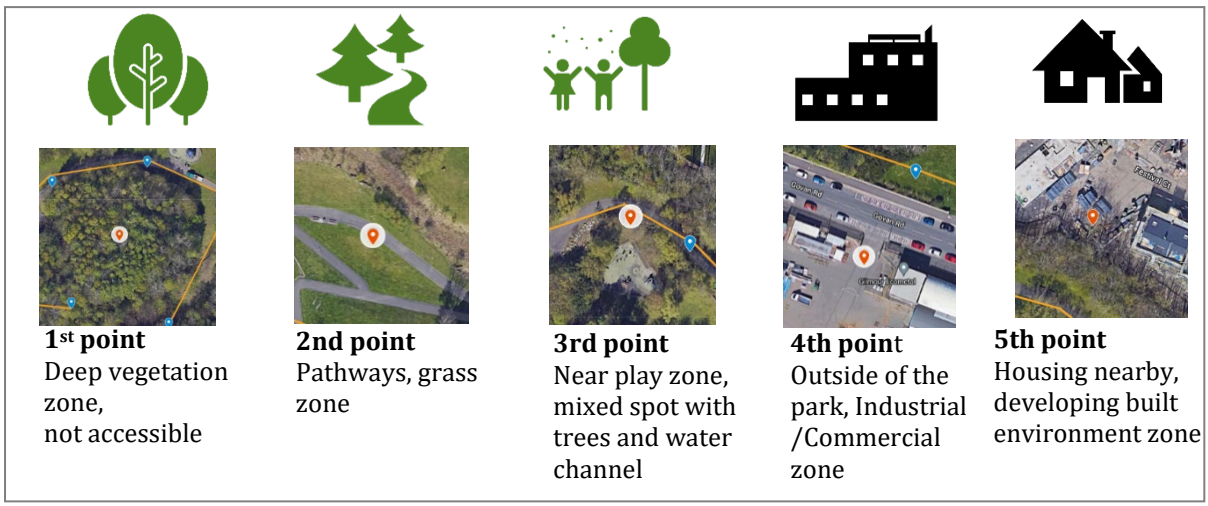
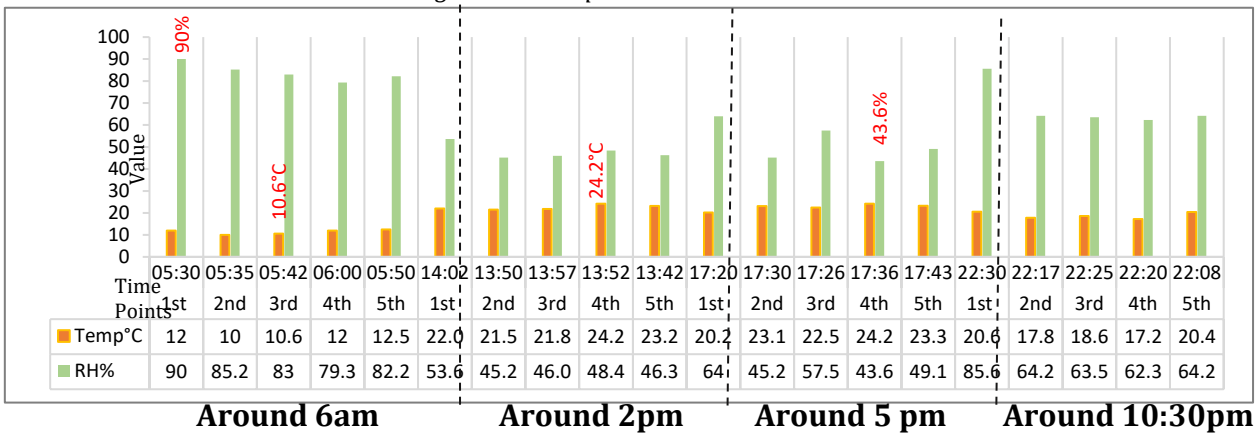


Figure 44: Five points in the Festival Park



Time	05:30	05:35	05:42	06:00	05:50	14:02	13:50	13:57	13:52	13:42	17:20	17:30	17:26	17:36	17:43	22:30	22:17	22:25	22:20	22:08
Points	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Temp°C	12	10	10.6	12	12.5	22.0	21.5	21.8	24.2	23.2	20.2	23.1	22.5	24.2	23.3	20.6	17.8	18.6	17.2	20.4
RH%	90	85.2	83	79.3	82.2	53.6	45.2	46.0	48.4	46.3	64	45.2	57.5	43.6	49.1	85.6	64.2	63.5	62.3	64.2

Table 20: Festival Park temperature and relative humidity data at five points

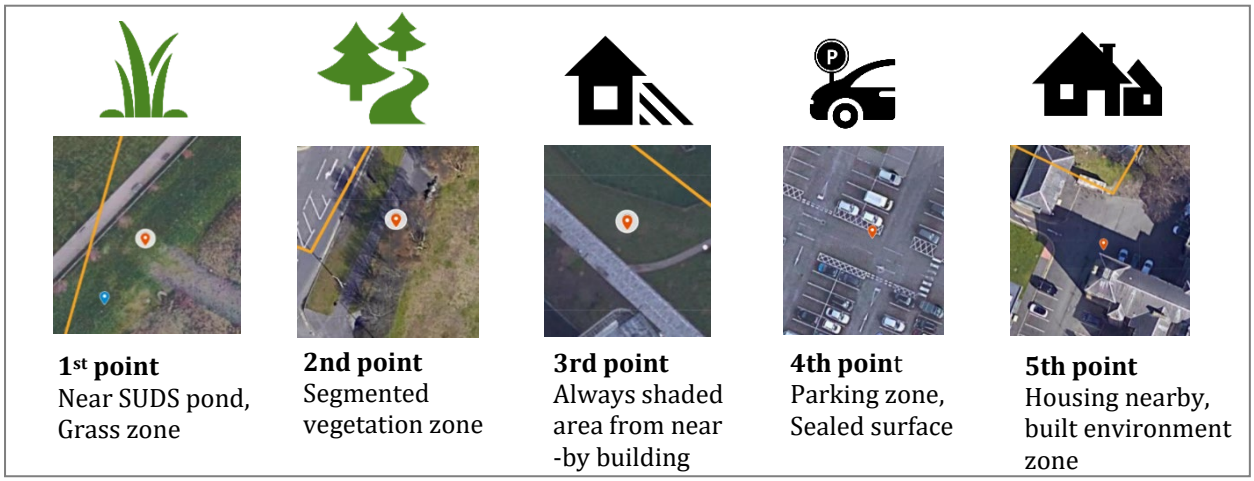
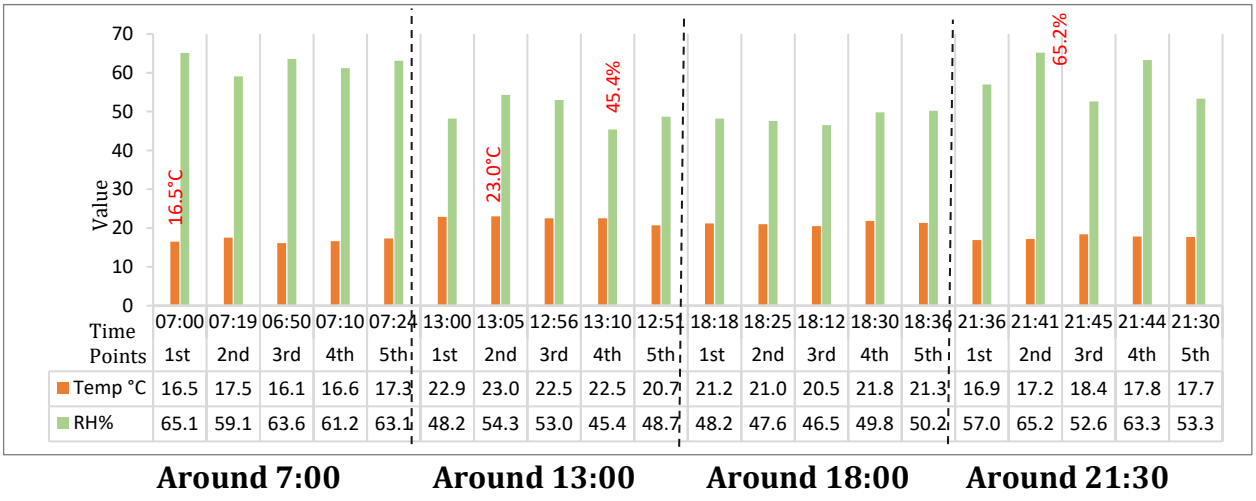


Figure 45: Five points in the QEUH campus open space (source author)



Time	07:00	07:19	06:50	07:10	07:24	13:00	13:05	12:56	13:10	12:51	18:18	18:25	18:12	18:30	18:36	21:36	21:41	21:45	21:44	21:30
Points	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Temp °C	16.5	17.5	16.1	16.6	17.3	22.9	23.0	22.5	22.5	20.7	21.2	21.0	20.5	21.8	21.3	16.9	17.2	18.4	17.8	17.7
RH%	65.1	59.1	63.6	61.2	63.1	48.2	54.3	53.0	45.4	48.7	48.2	47.6	46.5	49.8	50.2	57.0	65.2	52.6	63.3	53.3

Table 21: The QEUH campus open space temperature and relative humidity data at five points (source author)

5.6.2 TRAVERSE SURVEY 2ND PART JULY 2022 AND MODELLING

The second traverse survey was conducted on 18th July 2022, when the temperature showed extreme hot weather events and overall during red warning heat wave week in the UK. Glasgow reached 31°C in July 2022, almost like the last highest temperature record day in 2018. Therefore, the air temperature data were collected on the same 20 points, and it was measured for the warm day simulation analysis

5.7 MICROCLIMATE AND THERMAL COMFORT SIMULATIONS ON WARM DAYS

The current year's reflected temperature and humidity transitions, 18th July 2022, is the first part of the simulation analysis. The selected hour is shown here in two sets, one is at pick temperature hour (16:00), and another is around sunset (22:00). Three scenarios for each case study are shown in a comparative table. These scenarios are compared in this chapter to reach the results of the microclimate effect in the case studies. Eventually, five points of each case study show the PET and UTCI features of the simulation. The date,

	QEUH Campus Park Area at 16:00:00			
Point	**Measured Temperature**	**Model Temperature**	**Difference Error**	**Error Square**
P1	30.7	29.55	1.15	1.32
P2	32.5	30	2.5	6.25
P3	29.7	29.62	0.08	0.01
P4	30.8	29.23	1.57	2.46
P5	30.9	29.5	1.4	1.96
P6	30.7	29.5	1.2	1.44
P7	31.8	29.4	2.4	5.76
P8	29.6	29.42	0.18	0.03
P9	30.7	29.6	1.1	1.21
P10	30.1	29.5	0.6	0.36
P11	28.8	29.24	-0.44	0.19
P12	30.2	29.2	1	1.00
P13	29.5	29.14	0.36	0.13
P14	30.2	29.06	1.14	1.30
P15	30.6	29.07	1.53	2.34
P16	31.2	29.2	2	4.00
P17	29.1	29.5	-0.4	0.16
P18	30.1	29.1	1	1.00
P19	28.8	28.8	0	0.00
P20	28.4	29	-0.6	0.36
Average				1.56
Root Mean Square Error				1.37

Table 22: RMSE Square value of measured and model temperatures on 18th July 2022 in the QEUH Campus Park area (by Author)

	Festival Park at 16:00:00			
Point	**Measured Temperature**	**Model Temperature**	**Difference Error**	**Error Square**
P1	28.3	29.13	-0.83	0.69
P2	30.2	29	1.2	1.44
P3	30.8	28.87	1.93	3.72
P4	30	29.01	0.99	0.98
P5	29	29.08	-0.08	0.01
P6	29.8	29.15	0.65	0.42
P7	30.7	29.06	1.64	2.69
P8	29.1	29.18	-0.08	0.01
P9	31.1	29.22	1.88	3.53
P10	30.5	29.15	1.35	1.82
P11	30.6	29.24	1.36	1.85
P12	30.5	29.29	1.21	1.46
P13	31.7	29.37	2.33	5.43
P14	31.2	29.63	1.57	2.46
P15	31.5	30.17	1.33	1.77
P16	31.1	29.7	1.4	1.96
P17	31.4	29.55	1.85	3.42
P18	29.3	29.38	-0.08	0.01
P19	30.1	29.23	0.87	0.76
P20	29.4	29.19	0.21	0.04
Average				1.72
Root Mean Square Error				1.31

Table 23: RMSE Square value of measured and model temperatures on 18th July 2022 in Festival Park (by Author)

18th July 2022, falls into the "extreme heat weather red warning" week. The ENVI-met Model validation data is extracted from the Travers study on that day. The model validation used the Root Mean Square Error (RMSE) value analysis around 16:00 hours of that day. For both case studies, the RMSE value is around 1.3. It was addressed as an accepted value for the base model for both case studies. Due to the limitation of only an hour, 16:00 was taken from the traverse study. The technical inefficiency and limitation are discussed in the limitation chapter.

5.8 CURRENT WARM DAY SIMULATION 18TH JULY 2022

The simulation results are shown in three different scenarios at hour 16:00 and hour 22:00, and the highlighted areas depict the simulation analysis in terms of PAT, MRT, PET

and UTCI.[3] Beginning with the Base case scenario, the 2nd and 3rd scenarios and their comparison is the main part of the simulation tables on the next page. The base case of both case studies represents the current condition of the open green space.

For Festival Park case studies, 2nd scenario is created based on the past demarcation and green cover of the park till the year 2002. Trees and plantations were placed by following topographical data. Next, Scenario 3 highlights the possible integration of vegetation around the east and west edges adjacent to the vehicular road, permeable pathways inside the park, placements of more trees from the tree footprint of old Festival Park, and more opening towards the south side neighbourhood.

Figure 46: Festival Park base case scenario (by aurhor)

Figure 47: Old Festival Park scenario (by aurhor)

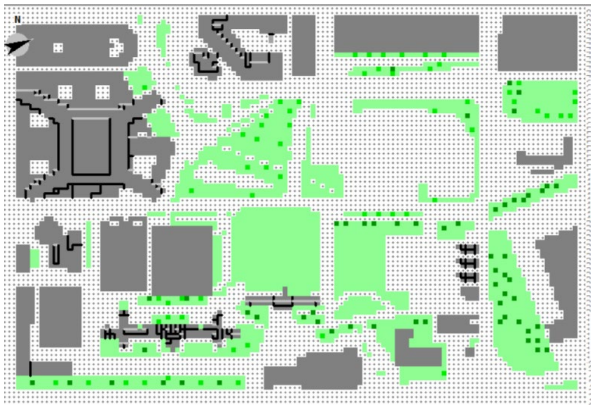


Figure 48: The QEUH campus base case scenario (by aurhor)

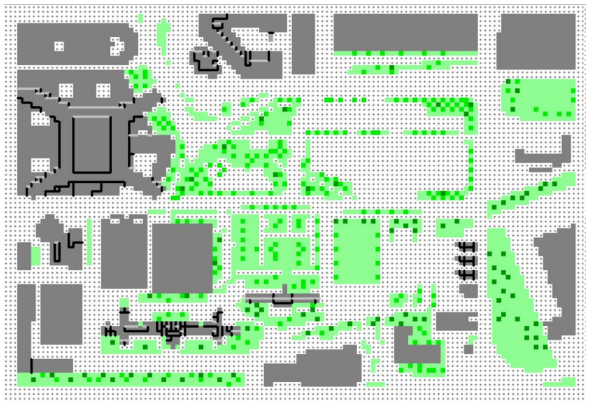


Figure 49: Proposed Greenspace development plan by NHS and ERZ Studio (interpretation by aurhor)

For the QEUH campus park, the base case is the existing site and green roof. The soil quality has also been reduced to make it more contextual with the site's current condition. 2nd scenario is the NHS Design proposal model, which has been adopted by the

[3] From table 24 to table 35, the simulation results are shown in in three different scenarios at hour 16:00 and hour 22:00. The white box in each case is highlighting the model validation part. The red outlined box is highlighting the significant change between value in different scenarios..

proposed landscape design provided by the architects and planner of the project. Scenario 3 highlights the integrated KPI indicators and additional climate-focused planning recommendations on top of the NHS proposed plan. It includes a green roof on the exiting parking building, less surface parking, and more permeable surfaces with better soil conditions.

Figure 50: Proposed Festival Park ENVI-met Modelling (by: author)

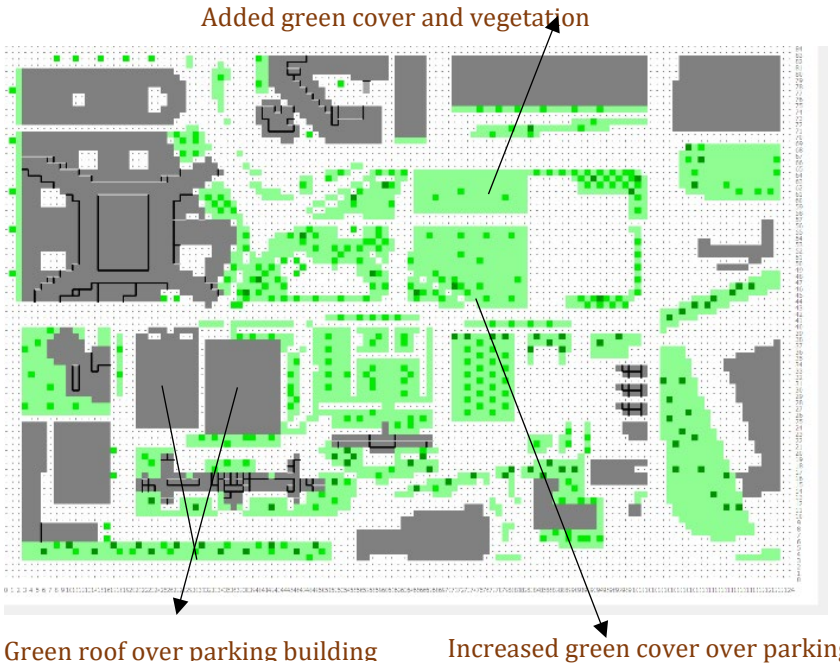


Figure 51: Proposed QEUH Campus Park ENVI-met Modelling (by author)

ENVI-met Model Settings Detail:

ENVI-met Model Parameters	Festival Park Model	QEUH Campus Park Model
Model dimensions	123 by 123 by 18	125 by 85 by 41
Cell size	3 by 3 by 3	3 by 3 by 3
Model rotation	N/a	(-) 68.1
Nesting Grid	5	5
Vegetation	New conifers, DM, DS small (5m to 15m), Grass XX 25 cm to 50 cm	Leafless base T1, New conifers, DS small 5m Grass XX 25 cm to 50 cm
Building material	ST, BR, PG, Customized	ST, BR, PG, Customized
Soil	Loamy soil	Loamy soil (customized)
Date	18th July 2022	18th July 2022
Humidity	Max 90%, Min 30%	Max 90%, Min 30%
Temperature	Max 31.20°C Min 12.70	Max 31.20°C Min 12.70
Constant Windspeed	3.50	3.50
Constant Wind direction	225	225
Roughness length	0.01	0.01
Root Mean Square	1.31 at 16:00 hour	1.37 at 16:00 hour

5.8.1 POTENTIAL AIR TEMPERATURE (T^{PAT})

Simulation results of T^{PAT} in Festival Park have a notable change in the Old Scenario. The T^{PAT} is 28.63°C to 29.29°C, whereas in the base case, it is above 28.93°C at hour 16:00. However, Scenario 3 with permeable pavement and the extended green cover does not reflect any better changes with the base case.

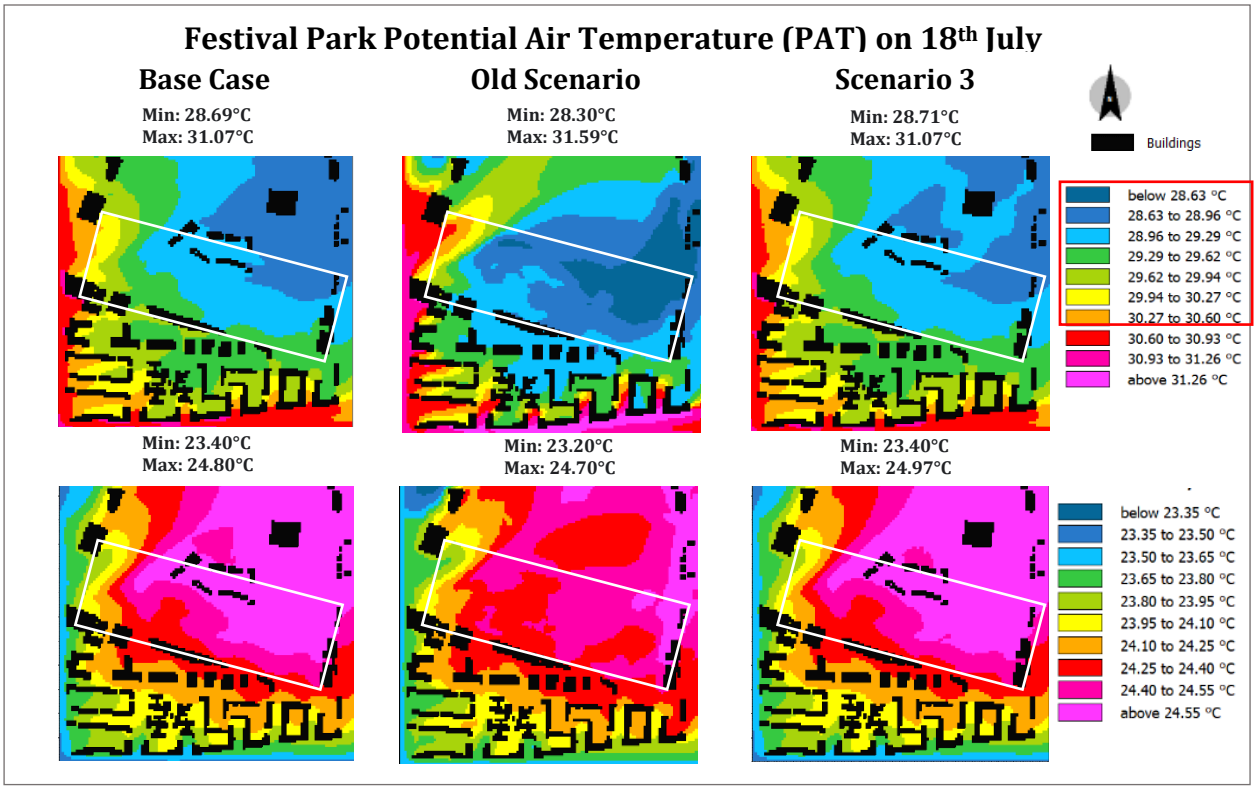


Table 24: Three scenarios of Festival Park PAT (T^{PAT}) on 18th July 2022 at hour 16:00 and 22:00 (by author)

The T^{PAT} in the QEUH campus park base case is 0.03°C (table 25), more than the Festival Park. Also, there is a significant change in NHS Design Scenario. The T^{PAT} is reduced and has a cooling effect because of the proposed landscape design. NHS proposed design simulation has effective lower T^{PAT}, which has decreased around 1°C at hour 16:00. Proposed Scenario 3 is almost similar to it and has a similar impact, except there are less T^{PAT} in the eastern side reduces surface heating as the green cover is more and parking area is reduced in Scenario 3 (see the red circled shape on the map). At hour 22:00, the T^{PAT} also has smiler features. However, it dropped down to 22.69°C in the green park area.

In the proposed simulation, the T^{PAT} is less in the QEUH campus park than in Festival Park. The building shadow and wind circulation might strongly influence this change.

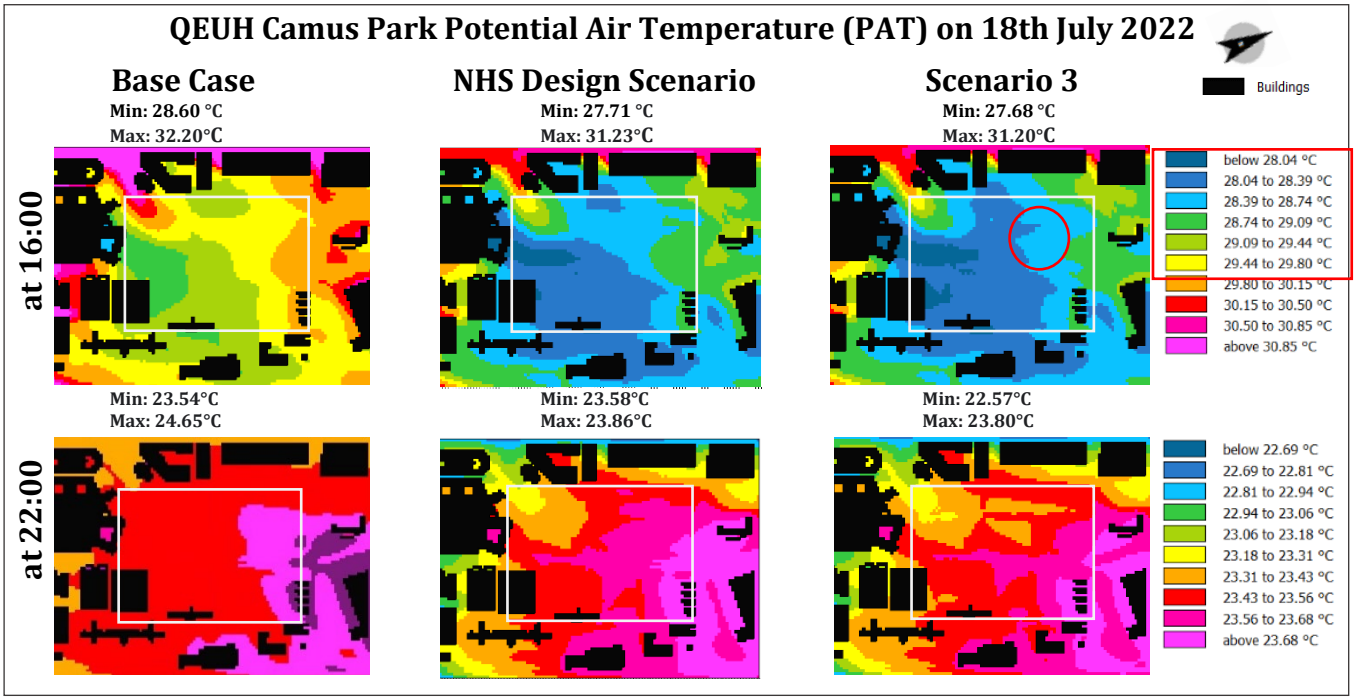


Table 25: Three scenarios of the QEUH campus park PAT (T^{PAT}) on 18th July 2022 at hour 16:00 and 22:00 (By Author)

5.8.2 Mean RADIANT TEMPERATURE (T^{MRT})

The Old Scenario showed higher T^{MRT} than the Base case, and the large portion of mown land impacted the simulation. Scenario 3, with more opening towards the south street and added peripheral vegetation, promisingly reduce the T^{MRT} at the warmest hour (16:00). After sunset, the warming effect is visible in all cases, as the humidity increases and T^{PAT} decreased the T^{MRT} clearly exemplifies the effect the microclimate influences a park provides in the neighbourhood. The vegetation area has a warming effect at hour 22:00, and the T^{MRT} value showed above 22.6 °C

In the QEUH campus park, the T^{MRT} did not give any significant change for Scenario 3. It is almost like the NHS design scenario. However, like T^{PAT}, the T^{MRT} has decreased in both scenario two and Scenario 3 than the existing situation. Due to the lack of vegetation at hour 22:00, the T^{MRT} dropped to 16.13°C. However, the proposed and NHS design scenarios increased the T^{MRT} value to around 19°C.

The difference in the T^{MRT} value of the Base Case scenario is very high between the two case studies because of the different amounts of vegetation cover.

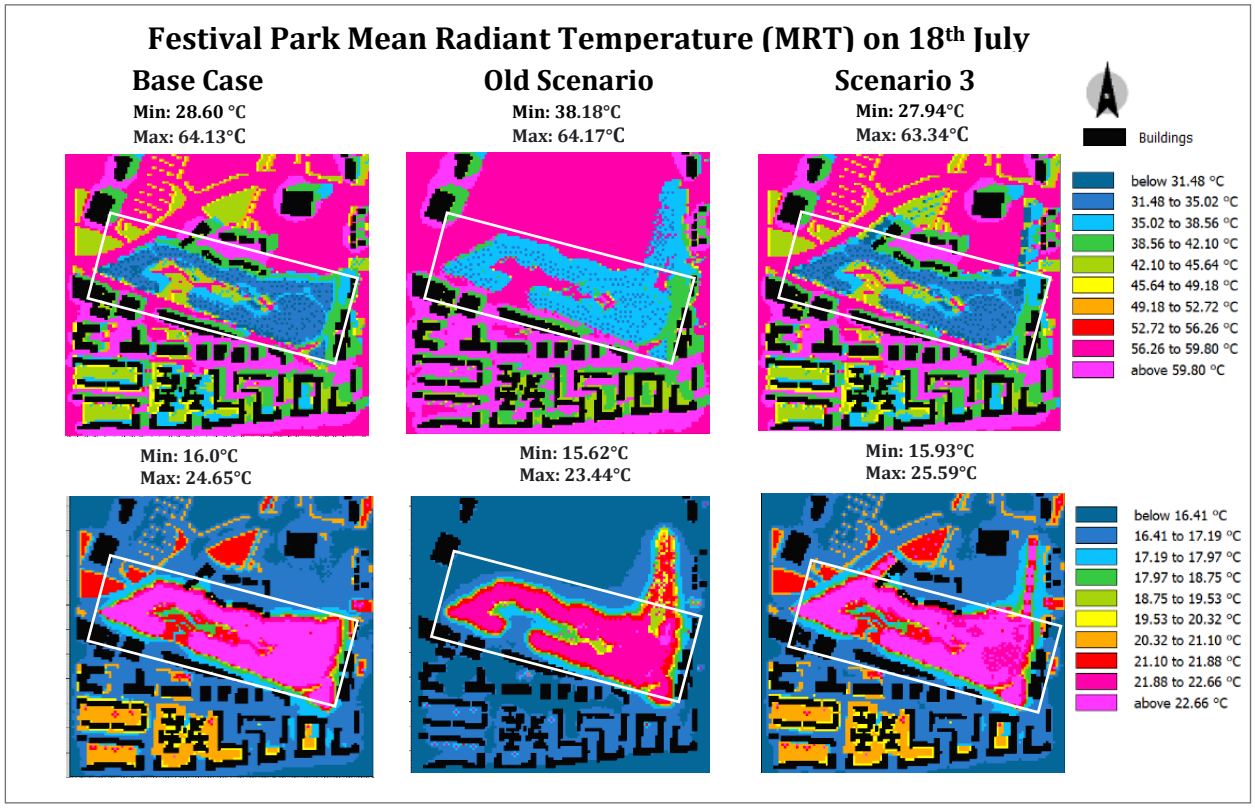


Table 26: Three scenarios of Festival Park MRT (T^{MRT}) on 18th July 2022 at hour 16:00 and 22:00 (By Author)

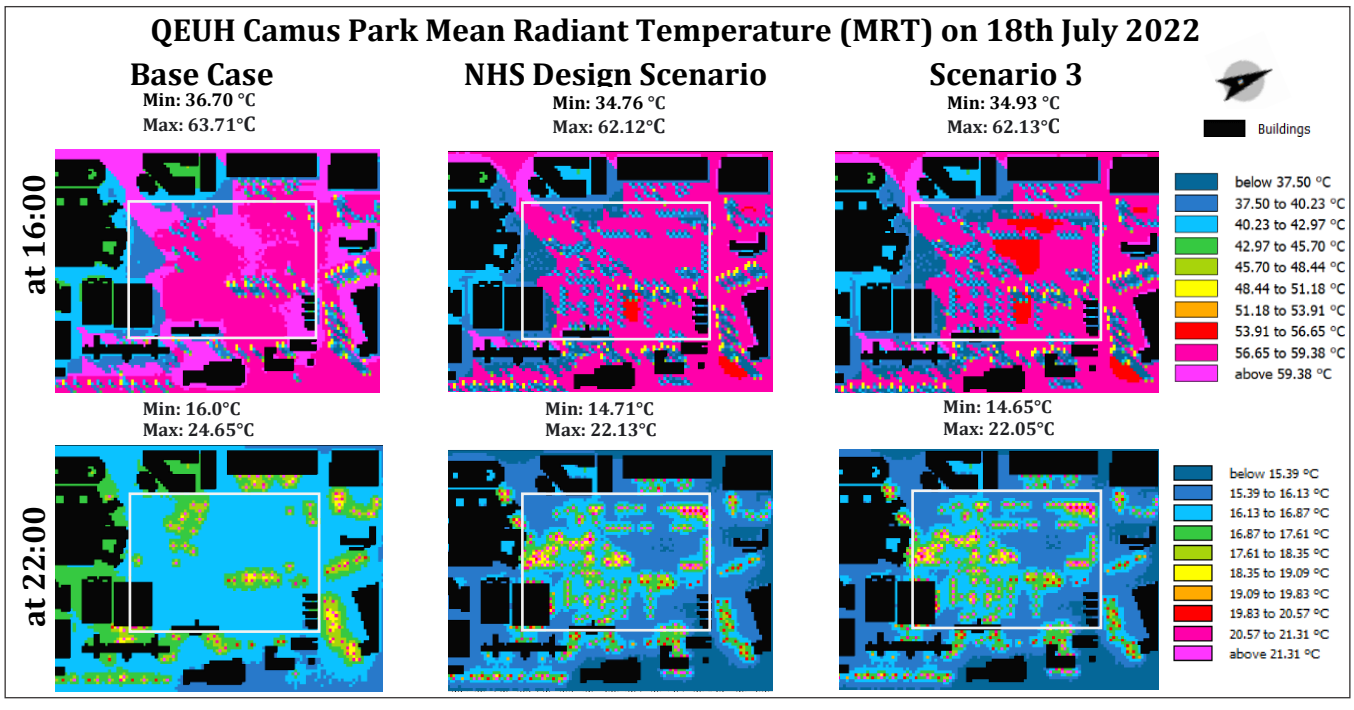


Table 27: Three scenarios of the QEUH campus park (T^{MRT}) on 18th July 2022 at hour 16:00 and 22:00 (By Author)

5.8.3 PSYCHOLOGICAL EQUIVALENT TEMPERATURE (T^{PET})

In both cases, T^{PET} is out of comfort level in Glaswegian tolerance.[4] Surprisingly older state of the Festival Park has T^{PET} >30.37°C compared to the current scenario. It is assumable that mown land and unplanned green cover of old Festival Park was not entirely effective except for the vegetation zone. However, proposed scenario 3 has an impactful change as it reduces the T^{PET} *to* 29.02°C because of the addition of vegetation cover and permeable surfaces. Among the five points measured on the site, the highest can be seen on the 4th point (outside of the park, commercial/industrial point), and the 1st point (deep vegetation point inside the park) has the lowest among the five points. 3rd point is similar for all scenarios.

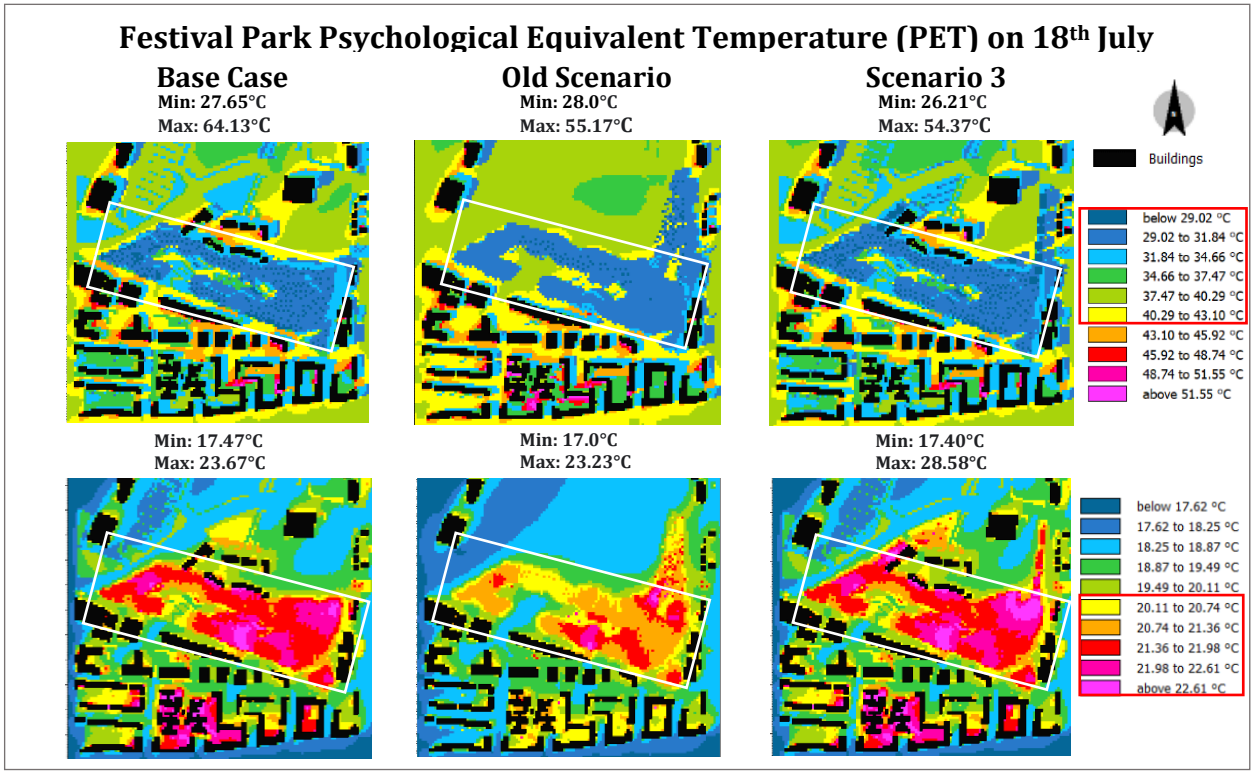
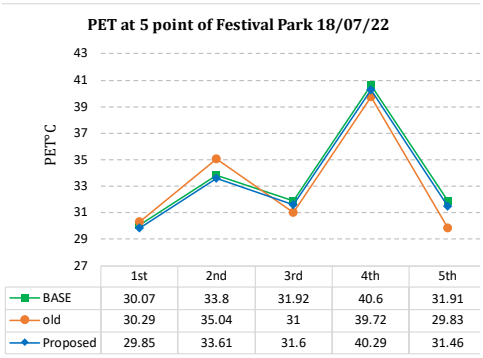
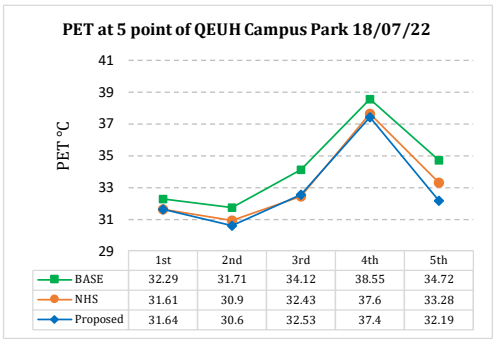


Table 28: Three scenarios of the Festival Park PET (T^{PET}) on 18th July 2022 at hour 16:00 and 22:00 (by Author)



	1st	2nd	3rd	4th	5th
BASE	30.07	33.8	31.92	40.6	31.91
old	30.29	35.04	31	39.72	29.83
Proposed	29.85	33.61	31.6	40.29	31.46



	1st	2nd	3rd	4th	5th
BASE	32.29	31.71	34.12	38.55	34.72
NHS	31.61	30.9	32.43	37.6	33.28
Proposed	31.64	30.6	32.53	37.4	32.19

Table 29: T^{PET} value on 5 points Festival Park(left) and QEUH campus (right) on 18/07/22 at hour 16:00 (by Author)

[4] The optimal ranges of PET index are suggested as 18°C to 23°C in the literature (MATZARAKIS, MAYER & IZIOMON,) but in PET study based in Glasgow suggested that it is lower than the usual range, which 9°C to 18°C

The T^{PET} value reduces by almost 1.5°C in the QEUH campus future scenario. Measured five points has shown a similar gradual change from base case to Scenario 2 and Scenario 3 except for the 5th point.

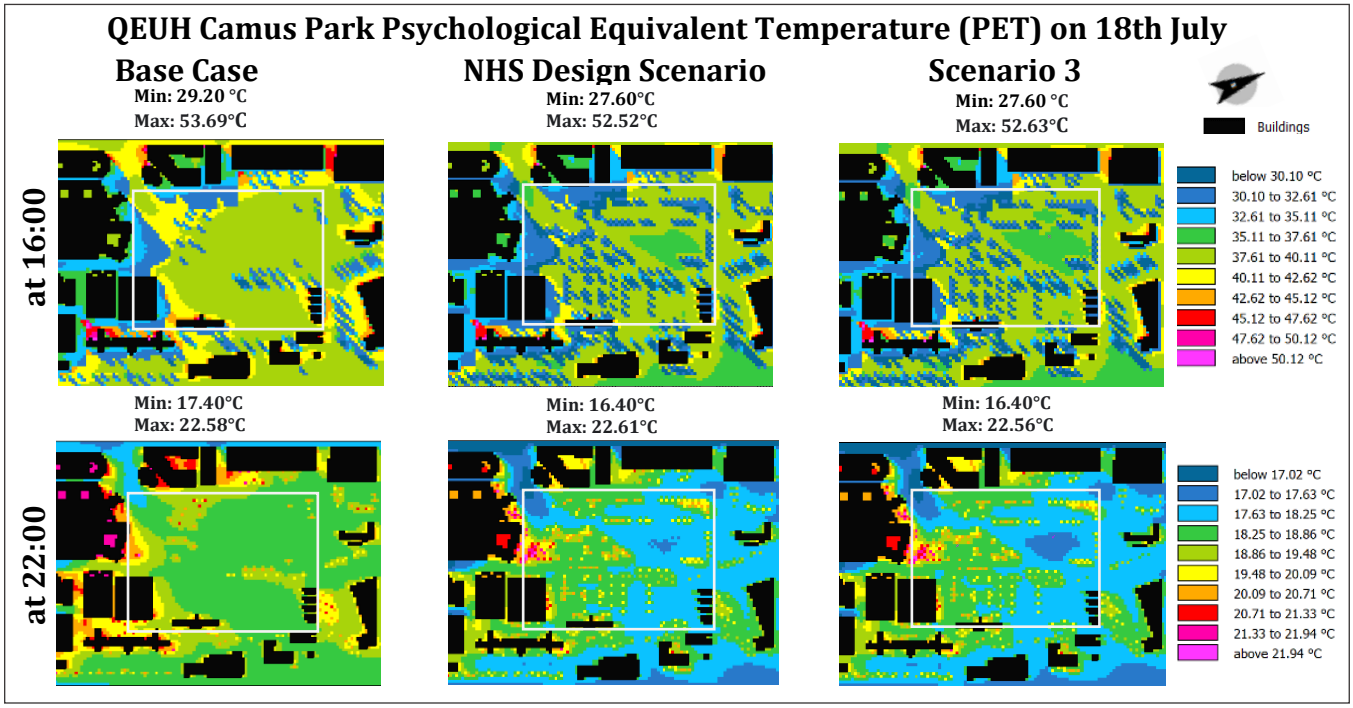
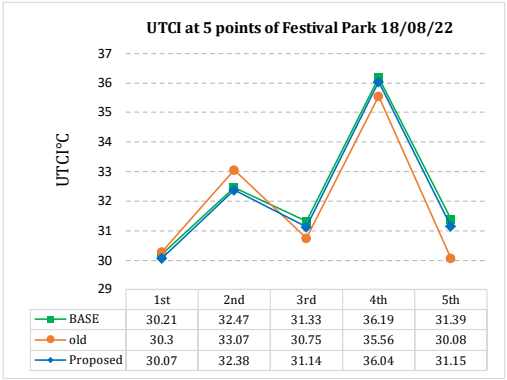


Table 30: Three scenarios of QEUH campus park PET (T^{PET}) on 18th July 2022 at hour 16:00 and 22:00 (By Author)

During hour 22:00 the Festival park shows a Comfortable PET range in all three cases. The base case of QEUH campus park however began to cool down after sunset and reflected slightly cool rang in NHS design and proposed scenario.

5.8.4 UNIVERSAL THERMAL CLIMATE INDEX (UTCI) (T^{UT})

T^{UT} value has a significant impact on Scenario 3 of the Festival Park other than T^{PET} and T^{MRT}. It shows a cohesive T^{UT} value all around the park area and in the extended green cover. At hour 22:00, the T^{UT} value is higher than the other two scenarios. Due to insufficient opening and wind flow, T^{UT} in the adjacent part to the housing area is very high (the reasoning is based on the assumption in this context). On the other hand, the T^{UT} value in the QEUH campus park is higher than in Festival Park. 3rd point has a lower value due to the all-time shading effect from the building on the hospital campus.



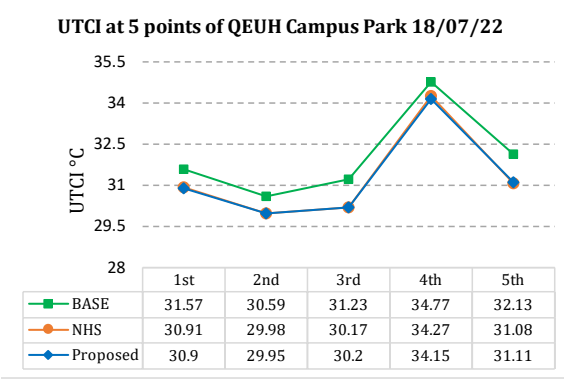


Table 31: T^{UT} value on5 points in the (left) Festival Park and (right) QEUH campus on 18/07/22 (S: Author)

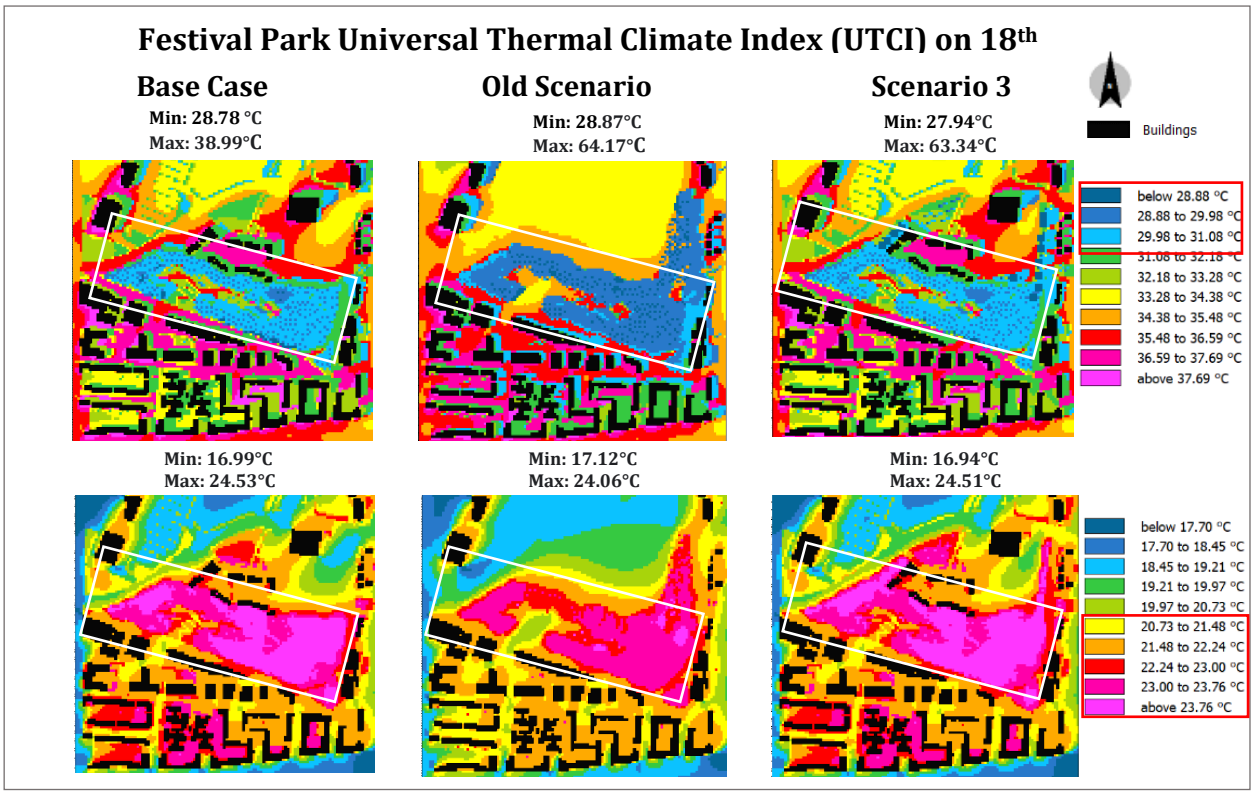


Table 32: Three scenarios of Festival Park T^{UT} on 18th July 2022 at hour 16:00 and 22:00 (by Author)

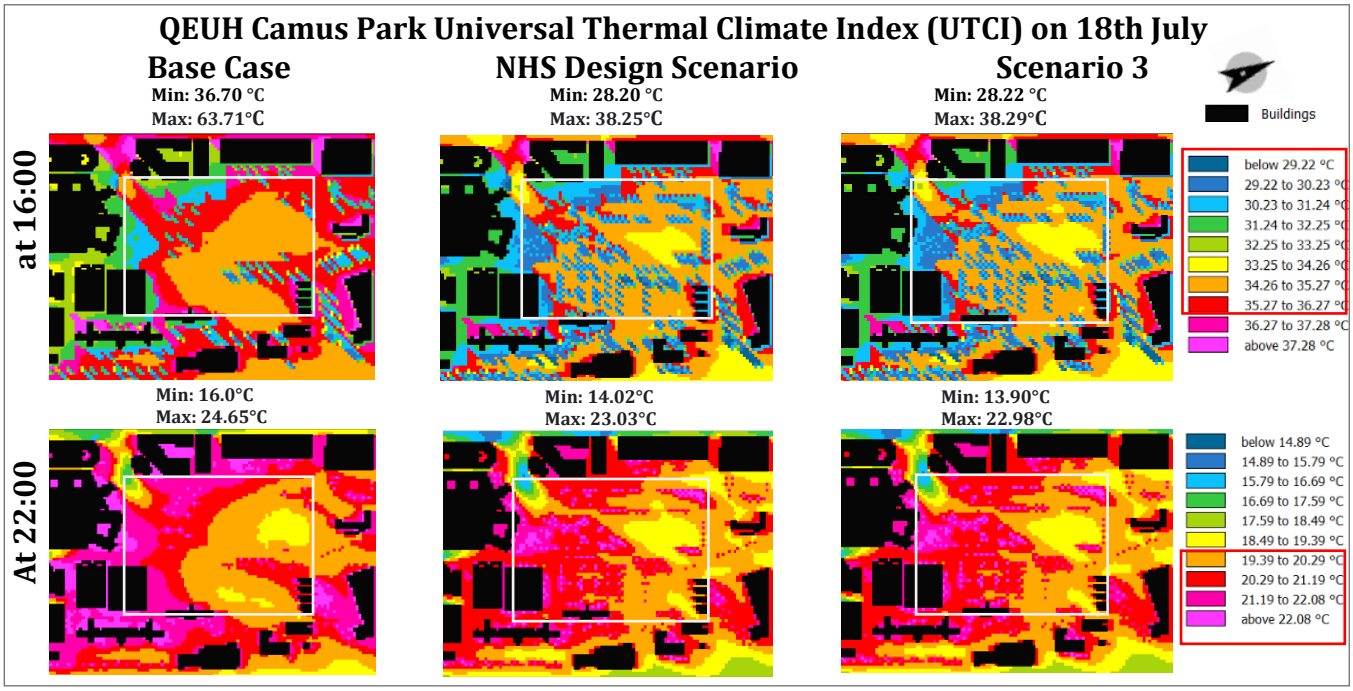


Table 33: Three scenarios of QEUH campus park T^{UT} on 18th July 2022 at hour 16:00 and 22:00 (by author)

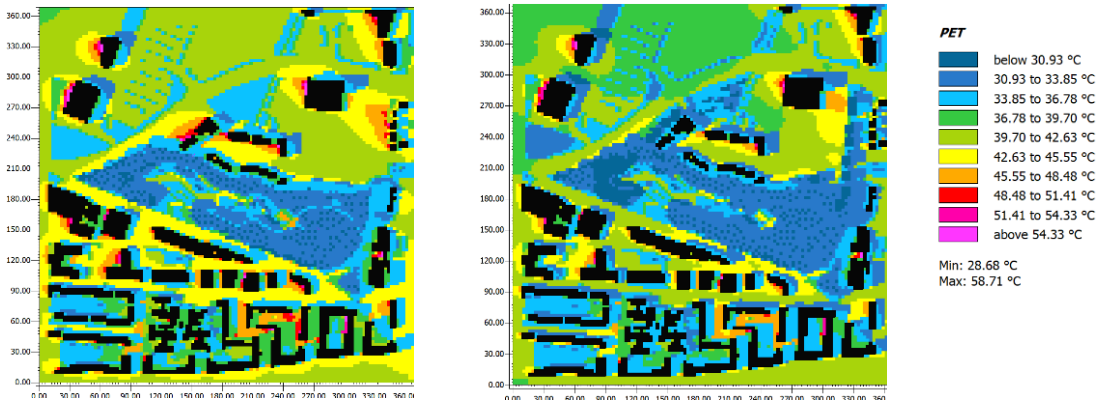
At hour 22:00 the T^{UT} value changed towards Slightly Warm to Warm range of UTCI in the QEUH campus park. Similarly Festival Park T^{UT} value increased further to Warm range around the vegetation cover.

5.9 RECORD WARMEST DAY SIMULATION 28TH JUNE 2018

During the warmest day in the record, it had the highest temperature of 32°C in Glasgow. For both base cases, the simulation result shows that T^{PET}>28.68°C is higher than 18°C-26°C, above the comfort zone. Inside the Festival Park, T^{PET} has a Slight Heat Stress level of up to 30.93°C<32°C. In comparison, the QEUH campus park zone exceeds that level and falls into the Moderate Heat Stress level of PET index and the T^{PET} value between 34°C to 46.93°C. However, the proposed scenario in the QEUH campus park has a reduction of 1°C from the base case, and in the Festival park, the reduction is around 0.6°C. Because of the design interventions, the result has a difference, yet the festival park is in slight heat stress level whereas the proposed campus park is higher than that.

FESTIVAL PARK BASE CASE (T^{PET})
Min: 28.68 °C
Max: 58.71°C

FESTIVAL PARK PROPOSED (T^{PET}) Min: 28.0 °C
Max: 57.28°C



QEUH CAMPUS PARK BASE CASE (T^{PET})
Min: 31.40 °C
Max: 57.25°C

QEUH CAMPUS PARK PROPOSED (T^{PET})
Min: 30.40 °C
Max: 55.60°C

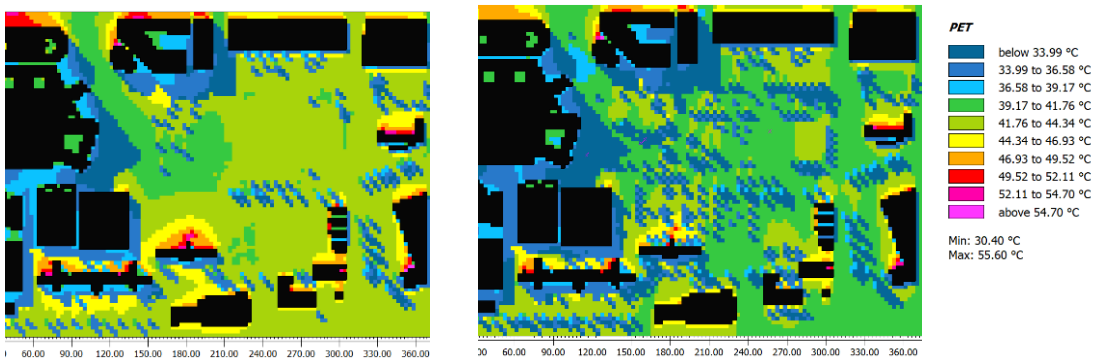
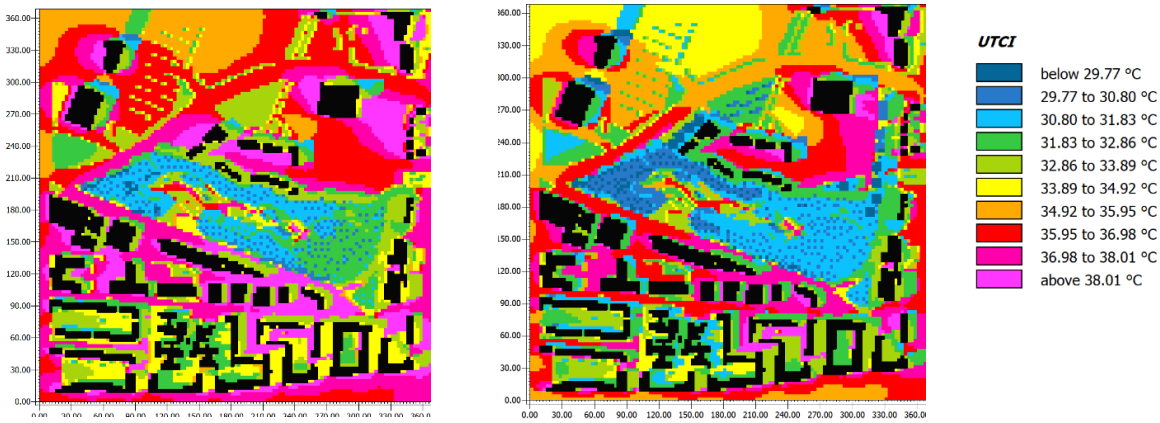


Table 34: The comparison between two scenarios of Festival Park (T^{PET}) (above) and two scenarios of QEUH campus park PET (T^{PET}) (below) on 28th June 2018. The time is hour 16:00 for both (by author)

FESTIVAL PARK BASE CASE (T^{UT})
Min: 29.39 °C
Max: 39.78°C

FESTIVAL PARK PROPOSED (T^{UT})
Min: 28.74 °C
Max: 39.05°C



QEUH CAMPUS PARK BASE CASE (T^{UT})
Min: 30.28 °C
Max: 40.46°C

QEUH CAMPUS PARK PROPOSED (T^{UT})
Min: 29.13 °C
Max: 39.38°C

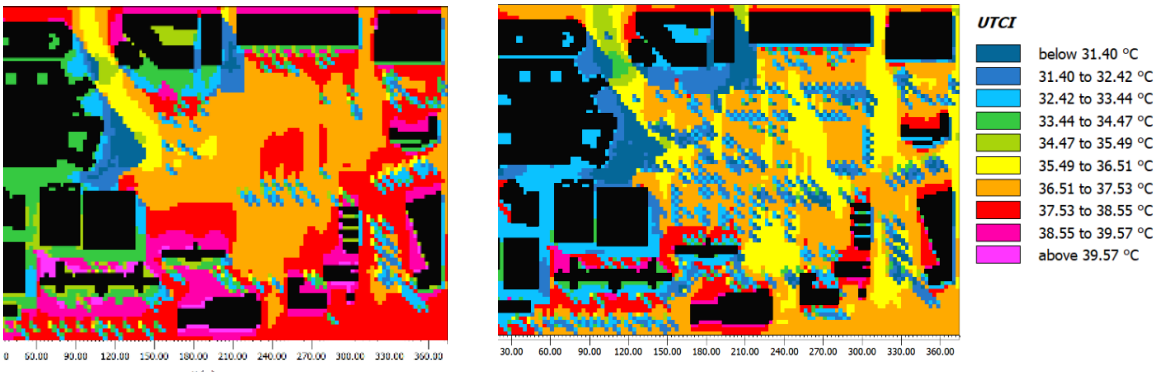


Table 35: The comparison between two scenarios of Festival Park (T^{UT})(above) and two scenarios of QEUH campus park PET (T^{UT}) (below) on 28th June 2018. The time is hour 16:00 for both (by author)

The simulation results of T^{UT} (UTCI) simulation results are higher than 29°C >26°C and above the comfort zone. For the Festival Park, the T^{UT} has moderate heat stress levels up to 31.51°C<32°C. Lack of shading and vegetation profile resulted in the T^{UT} value between 36.39 to 38.42°C. One parking site adjacent to the park has very high T^{UT} value, Very Strong Heat Stress >38°C. The proposed case decreased the T^{UT} value to 1.15°C in the campus park, and the Festival park also has a reduction of 0.65°C. Similarly, as the PET value, the UTCI is also higher in the campus park in the proposed scenario.

CHAPTER 6: DISCUSSION & RECOMMENDATION

The current and past warmest day simulation result reflects the microclimatic influences of different spatial segments of both case studies. It reflects on the indicators listed in the KPI of UGOS in the discussed case study with significant impact. The discussion aims to achieve UGOS as a resilient urban element and the holistic contribution of neighbourhood UGOSs to the larger urban area as a group.

6.1 DISCUSSION OF THERMAL COMFORT ON PROPOSED SCENARIOS

The comparative result of the record warmest day in Glasgow highlights the differences between the two types of parks and their contribution to the thermal comfort, spatial placement, and ecology of the surrounding built environment. The five locations demonstrated the effect of green cover and the UHI effect in both cases. 4th point in both

Figure 52: Five points from travers study on the Festival Park

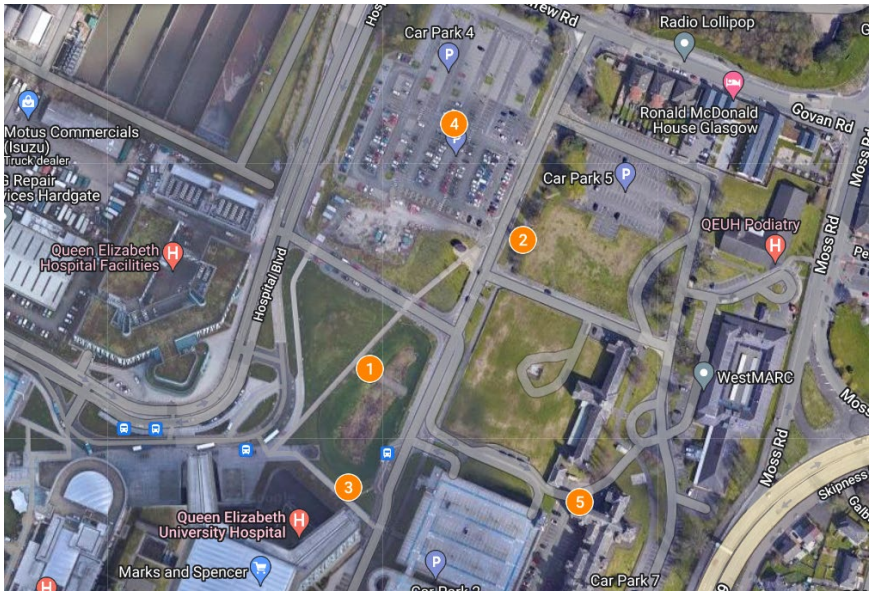


Figure 53: Five points from the travers study on the QEUH campus area

UGOS around the commercial zone in POS and the parking area in PIS has shown a higher value than the green cover point. Implemented design strategy has shown a slight decrease on the 4th point in the Festival park due to a subtle increase in vegetation. However, QEUH campus analysis results show that greening the parking area from NHS's proposed design reduces the T^{UT} value more than the T^{PET} value.

It can be assumed on average summer days, it is possible to bring the heat stress down to a comfortable T^{UT} range with proper green infrastructure in focused areas in reference to the warmest day results. Similarly, it decreases more if the parking space is replaced by plain grass and plantation. Therefore, a small consequential change in microclimate eventually rows the future impacts for each UGOS climate-mitigation planning and design solution.

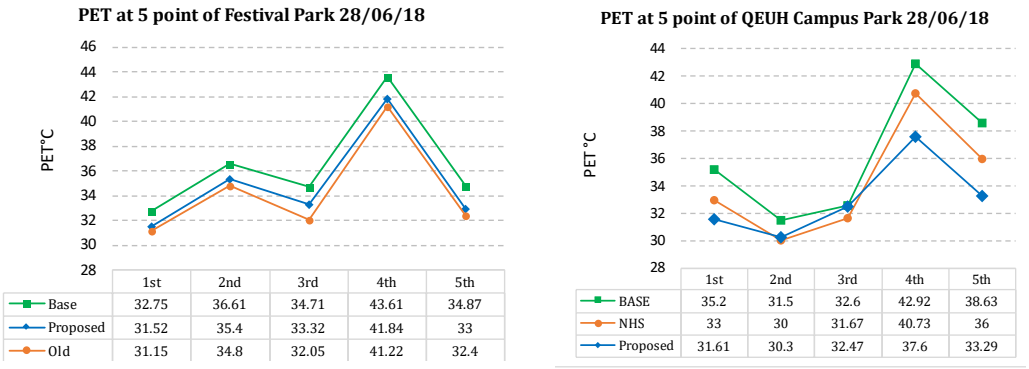


Figure 54: PET value of Festival Park and QEUH campus park at hour 16:00 on the record warmest day 28th June 2018

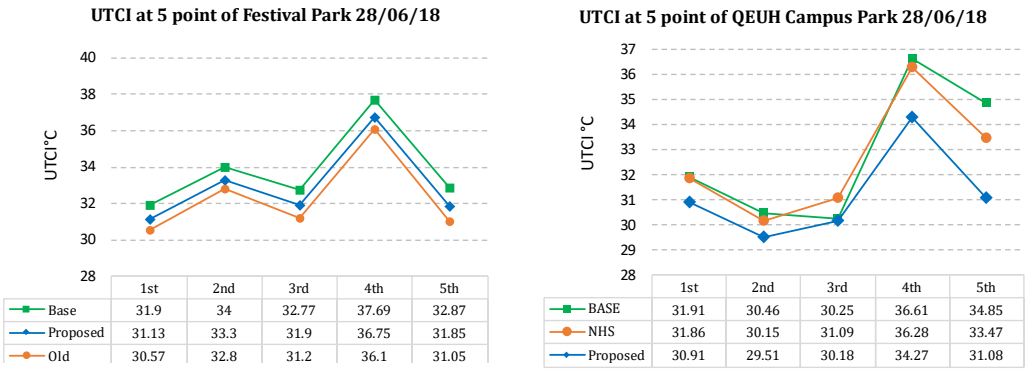


Figure 55: UTCI value of Festival Park and QEUH campus park at hour 16:00 on the record warmest day 28th June 2018

6.2 CLIMATE-FOCUSED UGOS KPI RELEVANCY

UGOS conservation usually comes to relevance as a means of protecting biodiversity; it is often separated from general open space guidelines and pre-defined as significant for only ecological context. Adequate green infrastructure and permeable surface cover initiated by climate-focused KPI for UGOS results in a comfortable range in micro-climate indices. An improved micro-climatic environment obtained in the case studies through design proposals contributes to most of the prioritised KPI for UGOS. These findings serve objective four, a directory of KPIs for UGOS, integrating expert opinion and climate

KPI For UGOS (QEUH Campus Park)	Priority Measure Level
6) Equity and inclusivity 9) Balanced sunlight exposure 10) Landscape shading 11) Regulated air quality 12) Sustainable material furniture 13) Permeable material for ground cover 26) Interactive space for diverse age group 27) Third place (Relaxation) 28) Flora and fauna diversity 29) Site-based habitat provision 30) preservation of heritage tree	(↑↑↑↑↑)

Table 36: Highly Prioritise KPI for the QEUH park development

change adoption-led design approach. Each KPI shown in table x has been marked as highly prioritised, and the ongoing development can primarily focus on these criteria. Ultimately listed relevant indicators of UGOS benefits the wider network of city planning and mitigation measures. However, the QEUH campus park has more opportunities as it is going under greenspace development.

6.3 PARTNERSHIP OF STAKEHOLDERS AND USERS GROUP

Integration of experts' opinions in this research portrays the significant contribution of design and planning guidelines that are often unforeseen due to the time frame of UGOS project development and lack of expression from the associated partners. Who and when this collaboration takes place should be part of the process of UGOS provisioning. Surveying the user's group of the UGOS will not entirely benefit the design decision unless there is an exchange of counsel among the designers, planners, and users. The NHS proposed ongoing development of UGOS in the hospital campus and had a broad collaborative approach such as the Green Exercise partnership consisting of users' reflection and Green Health Advisors (Nature Scot), active travel planner (Sustrans - National Cycle Network UK). The Green Health Advisor Anne Lumb quoted, *"these projects are led by engineer's programme managers and architects-design consortium who in my experience often think greenspace is the bit that happens at the end of the project with space left over after building –which is not a nature-based sustainable design approach we now advocate and need to address climate and health wellbeing"*. Certainly, the QEUH campus could be more effective if the planning process was integrated with the same focus for the UGOS as the hospital building received because that is more cost-effective and straightforward maintenance than the current situation. Adopted KPI for UGOS (listed indicators in chapter 5.5) for an optimal UGOS with a climatic perspective, enhanced biodiversity and user's wellbeing comprehend not only the expert's opinion but also represent a clear vision for planning and design approach. Adequate tree and

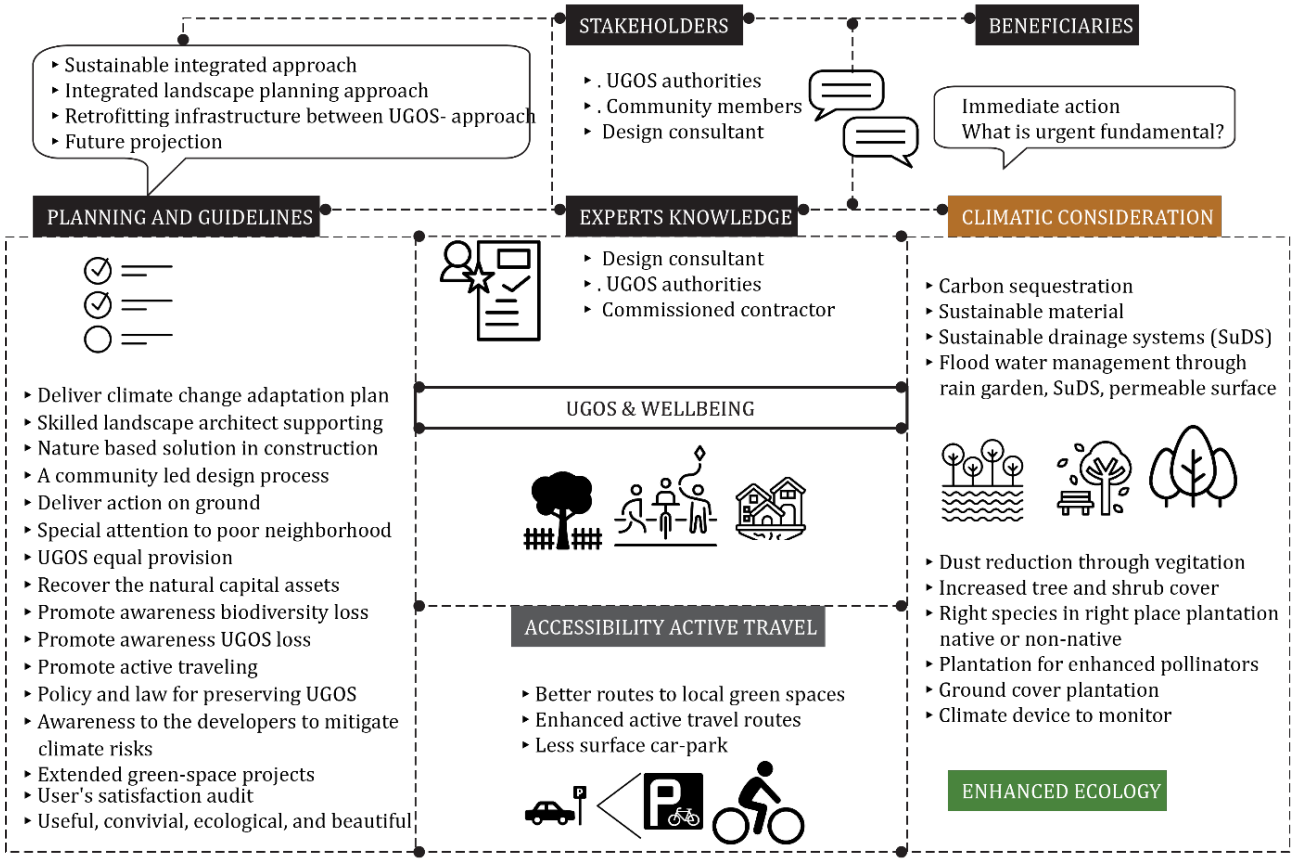


Table 37: Flowchart table of recommended UGOS planning and development aspects (by author)

shrub cover, wildflower planting rather than mown lawn and active travel routes are fundamental elements for reviving the "green desert" (current QEUH campus park), mentioned by another expert interviewee (Gemma Kitson, Greenspace and Urban Realm Officer for NHSGGC). Integrated landscape experts (ERZ Studio) in hospital UGOS expressed the immediate actions for taking account of climate change and providing the needs of the diverse range of user groups in the hospital as the impacts of climate change are only set to worsen. Table 37 highlights the transparent integration of planning and development flow of discussed features for UGOS. The recommendations are adopted from the expert's opinion and research outputs. All the expert interviewees expressed that the climate change mitigation strategy is below the expected to moderate level in ground action. Also, awareness of active travel and biodiversity loss is fundamental to approaching a sustainable UGOS development.

6.4 PROPOSAL AND DESIGN STRATEGY RECOMMENDATION

The city needs to emphasise the combination of climate-focused spatial configuration and landscape planning to prepare for a warmer climate. The design strategy and recommendation primarily focus on the PIS case study to aid the adaption and climate justice strategies for the most vulnerable to climate change impact. The common issues for NHS outdoor estates are that they are often underused, uninspiring, undervalued and less appreciated (Scottish Government, 2021). The KPI for UGOS findings and micro-

climatic simulation results of the QEUH campus park resonates that the spatial configuration is in a critical landlocked state, and the concentration of significant buildings in the south-western part creates a complex and imbalanced micro-climatic situation.

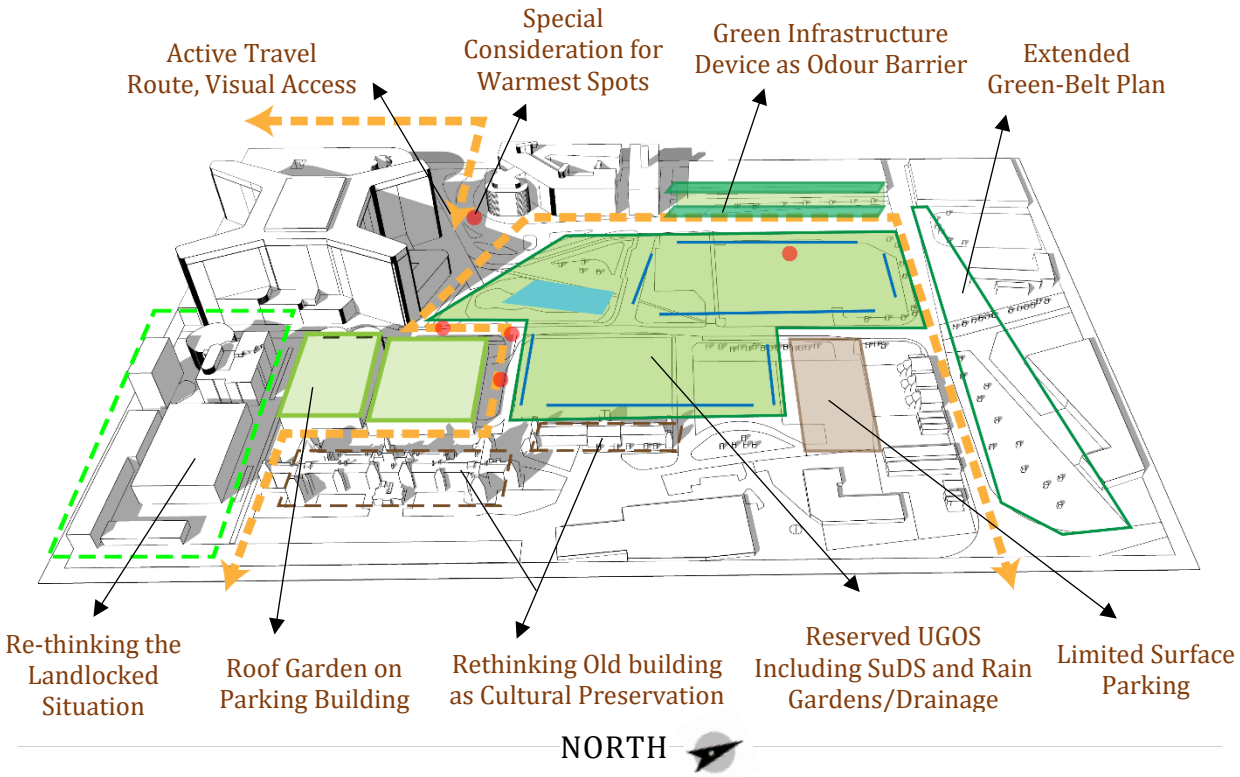


Figure 56: Design strategies and planning recommendation for the QEUH campus park (by author)

The ongoing greenspace development, NHS design scenario and proposed scenario in the previous chapter reflect similar results for a range of micro-climatic indices. Despite that, certain aspects still need bold design and planning evaluation to revive the campus park in an optimal condition and sustainable for future risks. Figure 58 highlights the considered design strategies and the proposed scenario concept aligned with the planning flow chart (table 37) and the ongoing greenspace development except for the parking area. To achieve a high-quality landscape setting, re-think the parking facilities in a more advanced way is vital. Despite greening the existing surface car park, it can be allocated into compact, sustainable, low, storey buildings which will not impact the wind flow on the campus. Also, according to the users-reflection survey abducted by the landscape team of ongoing design, the odour from the waste treatment plant from the north-western part significantly impacts the open spaces and users feel discouraged being in outdoor areas.

Regarding ongoing biodiversity and green management development, interventions should be included from climate data specific points such as the warmest spots and coldest spots (all-time shaded areas from the buildings). Sunlight exposure and the shaded area should be balanced by the open grassland, tree canopies, or artificial

shading (e.g., sun sail). Equally distributed active travel routes may encourage the users and employees to reduce vehicular activity on the roads and paths adjacent to the parking area. Therapeutic design for conviviality and art platform design strategy adopted by the NHS new proposal is a unique opportunity, and it can be enhanced by exiting old building conservation.

Even though the indicators of Gv and Gvii were not top prioritised, they also have an influential contribution to future growth and cost maintenance for both case studies. Volunteers and educational campaigns can bring awareness and enhance the examination aspects of the UGOS, such as experimenting with landscape equipment or weather measuring tools.

The highlighted design strategies and recommendation expands the critical knowledge and support for optimising UGOS design and evaluation. This research methodology can help design professional communities and decision-makers enhance the performance of existing schemes and new proposals for UGOS.

6.5 LIMITATION

• This research work's time frame was insufficient to pursue reliable climate data. The study should be continued for a more extended period. During the study, a static temperature reading was difficult to follow due to sudden wind flow and cloud cover.

• The RMSE value in the model could be more precise. However, it needed more calibration with more climate data.

• Measuring two case studies at the same time is more effective for getting a viable comparison result. Nonetheless, a fixed data logger and more on-site observation can reduce these limitations for future studies.

• The current construction at the Hospital campus also reduced the accuracy of existing site conditions as it is transitioning.

• Festival Park data could not be retrieved entirely as it is an old park. Even though there are presence of different kinds of pathways in middle of the high vegetation area it is inactive due to wild plants. It is a common scenario for exiting UGOS and the lack of maintenance approach became a limitation in this research due to its low effectiveness.

• The meteorological data is also not quite reliable regarding the site-specific survey. The weather station hourly information limited the wind flow analysis.

• ENVI-met analysis can be justified only in the site's measured point location and focused area rather than the whole area. Therefore, it limits the analysis of UGOS and the surrounding built environment.

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6.6 CONCLUSION

Looking at the UGOS case studies in Glasgow, it is now vital to take measures and upgrade UGOS design practise and planning provisions for mitigating future climate change threats. The analysis result showed that by fine-tuning planning and design consideration in a site-specific context, it is almost possible to manoeuvre the course of thermal comfort level for the users and neighbour habitants around an urban green open space. Climate change mitigation led existing strategies and policies derived for UGOS have common intentions of achieving it by the next decades. However, it is over-ambitious within the timeframe as there is no strong imageability of potential UGOS acts on the ground. The approach may have a beginning but still lacks efficiency and priority as they are not focused due to other emergent climate change factors. The actors and stakeholders involved in decision-making have a significant role, and their expertise should be integrated with a collaborative system and not in an individual set-up.

Public institutional space such as the QEUH campus park development has similar notion as PIS examples led by NHS and administrative body. Some UGOS examples have high remarks on achieving a sustainable and successful UGOS, such as Forth Valley Hospital, awarded in the landscape category for developing a country park with improved landscape multi-functionality and enhanced biodiversity(Building with Nature, 2020). For the discussed case study, it is crucial to achieving high qualities due to the morphological setting and landlocked situation. Best practise needs to be evolved in a specific context from the very early stage of any development. For the overall UGOS provisioning, the maintenance cost with less visible benefit, high demand for landuse and budget constrain often led these remaining medium UGOS as a liability and not a resilient element to the mitigation plan. Therefore, critical observation should be implemented to make a sustainable management system. Incorporating innovative functions like urban farming and community engagement can facilitate UGOS sustainability.

Analysing UGOS case studies can highlight contextual development strategies for one common cause of making it climate-resiliency and sustainable city development. Cities that already have published audits of climate-resilient optimality and user's reaction to UGOS can encourage others to develop UGOS-led urban design as a more concrete benchmark to show its benefits. For both case studies, it was visible that the accessibility is compromised due to service and housing facilities, and it is not equally distributed. Hence, UGOS strategies must be enforced at the planning level with legal standards.

The research represented an embedded performance system with attempted objectives. The emergent trend of warm and dry summer should be approached with UGOS to promote good health and well-being. A coherent argument is still not there regarding how to approach such events efficiently, how the taken measurements can project for the common good and how they can be delivered on time. Integrating KPI for UGOS can

predict the risks and benefits for functioning when needed and enable UGOS to knit the built forms of different amenities and combined them into those meaningful experiences.

6.7 COMMENTS FOR FURTHER STUDY

For future study this research paper can be expanded by integrating the concept of UGOS embedded system into administrative auditory system with more reliable climate data extraction. Socio-environmental and infrastructure planning consideration can be incorporated to find the fitness of UGOS performance. Critical case studies can be evaluated for further challenges specifically during heat stress events as well as cold stress events. Different urban morphological setting can also be examined within high dense urban area. Different use of green infrastructure and landscape device in sensitive thermal distress area can be the focus of further study.

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APPENDIX 1

EXPERTS OPINION (QUESTIONER RESPONSE)

Dissertation Questionnaire for the Master's program in Urban Climate and Sustainability (MUrCS Erasmus Mundus Joint Master 20/21), Glasgow Caledonian University
Student: Zarin Tasnim
Dissertation topic: Climate resilient neighbourhood scale green spaces: a case study in Glasgow

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*Note: This questionnaire is based on assessing the quality of **neighbourhood-scale park-type green spaces** in a growing urbanization context to determine the resiliency to the current climate change impact and the socioenvironmental benefit of public park-type green spaces. It is vital to assess the quality as it is directly involved with the health and wellbeing of the users. The questioner will find your valuable comments from the administrative point of view and as users. The case study of Queen Elizabeth University Hospital (QEUH) campus green space development is part of the dissertation and is labelled as institutional park-type green space in the surrounding neighbourhood.*

Questionnaire Response 1:

Please share your brief thoughts and answers to the questions listed below. (Approximate spending time 15 to 20 minutes).

1. Please mention how you got involved with NHS Greater Glasgow & Clyde (NHS GG&C)?
   a) What is your primary role in this organization?
      I am the Greenspace and Urban Realm Officer for NHSGGC. My role involves managing projects to improve the outdoor estate for the benefit of biodiversity and the mental and physical wellbeing of patients, staff, and visitors to NHSGGC.
   b) What are the background intention and target goals of your team and organization?
      I work within the Sustainability department at NHSGGC, which has the goal of reducing the significant negative impact that the operation of healthcare services has on the environment and promoting a sustainable healthcare service.
2. Please illustrate the current activities regarding green space management.
   a) Is there any specific initiative and targets in neighbourhood scale "park type" green space?
      We operate a program of improvement works across NHSGGC to enhance the outdoor estate for the benefit of biodiversity and amenity value. So far this has involved biodiverse planting and new pathways, seating etc. at several large hospital sites. There are also food growing and volunteering projects at several sites, which involve members of the local community as well as patients and staff from NHSGGC
   b) Which areas are these targets focused on?
      These projects have been undertaken on a case-by-case basis so far rather than in a coordinated way. They have involved projects at the Royal Alexandra Hospital; the

Queen Elizabeth University Hospital; Gartnavel Royal Hospital; and Leverndale Hospital.

3. Is it a collaborative administration system?
   a) Who are the stakeholders/department, and what is the chronology of providing the support from each department?
      The stakeholders include clinical staff who work in the hospitals, estates & facilities staff who are responsible for the upkeep of the sites, funding bodies and external contractors and consultants responsible for the construction works. Some project have also involved public consultation with local communities.
      Generally, project ideas are originated either by clinical staff or estates & facilities staff at the hospitals. The first step would be for these two groups to discuss the project idea. Funding bodies would then be approached with a proposal. Once funding has been committed, design consultants would be commissioned and would work collaboratively with NHS staff to develop the design. Contractors would then be commissioned to deliver the construction works.
   b) Who are beneficiaries of this development? Which sectors are highly focused on in terms of user experience?
      The beneficiaries are the staff at each site; patients and their visitors who may be staying in hospital or visiting them; and members of the local communities who can use the greenspaces for recreation. The projects are mainly aimed at staff and patients, and consideration for user experience tends to put their needs first.
4. To which level climate change impact is integrated with the planning and management, and do you have effective outcomes?
   i) below expected level
   ii) moderate level
   iii) prior action level
   iv) immediate action level
   v) other

   Climate change is a consideration in the planning of projects, and this involves e.g., increasing the planting for carbon sequestration and biodiversity, sustainable drainage systems, active travel opportunities etc. Sustainable materials and methods are also utilized where possible to avoid detrimental impacts from the construction e.g., avoiding use of concrete etc. However, the main consideration is usually the health and wellbeing benefits that the project can provide.
5. What are the most important aspects of developing and maintaining green spaces and why?
   i) enhancing biodiversity
      projects include biodiverse planting and planting for pollinators etc.
   ii) climate change mitigation
      increasing tree cover
   iii) socio-environmental integration
      encouraging use of NHSGGC estate for members of the local community who may not have access to other green spaces / nature
   iv) blue-green conservation
      incorporating sustainable drainage systems where possible, adding vegetation cover to existing sites

v) green infrastructure
increasing vegetation cover through tree planting etc.
vi) active travel management
active travel plans developed for main hospital sites; projects to create better active travel links both between NHSGGC sites (e.g., QEUH and Gartnavel) and between sites and the surrounding areas currently at feasibility stage.
vii) Community participation
some consultation done with surrounding communities on greenspace projects, although this could be extended
viii) sustainable built environment
where applicable local and sustainable materials chosen e.g., avoiding use of concrete, selecting locally quarried stone etc.
ix) sustainable wellbeing & health
communications used to promote benefits of time spent in nature to staff at NHSGGC; projects to improve provision of e.g., seating and pathways through sites so staff can spend time outside
x) sustainability in general (all above)

6. How do you feel about Glasgow's unprecedented heatwave and the integrated emergency in people's wellbeing and health sector?
Heatwaves and other climate effects have a direct impact on people's health and current healthcare provision is already stretched, so increasing incidences of heatwaves will stretch the existing services further. Also, certain buildings etc. are not designed to cope with heat stress to the extent at which it is now being experienced so improvements to building stocks etc. will need to be made.
7. What consequences do you think Glasgow may face largely in the future?
i) damage to built forms
ii) overheated roads and pavements
iii) arising diseases
iv) mental stress
v) burning wildfires
vi) hazardous risk
vii) others
viii) none
All the above, plus consequences of flooding because of dry spells followed by heavy downpours.
8. What is a neighborhood scale green space's most substantial influence on mitigating microclimate heat stress events in Glasgow?
The most substantial influence is the contribution that trees and other vegetation have on reducing heat stress. In particular, having as much ground cover planting as possible rather than hard surfacing can help to reduce temperatures.
9. Regional and community parks are more protected than neighborhood scale parks in terms of conservation. Do you find the current growth and planning of the built environment to significantly influence small and medium green spaces in growing urban areas?
I don't think that current planning has particular effects on established parks and green spaces (i.e., building directly on existing small and medium parks is rare), but there

could be better requirements for the provision of parks and green spaces as part of new built development.

10. Are you involved with Queen Elizabeth University campus green space management?
    a) How effective is the planning on the campus? Is there any specific observation that you think should be more highlighted?
       The existing planning is poor, with the outdoor environment taking the form of a "green desert" i.e., lots of grass but a lack of biodiversity and green infrastructure. Wayfinding for pedestrians and cyclists is also poor – the site is mainly designed for cars, and several pedestrian / cycling paths lead nowhere or are difficult to navigate. The main barrier to enhanced biodiversity and green infrastructure is the issue of ongoing maintenance. There is a lack of understanding of the need for increased biodiversity and often this is seen as being "messy". Better understanding of the benefits of e.g., wildflower meadow rather than cut lawn and better communication with maintenance teams around this would help improve the campus.
    b) What are the opportunities in the given context associated with the campus and their amenity values?
       There are opportunities to increase the vegetation cover and provision of green infrastructure e.g., blocks of tree planting, biodiverse wildflower planting etc. instead of mown lawn. There are also opportunities to link the site with the surrounding environment better e.g., creating active travel routes within the site which are separate from existing roads, and creating better routes to local green spaces e.g. Elder Park.
11. Are you content with the current development in the overall approach of provisioning green space value?
    a) How satisfied are you with the quality and performance of the existing park and green space with integrated amenity value?
       unsatisfied
    b) What would you change or act on to enhance the performance of "park type" green space holistically integrated with climate change resiliency?
       Park type green space could be improved by having a higher proportion of vegetation cover, primarily tree and shrub cover and wildflower planting, rather than mown lawn. Also, better provision of active travel routes for pedestrians and cyclists to discourage use of cars.

Questionnaire Response 2:

Please share your brief thoughts and answers to the questions listed below. (Approximate spending time 15 to 20 minutes).

1. Please mention how you got involved with Nature Scot and Greenspace Health Advising.
   Previously Landscape and policy adviser SNH – took Secondment to NHS from SNH to bring health and environment sector come together to deliver on shared agenda.
    a) What is your primary role in this organization? Greenspace and Health Adviser in People and places Team Nature Scotland.
       To deliver NHS Greenspaces demonstration programme –develop pilot projects in all mainland Health Boards - bring outdoor NHS estate into use for improved health

well being outcomes for patients families staff and local community and improve biodiversity outcomes. Promote an integrated and therapeutic design and sustainable management approach to improving and managing NHS outdoor estate and embed thinking and new approach to value greenspace within NHS , one of biggest owners public outdoor spaces.

b) What are the background intention and target goals of your team and organization?
Deliver on health wellbeing and improved care in all health care settings across Scotland for benefit of all. Deliver for climate change biodiversity and adaptation.

2. Please illustrate the current activities regarding green space management.
   a) Is there any specific initiative and targets in neighbourhood scale "park type" green space?
   The NHS Greenspace programme has Multiple targets and different approaches by different health boards –it is a National programme- examples include QEUH NHSGGCHB which is intended via delivering greenspace masterplan to improve and create active link between local community Govan and the hospital greenspace; Forth Valley Hospital NHS Forth valley new capital build was developed in conjunction with creation and connection to new country park; Forester hill NHS Grampian one of oldest biggest hospital campuses part owned by university developed masterplan to improve connectivity and access to greenspace via a European Regional Development fund sustainable urban drainage project –at same time as creating new accessible improved public greenspace it enabled new mortuary and university innovation centre to be built on previously undevelopable land due to poor non sustainable drainage issues –the new habitat nature area and water feature (SUDS) on the hospital campus provides new and accessible urban greenspace for community staff patients and visiting families and improves site biodiversity and contact with nature .

   b) Which areas are these targets focused on*?*
   Scotland all mainland and island Health board areas and local HSCP –all health care settings and facilities

3. Is it a collaborative administration system?
   Very collaborative involving partnership between 4 Health and Environment public sector organisations called Green Exercise partnership these currently are Nature Scotland; Forest Scotland; NHS- Public Health Scotland and National Services Scotland working to support range staff from estates facilities capital planning and clinicians etc. to improve the NHS outdoor estate

   a) Who are the stakeholders/department, and what is the chronology of providing the support from each department?
   Stakeholders are many- all the partner organisations listed above; all staff based at the health care facility /working at Health care setting; volunteers and local community organisations third sector and the community that lives within that local area and of patients and support groups that use the grounds for improved recovery and therapeutic purposes. For example, recently completed project at RAH in paisley involved GEP; Estates and sustainability staff; clinicians patients design concultants staff and families using hospital and was delivered using local Environment group and Trust. QEUH will be successful precisely because its design will evolve with a large stakeholder list and successful change and creation of greenspace needs to be directed influenced and involve all those who benefit from and will use it.

b) Who are beneficiaries of this development? Which sectors are highly focused on in terms of user experience?
As above patients staff community families all benefit from access to attractive useable high-quality greenspace close to where they are being treated, work or live.

4. To which level climate change impact is integrated with the planning and management, and do you have effective outcomes*?*
Completely-Greenspace sustainable management is integral to delivering on climate change. The NHS has a climate change and adaptation strategy, and all new greenspace/NHS outdoor estate will be expected to deliver on this strategy. Greenspace can easily deliver on this agenda at same time as benefiting intended user Groups. Grassland woodland and planting using right species in right place and well designed- for example can be good for biodiversity; look attractive; enable people to engage and be active in the greenspace and improve health well- being if it has a therapeutic integrated design approach such as the masterplan for QEUH. Every square metre of the outdoor hospital estate needs to deliver multiple benefits for people and climate-a good example of one simple action providing multiple climate outcomes- trees vegetation close to buildings well designed will improve view to recovering patients; improve building microclimate keeping it cooler in summer; improve air quality; manage heavy rainfalls take up and hold moisture and provide habitat for birds and pollinators and provide structure to create attractive useable greenspace to enjoy being in for staff visitors patients and community. Integrated design delivers multiple outcomes –but it requires understanding of using Nature based design approach and managing Natural capital it's no longer an either or –it's delivered on whole agenda in integrated design approach or in my experience it's just lost opportunities and bad or no design. Unfortunately whilst it takes 7 years to qualify as a landscape Architect – often no one bothers to appoint one or bring them in at project outset , building Greenspace projects are often developed without design by those who do not have the required skills –yet we don't build a house without using an architect unless we are aiming for a box …..we don't build a road without an engineer ? but we often develop public greenspaces without input of skilled Landscape architect? Ideal solution is a skilled landscape architect supporting and enabling a community led design process in delivering a useable space.
   i) below expected level
   at moment majority spaces and projects its below required or expected level or moderate at best –policy requiring it is at immediate action but delivering on this climate policy is in my view below expected level.
   ii) moderate level
   iii) prior action level
   iv) immediate action level

5. What are the most important aspects of developing and maintaining green spaces?
   i) enhancing biodiversity
   fundamental
   ii) climate change mitigation fundamental
   iii) socio-environmental integration
   iv) blue-green conservation
   v) green infrastructure
   fundamental

vi) active travel management
urgent fundamental
vii) community participation
essential to good design for useable spaces
viii) sustainable built environment
ix) sustainable wellbeing & health
essential
x) sustainability in general (all above)
all above they are not either or mutually exclusive if an integrated sustainable design approach is properly understood and applied

6. How do you feel about Glasgow's unprecedented heatwave and the integrated emergency in people's wellbeing and health sector?
I live in leafy west end area city in a cool stone property, but this is a wealthy area with wealth of historic Victorian street planting and quality greenspace –not now valued or adequately cared for judging by treatment trees on development sites- but this is not replicated in other areas city. Poorest areas Glasgow has poorest environment and most impacts from traffic…. how they feel is more relevant …not enough being done quick enough to adapt to climate change loads policy good words not so much delivery action on ground.
7. What consequences do you think Glasgow may face largely in the future?
i) damage to built forms
ii) overheated roads and pavements
iii) arising diseases
iv) mental stress
v) burning wildfires
vi) hazardous risk
vii) others
loss of the natural capital assets it already has through poor planning control and management
viii) none
8. What is a neighbourhood scale green space's most substantial influence on mitigating microclimate heat stress events in Glasgow?
Health well -being cooling by retaining water; managing air pollution dust providing somewhere comfortable to be outdoors it provides same health well -being benefits to everyone the poorest or the wealthiest so it helps reduce health inequality.
9. Regional and community parks are more protected than neighbourhood scale parks in terms of conservation. Do you find the current growth and planning of the built environment to significantly influence small and medium green spaces in growing urban areas?
In my local area there has been loss and decrease in local small incidental greenspaces and street trees via over development lack of stringent conditions on developers to mitigate biodiversity /greenspace loss
10. Are you involved with Queen Elizabeth University campus green space management? ONLY SUPPORT AND ADVICE AS REQUESTED
a) How effective is the planning on the campus? Is there any specific observation that you think should be more highlighted?
It is one of few examples of sustainable integrated approach to site design and

improvement – I think it is a good practice example and just hope that the funding comes together to deliver it, the whole masterplan for campus not just parts of it.

b) What are the opportunities in the given context associated with the campus and their amenity values?
Refer Landscape Masterplan and project design brief erz landscape consultants

11. Are you content with the current development in the overall approach of provisioning green space value?
It is a retro fit around an already built new hospital campus improving existing greenspace and creating new opportunities and addressing poor suds! So no- it would have been better to have the integrated landscape plan delivered as integral part of new capital build new hospital and cost less to do so. The new campus greenspace plan now restricted by the road and building decisions made and established –so for example it is now difficult and costly to connect provide green or active travel safe routes for community Govan to easily access this new greenspace not by car or bus. It requires major infrastructure changes- retro fit a new campus greenspace can never be as good or effective as planning for it at the out -set of large-scale building project.
Unfortunately, these projects are led by engineer's programme managers and architects-Design consortium who in my experience often think greenspace is the bit that happens at end of project with space left over after building –which is not a nature based sustainable design approach we now advocate and need to address climate and health wellbeing.

a) How satisfied are you with the quality and performance of the existing park and green space with integrated amenity value***?***
N/A

b) What would you change or act on to enhance the performance of "park type" green space holistically integrated with climate change resiliency?
See QEUH proposed landscape masterplan erz design concept plan for greenspace

Questionnaire Response 3:

Please share your brief thoughts and answers to the questions listed below. (Approximate spending time 15 to 20 minutes).

1. Please mention how you got involved with landscape development and consultancy.
Erz were appointed by NHS GGC in 2021 to undertake a landscape opportunities study for the QEUH campus. We were then further appointed to develop proposals for landscape concept and spatial designs for the eastern boundary and central park areas of the site.

a) What is your primary role in your organization?
I am a landscape architect at erz

b) What are the background intention and target goals of your team and organization?
Erz are a team of landscape architects, architects and designers based in Glasgow and working across the UK. Established in 2007 by directors Rolf Roscher and Felicity Steers, erz has grown over the past 13 years to become a multi-award-winning landscape architecture practice with a strong and diverse portfolio of work. Working at many scales, from regional strategies to urban pocket arks, our work is

recognized as useful, convivial, ecological, and beautiful. Our systems-based approach creates multifunctional places, where people can connect easily, meaningfully, and joyfully with the outdoors. Placemaking, innovation and creativity lie at the heart of our approach; our established tripartite approach is based on looking at systems and networks of ecology, economy, and community.

2. Please illustrate the current activities regarding green space management.
   a) Is there any specific initiative and targets in neighborhood scale "park type" green space?
      To take a strategic look at opportunities and constraints of the site, to explore and identify the potential of the QEUH campus landscape for the social, environmental and economic benefit of the hospital, its staff, patients and visitors and those who live in its vicinity.
   b) Which areas are these targets focused on?
      The initial study looked at the campus, the concept and spatial design study focused on the eastern boundary and central park areas.
3. Is it a collaborative administration system?
   a) Who are the stakeholders/department, and what is the chronology of providing the support from each department?
      Stakeholders included the hospital, its staff, patients, and visitors and those who live in the vicinity. Dialogue was also undertaken with Glasgow City Council.
   b) Who are beneficiaries of this development? Which sectors are highly focused on in terms of user experience?
      As above.
4. To which level climate change impact is integrated with the planning and management?
   a)
   i) Below expected level
   ii) moderate level
   iii) prior action level
   iv) immediate action level
      Full consideration for climate change impact was given to proposals and their ongoing maintenance / management.
   v) Other
      b) How do you define the sufficient level? Do you have effective outcomes?
         Considering impacts in terms of micro-climate, water management and usage, increased levels of active travel, land use / habitat / biodiversity etc. and integrating into the proposed scheme.
5. What are the most important aspects of developing and maintaining green spaces for? (e.g., enhancing biodiversity, climate change mitigation, blue-green conservation, etc.)
   Enhancing biodiversity; consideration of local flora and fauna, what they eat / where the live / what ecological corridors they use / whether native or non-native etc.
   Climate change mitigation: water management and usage (use of SuDS, reuse of water for irrigation), changes in microclimate (increase in high rainfall events, wind direction and velocity, increase in temperatures including periods of drought; ensuring levels of human comfort and right match of plants to conditions)
   Blue-green conservation; holistic designs with blue green networks functioning as one of many layers/ networks which combine into the overall landscape system.

Increased levels of active travel; ensuring spaces can be accessed and enjoyed by all and encouraging active travel.

6. How do you feel about Glasgow's unprecedented heatwave and the integrated emergency in people's wellbeing and health sector?
   A reminder of the impacts of climate change, which are only set to worsen. Proposals should take account of the changing climate and provide for the needs of the diverse range of users/user groups on hospital sites in this context.

7. What consequences do you think Glasgow may face largely in the future?
   a) damage to built forms
   b) overheated roads and pavements
   c) arising diseases
   d) mental stress
   e) burning wildfires
   f) hazardous risk
   g) others
   h) none
8. What is a neighbourhood scale green space's most substantial influence on mitigating microclimate heat stress events in Glasgow?
   Reducing the heat island effect with trees and vegetation, providing amenable space where people can enjoy the outdoors comfortably (e.g., providing areas of shelter / shade)
9. Regional and community parks are more protected than neighbourhood scale parks in terms of conservation. Do you find the current growth and planning of the built environment to significantly influence small and medium green spaces in growing urban areas?
   Yes, they are directly related.

10. Are you involved with Queen Elizabeth University campus green space management?
    a) How effective is the planning on the campus? Is there any specific observation that you think should be more highlighted?
       We are not involved in the management of the campus, however our concept and spatial design study included consideration for maintenance and management of the proposals as outlined. The study began with a detailed site analysis, including building use and qualities, key topography and views, existing trees, microclimate, drainage, key services, land use / habitat potential, routes and movements, parking, barriers to movement. A key observation in terms of the maintenance of the green spaces is that the campus is not currently very biodiverse, with large areas of mown amenity lawn. Much of these amenity lawn areas could be allowed to develop into a more biodiverse meadow; a quick win, reducing maintenance costs whilst also increasing biodiversity.
    b) What are the opportunities in the given context associated with the campus and their amenity values?

       As above.

11. Are you content with the current development in the overall approach of provisioning green space value?

a) How satisfied are you with the quality and performance of the existing park and green space with integrated amenity value?
Our site analysis work highlighted opportunities within the existing park and green spaces to increase amenity / human comfort, biodiversity and habitats, wayfinding, sustainability, active travel, access etc.; our proposed sought to address amenity value alongside the topics as outlined in Q10.a)

b) What would you change or act on to enhance the performance of "park type" green space holistically integrated with climate change resiliency?
As outlined in our report.

APPENDIX 2
Quality Assessment Matrix by Glasgow City Council Open Space Strategy 2020 Table

	Score 5 - Excellent	Score 4 - Very Good	Score 3 - Good	Score 2 - Fair	Score 1 - Poor	Minimum Required Score
A) Size – as specified in the accessibility standard, sites should be of 0.3 ha or more to provide enough space for a variety of uses.	Site is 0.3 ha or more in size	Spaces intended to address deficiencies in publicly usable open space provision should generally be a minimum of 0.3 ha, big enough to be multifunctional and accommodate the rest of the quality standard considerations. Note that there may be instances where it is not possible to deliver a space of 0.3 ha in the required location – Supplementary Guidance indicates what should happen in such instances.				see note **a)**
B) Configuration – the open space should be of a shape that encourages use by all members of the community. Long, thin, irregularly shaped or steeply sloping spaces may be less able to accommodate a variety of uses. Exceptions might include where the space would play a key role in, eg water management, that would necessitate a certain configuration.	The space is of a topography, size, shape and configuration that can easily accommodate the intended range of functions (Gi-Giv) on it, and is designed and located to maximise its benefit to the wider place. No part of the space is rendered less functionally useful as a result of the shape of the space.	The space is of a topography, size, shape and configuration that can accommodate the intended range of functions (Gi-Giv) on it, and is designed and located to provide benefits to the wider place. Little of the space is rendered less functionally useful as a result of its shape.	The space is of a topography, shape and configuration that can accommodate some of the intended range of functions (Gi-Giv) and is designed and located with a view to providing no dis-benefit to the wider place. Much of the space is rendered less functionally useful as a result of its shape.	The space is of a topography, shape and configuration that can only accommodate some of the intended range of functions (Gi-Giv) with difficulty and in a form that would impact on their functionality. It has been designed and located with little thought given to the wider place. Large parts of the space are rendered less functionally useful as a result of its shape.	The space is of a topography, shape and configuration that cannot accommodate the intended range of functions (Gi-Giv) in a functionally useful way. It has been designed and located with no thought given to the needs of the wider place and is likely to have detrimental effects on it.	**4**/5

C) Surveillance – wherever possible, the areas of the space that people are likely to use most often ("key areas" – especially areas for quieter relaxation) should be visible from surrounding buildings, encouraging responsible use - secluded corners should be used for appropriate purposes, such as biodiversity.	**For smaller spaces** (less than 1ha), effectively all parts of the space (90-100%) would be overlooked by buildings likely to be occupied during daylight hours. **For larger spaces**, key areas would be overlooked by buildings likely to be occupied during daylight hours.	**For smaller spaces**, most parts of the space (65-89%), including key areas, would be overlooked by buildings likely to be occupied during daylight hours. **For larger spaces**, most of the key areas would be overlooked by buildings likely to be occupied during daylight hours.	**For smaller spaces**, about half the space (35-64%), including key areas, would be overlooked by buildings likely to be occupied during daylight hours. **For larger spaces**, many of the key areas would be overlooked by buildings likely to be occupied during daylight hours.	**For smaller spaces**, key areas would be overlooked by buildings occupied during daylight hours. **For larger spaces**, some of the key areas would be overlooked by buildings likely to be occupied during daylight hours.	**For smaller spaces**, none or very few of the key areas of the space would be overlooked by buildings likely to be occupied during daylight hours. **For larger spaces**, very few of the key areas would be overlooked by buildings likely to be occupied during daylight hours.	**2**/5
D) Accessibility – the space should be easily accessible from the wider area, should utilise DDA compliant paths and access points and should, where appropriate, incorporate any longer distance routes. Access for maintenance purposes should be easy and direct. Key entrances should benefit from lighting on surrounding roads/ paths.	The space is readily accessible from the wider area/all surrounding streets and entrances are DDA compliant. Movement within and through the space is facilitated by a network of well-surfaced, DDA compliant paths along desire lines and to surrounding routes. No barriers (e.g. high kerbs) should restrict movement between the path and important areas of the site (eg for relaxation or children's play). Key entrances benefit from	The space is directly accessible from most of the wider area/ surrounding streets and most entrances are DDA compliant. Movement to key areas of the space is facilitated by a network of DDA compliant paths. Any barriers (e.g. high kerbs) between the path and important areas of the site (eg for relaxation or children's play)	The space is designed to be accessible from parts of the wider area/some of the surrounding streets and key entrances are DDA compliant. Movement to key areas of the space is facilitated by DDA compliant paths. Any barriers (e.g. high kerbs) between the path and important areas of the site (eg for relaxation or children's play)	Access to the space is limited and may be from only one entrance. Only some of the paths, routes and accesses would be DDA compliant. Opportunities haven't been taken to link to the wider route network in the surrounding area. Entrances are poorly lit. Barriers (e.g. high kerbs) between the path and important areas of the site (eg for relaxation or children's play) may exist and would prove	Access to the space is limited and may be from only one entrance or be informal in nature. Paths and accesses have not been designed to be DDA compliant. Entrances are poorly lit and barriers between the path and important parts of the site exist that could not be negotiated by many users.	**3**/5

	lighting on surrounding roads/paths.	should be limited and negotiable. Key entrances benefit from lighting on surrounding roads/paths.	should be negotiable. Key entrances benefit from lighting on surrounding roads/paths.	difficult to negotiate for users with limited mobility		
E) Aspect – much of the space should, where possible, benefit from direct sunlight (planting should provide some shade from the sun).	All of the usable/flat parts of the space (including key areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for much of the day.	Most of the usable/flat parts of the space, (including areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for much of the day or all of the usable/flat parts of the space (including areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for some of the day.	Some of the usable/flat parts of the space (including areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for much of the day or most of the usable/flat parts of the space (including areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for some of the day.	Some of the usable/flat parts of the space (including areas likely to be used for informal sports/ recreation and relaxation) are likely to benefit from direct sunlight for some of the day.	The usable/flat parts of the space (including areas likely to be used for informal sports/ recreation and relaxation) are unlikely to benefit from direct sunlight for some of the day.	**3/5**

F) Place Quality – the location of the space, its planting and landscaping should create a sense of wellbeing for users of the space, in addition to complementing surrounding uses and contributing to their amenity.	The location, planting and landscaping of the space contributes significantly to the amenity of the surrounding area, particularly homes, and is likely to provide a sense of wellbeing for users of the space.	The location, planting and landscaping of the space contributes positively to the amenity of the surrounding area, particularly homes, and is likely to provide a sense of wellbeing for users of the space.	The location, planting and landscaping of the space provides some amenity for surrounding areas and contributes to the attractiveness of the space.	The location, planting and landscaping of the space provides little visual amenity for surrounding areas and does little to contribute to the attractiveness of the space.	The location, planting and landscaping of the space is likely to prove detrimental to the visual amenity of surrounding areas and may create a sense of discomfort for users of the space.	**3/5**
G) Use – the space should provide for a range of active and non-active uses, including:						

Gi) Informal sport/recreation – a good proportion of the space should be flat or gently sloping and would be well-drained to provide for use on dry days.	For smaller spaces (less than 1 ha), most of the space could facilitate informal sport/ recreation, particularly flat (or gently sloping) ground that is grassed or similar. All of this area is well drained, containing no soft or boggy ground during normal weather conditions (unless designed to flood during exceptional flood events). For larger spaces, a significant proportion of the space is flat (or gently sloping), grassed or similar and can accommodate informal sport. Each of these areas is roughly equivalent in size to a 5-a-side football pitch, or larger.	For smaller spaces, much of the space could facilitate informal sport/ recreation, particularly flat (or gently sloping) ground that is grassed or similar. Most of this area has been designed to be well drained, containing no soft or boggy ground during normal weather conditions (unless designed to flood during exceptional flood events). For larger spaces, some areas of the space are flat (or gently sloping), grassed or similar and can accommodate informal sport. At least one of these areas is roughly equivalent in size to a 5-a side football pitch, or larger.	For smaller spaces, a good proportion of the space would facilitate informal sport/ recreation, particularly flat (or gently sloping) ground that is grassed or similar. Most of this area has been designed to be well drained, containing no soft or boggy ground during normal weather conditions (unless designed to flood during exceptional flood events). For larger spaces, an area of the space is flat (or gently sloping), grassed or similar and can accommodate informal sport. It is roughly equivalent in size to a Multi-Use Games Area.	For smaller spaces, little of the space would facilitate informal sport/ recreation, particularly flat (or gently sloping) ground that is grassed or similar. Drainage may be an issue, even during dry periods. For larger spaces, little of the space is flat or gently sloping, grassed or similar - any such space is smaller in size than a MUGA.	For smaller spaces, very little of the space would facilitate informal sport/ recreation, particularly flat (or gently sloping) ground that is grassed or similar. It is unlikely to be well drained, even during dry periods. For larger spaces, very little of the space is flat or gently sloping, grassed or similar any such space is considerably smaller in size than a MUGA.	**3/5**

Gii) Children's play – the space should provide for children's play, particularly natural and imaginative play - see note b).	Looking at the space as a whole, there are a wide variety of natural play opportunities provided by the space's landscaping (including hard landscaping and water features), planting and vegetation, layout and topography. Fixed play equipment is available and is of good quality and in good order. Planting and landscaping has been designed to encourage and facilitate play. Together with the space provided for biodiversity and informal sport/ recreation, these different environments provide for imaginative and exploratory play for children of all ages and abilities as an integral part of the wider space.	Looking at the space as a whole, there are good opportunities for natural play provided by the space's landscaping, planting, layout and topography. Some limited fixed, good quality play equipment is available. Together with the space provided for biodiversity and informal sport/ recreation, these different environments provide for imaginative and exploratory play for children of all ages and abilities as an integral part of the wider space.	Looking at the space as a whole, there are adequate opportunities for natural play provided by the space's landscaping, planting, layout or topography. Together with the space provided for biodiversity and informal sport/ recreation, the space would provide opportunities for natural play for children of all ages and abilities as part of the wider space. Fixed play space may be available.	Looking at the space as a whole, opportunities for natural play provided by the space's landscaping, planting, layout or topography are limited and are poorly integrated into the wider space. Any fixed play equipment is limited and of poor quality.	Looking at the space as a whole, there are no opportunities for fixed play or for natural play provided by the space's landscaping, planting, layout or topography.	**3/5**
Gii) Children's play – the space should provide for children's play, particularly natural and imaginative play - see note b).	Looking at the space as a whole, there are a wide variety of natural play opportunities provided by the space's landscaping (including hard landscaping and water features), planting and vegetation, layout and	Looking at the space as a whole, there are good opportunities for natural play provided by the space's landscaping, planting, layout and topography. Some limited fixed, good quality	Looking at the space as a whole, there are adequate opportunities for natural play provided by the space's landscaping, planting, layout or topography. Together with the	Looking at the space as a whole, opportunities for natural play provided by the space's landscaping, planting, layout or topography are limited and are poorly integrated	Looking at the space as a whole, there are no opportunities for fixed play or for natural play provided by the space's landscaping, planting, layout or topography.	**3/5**

	topography. Fixed play equipment is available and is of good quality and in good order. Planting and landscaping has been designed to encourage and facilitate play. Together with the space provided for biodiversity and informal sport/ recreation, these different environments provide for imaginative and exploratory play for children of all ages and abilities as an integral part of the wider space.	play equipment is available. Together with the space provided for biodiversity and informal sport/ recreation, these different environments provide for imaginative and exploratory play for children of all ages and abilities as an integral part of the wider space.	space provided for biodiversity and informal sport/ recreation, the space would provide opportunities for natural play for children of all ages and abilities as part of the wider space. Fixed play space may be available.	into the wider space. Any fixed play equipment is limited and of poor quality.		
Giii) Relaxation – quieter areas, away from the parts of the space where informal sport/recreation and children's play are likely to take place, should be provided for relaxation and meeting people. Seating and bins should be provided in suitable locations, including to allow surveillance of areas likely to be used by younger children	The space includes areas that can cater for "quieter" uses, including relaxation, meeting, picnicking etc. Such areas are designed to discourage informal sport through the provision of sensitively located trees and shrubs that help provide shade and some shelter from the prevailing wind. They are not immediately adjacent to areas likely to be used for informal sport. Good	The space includes areas that can cater for "quieter" uses, including relaxation, meeting, picnicking etc. Design and location discourages informal sport. Trees and shrubs provide some shade and shelter. Seating and bins are provided and located to provide supervision of some areas in which children are likely to play. There is space for temporary structures	The space includes areas that can cater for "quieter" uses, including relaxation, meeting, picnicking etc and that are afforded some shade. Seating and bins are provided and located to provide supervision of some areas in which children are likely to play. There is space for temporary structures to provide shelter from the elements, helping	The design of the open space has given little thought to the need to cater for "quieter" uses, including relaxation, meeting, picnicking etc. Seating and bins may be provided, but are not well located.	There are no obvious areas of the open space that might cater for "quieter" uses, including relaxation, meeting, picnicking etc. Seating and bins may be provided, but are not well located.	**3/5**

	quality and robust seating, bins and picnic benches of an appropriate quality are provided and located to provide supervision of many areas in which children are likely to play. Permanent structures to provide shelter from the elements are provided, helping facilitate meeting/ outdoor education.	to provide shelter from the elements, helping facilitate meeting/ outdoor education.	facilitate meeting/ outdoor education.			
Giv) Biodiversity – spaces should provide for a variety of connected habitats and a variety of different plant and animal species.	The space provides areas for nature which are well connected both within the site and to adjacent habitats or corridors. These areas provide a number of different habitats (eg woodland, grassy areas of varying length (including some over 30cm), wetland etc). These habitats provide a wide variety of plants (including flowering plants) of different types and heights that would support wildlife by providing food and shelter. A high proportion of vegetation is native.	The space provides areas for nature which are connected both within the site and to adjacent habitats or corridors. These areas provide habitats that provide a variety of plants (including flowering plants) of different types and heights that would support wildlife by providing food and shelter. Much of the vegetation is native.	The space enhances the biodiversity of the area through provision of habitat that is physically connected or located to facilitate functional connection, with surrounding open spaces/habitats. A variety of vegetation exists of varying heights. Some of the vegetation is native.	The space would only provide for biodiversity to a limited degree. Connections to surrounding habitats are poor and disjointed and there is little variation in vegetation mix or height.	The space provides little biodiversity interest.	**3/5**

Gv) Maintenance and Condition – over and above routine maintenance (grass cutting, litter clearing etc) the infrastructure required to meet key criteria should be well maintained and in a usable condition.	All of the infrastructure that contributes to provision for: informal sport/recreation (flat, well-drained grassland or similar artificial surface and any enclosure); children's play (fixed play equipment); relaxation (seats, bins, picnic benches) and accessibility (paths and entrances) is of good quality and condition.	Much of the infrastructure that contributes to provision for: informal sport/ recreation; children's play; relaxation; and accessibility is of good quality and condition and the remainder is of reasonable quality.	Some of the infrastructure that contributes to provision for: informal sport/ recreation; children's play; relaxation; and accessibility is of good quality and the remainder is of reasonable quality.	Some of the infrastructure that contributes to provision for: informal sport/ recreation; children's play; relaxation; and accessibility is below reasonable quality.	All or most of the infrastructure that contributes to provision for: informal sport/ recreation; children's play; relaxation; and accessibility is below reasonable quality.	**3/5**
Criteria Gvi) and Gvii) should only be assessed where it has been identified that the space has potential to address surface water management issues in the wider area (criterion Gvi)) and/or where the space has been identified as having the potential to help address a deficiency in the provision of space for food growing in the wider area, identified through the Food Growing Strategy (criterion Gvii)).						
Gvi) Water Management – spaces should, where appropriate, help meet the requirement for natural flood water management.	Where landform is suitable, all opportunities have been taken to minimise/reduce flood risk and slow storm water run-off from the space and from the wider area. Where appropriate, water courses have been naturalised. Areas designed to help address water management requirements are safe, attractive and provide for	Where landform is suitable, some opportunities have been taken to minimise/reduce flood risk and slow storm water run-off from the space and from the wider area. Where appropriate, water courses have been partly naturalised. Areas designed to help address water management requirements are safe,	Where landform is suitable, the space has been designed to contribute to minimising and/or reducing flood risk, with areas designed for this purpose being safe and helping provide some amenity and biodiversity value.	Where landform is suitable, few opportunities have been taken to help minimise and reduce flood risk or slow storm water run-off.	Where landform is suitable, no opportunities have been taken to help minimise and reduce flood risk or slow storm water run-off.	**3/5**

	enhanced amenity and biodiversity.	attractive and provide for enhanced amenity and biodiversity.				
Gvii) Community growing/ allotment space – where appropriate and where a local demand has been established that cannot be easily met elsewhere in the area, spaces should provide for space for allotments/community growing - see note e). this is likely to require a publicly usable open space greater than 0.3 ha in size	The space would provide allotments/ community growing spaces that have been well located to benefit from direct sunlight and passive surveillance during much of the day. Where space allows, they would play a significant role in meeting demand in the immediate locality. Plots (including growing mediums) and ancillary facilities (as required) have been provided to a good standard and make use of rainwater harvesting. Allotments/community growing spaces would be secure but provide for visual and social	The space would provide allotments/ community growing spaces that have been located to benefit from direct sunlight and passive surveillance during some of the day. Where space allows, they would help meet demand in the immediate locality. Plots (including growing mediums) and ancillary facilities (as required) have been provided and make use of rainwater harvesting. Allotments/ community growing spaces would be	The space would provide allotments/ community growing spaces that have been located to benefit from enough direct sunlight to render them usable and some passive surveillance. Where space allows, they would help meet demand in the immediate locality. Plots (including growing mediums) and/or ancillary facilities (as required) have been provided to some degree and provide potential for rainwater harvesting. Allotments/ community	The space would provide little in the way of space for allotments/ community growing spaces. Any allocated space would not be located to benefit from direct sunlight or passive surveillance. Plots (including growing mediums) and ancillary facilities (as required) would not be provided or would be provided to a poor standard, and would not be secure. No use would be made of rainwater harvesting.	The space would provide no space for allotments/community growing spaces.	**3/5**

	interaction with the remaining space.	secure and provide for some visual and social interaction with the remaining space.	growing spaces are secure.			