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THE NEED FOR A CLIMATE DATABASE FOR FACILITIES MANAGERS TO MITIGATE THE CLIMATE CHANGE IMPLICATIONS ON BUILDINGS

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ABSTRACT

This study focuses on climate change impacts on built-environment categories, including buildings, built infrastructure, and land use. A facility manager is a key person who oversees the built-environment and faces challenges in recognising climate impacts and preparing mitigation strategies to ensure the organisation's operations continue. Climate change directly and significantly affects facilities management. Thus, in climate change mitigation data-driven decision-making in facility management is important. Climate data, such as temperature, precipitation, humidity, wind speed, solar gain, and CO_2 *level are already used in the decision-making in facilities management. However, there is less availability and complex accessibility of the existing climate data sources for non-climate expert users such as facility managers. In order to address this gap this paper aims to assess the need for a climate database for facilities managers to mitigate climate change implications on buildings. This study adopts a qualitative expert survey approach to data collection. Eight semi-structured interviews were conducted with industrial experts and their knowledge and experience on climate change were analysed. Facility managers and built-environment experts expressed that there are many available climate data sources that facility managers are not aware of. However, it is difficult to use available climate data for decision-making due to limited knowledge of climate science and the payments and permissions involved. Further, experts highlighted the need for a climate database with freely available recent years' climate data, visualisation tools for using climate data to make informed decisions and a user-friendly interface for non-expert users.*

Keywords: *Built Environment; Climate Change; Climate Data; Climate Database; Facilities Management.*

1. INTRODUCTION

The global climate is changing more rapidly and it is expected to be continued in the future due to changes in mean values for temperature, precipitation, humidity, solar radiation, wind, and also by man-made greenhouse gas emissions (Lacasse et al., 2020). Sri Lanka is also facing climate consequences which has an effect on identified key areas including agriculture, water resources, coastal and marine sector, health, human

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settlement and infrastructure, ecosystem and biodiversity, tourism, energy and transportation (Senevirathna, 2016).

Built Environment sector is also impacted by climate changes in different ways such as increase in cooling loads, premature degradation of building elements and moisture related issues of building elements (Lacasse et al., 2020). In built environment sector Facilities Management (FM) encompasses multiple disciplines including building services, energy management, water conservation, handling building management system and occupational health and safety (Pilanawithana & Sandanayake, 2017). According to Warren (2010) facilities managers must assess climate change risks and develop Business Continuity Management strategies to adapt to climate-driven disasters. Climate data are used for decision making in different FM aspects. In Sri Lanka, the meteorological stations provide climate data. However, there are limitations of using those climate data for different studies such as errors from instruments, measurements, data collectors and incomplete data sets (Chathuranika et al., 2022). Therefore, there is a need of a system for obtaining reliable long-term climate variables (Lacasse et al., 2020). Even though, Integrated Surface Database (ISD) free, it is not enough to create weather files for analysing. Weather files such as Energy Plus have no proper standards (Rao & Rastogi, 2020). Even though, the NASA Earth observations data is a freely available database, the usability is complicate and systematic (Yang et al., 2019) and it highlights the different consequences of accessing existing climate databases for decision making.

Perera and Emmanuel (2018) have identified that lack of data of local climate effects is a key difficulty in applying climate knowledge to decision making of urban planning. To initiate flood risk reduction measures, there is a lack of available historical flood records (Alahacoon et al., 2018). Boverkert climate declaration of Sweden has been introduced an open climate database for the construction phase of buildings (Sadri et al., 2022). Climate change data in Sri Lanka have been used to create a disaster database to draw policy makers' attention towards climate related adaptation (Weerasekara et al., 2021). This study is focused on need of climate database for facilities management applications. The objectives of the paper are: (1) to identify climate change impacts of different facilities management functions, and (2) to identify climate database requirements to mitigate the identified climate change impacts.

2. LITERATURE REVIEW

Different parts of the world are affected by climate change, disasters and challenges posed by climate changes, increasingly (Alam et al., 2023). Climate change has effects on socio-economic factors and other factors such as agriculture, health, rise of sea level and labour scarcity (Thathsarani & Gunaratne, 2018). In addition, climate change creates a variety of risks that affect the built environment, human and social capital (Alam et al., 2023). Sri Lanka is not an exception from the climate change challenges. Cevik et al.(2022) revealed that developing countries including Sri Lanka have significant effects from climate change as they have lesser capacity to adapt to and mitigate climate change. Disasters like floods and earth slips affect people's ability to adapt and their means of livelihood in Sri Lanka (Thathsarani & Gunaratne, 2018). Thus, Sri Lanka is a particularly suitable scenario to be used to evaluate the impacts induced by climate change (Weerasekara et al., 2021). In addition, high rise buildings are introduced to the tropical climate developing nations including Sri Lanka without considering climate sensitivity. This results to unfavourable outcomes to both human and environment (Amarathunga &

Rajapaksha, 2016). The built environment is created to protect, coordinate or change the environment in ways to promote human needs, desires and standards (Wang et al., 2019). Considering different built environment classifications of scholars, this study will continue by adapting to buildings, built infrastructure and land use categories (Joensuu et al., 2020; Lynch & Mosbah, 2017) .

2.1 CLIMATE CHANGE IMPACT ON BUILT ENVIRONMENT

Housing units those lacking proper ventilation are more vulnerable to climate change as they can overheat due to increased temperature (Rañeses et al., 2021). Climate change has an impact on the amount of energy usage in buildings (Jiang et al., 2019). According to United States Agency International Development (USAID) temperature changes in buildings cause health issues, impacting building systems and maintenance. Barrelas et al. (2021) declared that climate events such as landslides will cause to rise in building maintenance costs.

Climate change induced catastrophes have severely damaged infrastructure, including transportation, water, sanitation, and energy systems. Floods cause adverse impacts on land degradation, communication, roads and other infrastructure. Heat waves, hurricanes, and floods can be brought on by climate change can harm or disrupt information systems infrastructure (USAID, 2012a). Bektas and Sakarya (2023) expressed the flood volume in China is significantly impacts the efficiency of urban drainage system as evidenced by urban expansion.

Chathuranika et al. (2022) have studied the impact on hydrological aspects of climate change in consideration of soil and water. Climate change negatively impacts drinking water bodies (Vijayavenkataraman et al., 2012). The alterations of precipitation patterns lead to decrease soil's filtration capacity, porosity and change soil moisture content (Bektaş & Sakarya, 2023). The primary economic activity in Sri Lanka is agriculture and the annually affected croplands by floods is an average of 268 km^2 (Alahacoon et al., 2018). Perera and Emmanuel (2018) highlight the need for climate-sensitive urban planning in Colombo, as the increasing number of mid-rise and high-rise blocks along traffic arteries increases Urban Heat Island.

2.2 CLIMATE CHANGE IMPACT ON FACILITIES MANAGEMENT FUNCTIONS

Facilities managers have challenges in recognising the climate change impacts on the built assets and developing strategies (Jones et al., 2013). Meantime, they have to consider the physical injury and economic losses associated with natural disasters induced by climate changes. Thus, organisations focus on information technology resources to ensure data security in their business continuity plans (Warren, 2010). The following sections discuss the impact of climate change on key FM functions.

2.2.1 Climate Change Implications on Building Maintenance

Climate change may directly affect the deterioration of building equipment and components and affect their maintenance requirements and costs (D'Orazio et al., 2022). In changing climate context, maintenance planning needs to be improved. Lack of maintenance during the service life is also caused to the faults in building façade. Therefore, it is vital to take climate loads into account at every building stage (Barrelas et al., 2021). Bastidas-Arteaga et al.(2022) revealed that the corrosion of reinforced concrete structure will start faster due to the climate change.

2.2.2 Climate Change Impact on Energy Management

Climatic conditions are recognised to have an effect on building's energy efficiency (Najjar et al., 2019). Further, climate-sensitive planning is capable enough to achieve significant energy saving (Aghamolaei et al., 2022). Zhu et al.(2019) stated that energy consumption patterns in commercial buildings are influenced by summertime temperature differences causing a shift in demand. Energy demand for heating is getting decreases and demand for the cooling is getting increased (Fabbri et al., 2020). The best designs should take climate change into account. Ignoring the effects of climate change could result in serious energy disruptions.

2.2.3 Climate Change Impact on Occupational Health and Safety

In Sri Lanka, dengue, disabilities due to landslides and floods, and diseases due to air pollution are identified. Heat-related morbidity and mortality among construction workers are significant among them (Gandhi Marg, 2017). In Ethiopia, the spreading pattern of water and vector-borne diseases are changing due to rising temperatures and shifting rainfall patterns. Recent COVID-19 outbreaks show significant winter seasonality between December and April (Sajadi et al., 2020). Furthermore, USAID (2012b) identified that rising of building interior temperature can lead to heat stress, health problems and reduction of building occupant productivity.

2.2.4 Climate Change Impact on Building Performance

The climate change predications should allow to evaluate the building envelope performance and to design the buildings (Gaur et al., 2019). Building design, envelope, and climate classification all have an impact on performance factors in construction (Najjar et al., 2019). Building performance is influenced by heat transmission, thermal mass, solar heat gain through windows (Fabbri et al., 2020). It is difficult to measure the impact on thermal comfort due to climate conditions as it is subjective from person to person (Soutullo et al., 2020). According to Brown et al. (2022) assets degradation predictions and service life are influenced by climate zones and climate variables.

2.2.5 Climate Change Impact on Disaster Management

Low-income countries are more vulnerable to climate induced disasters than developed countries (Weerasekara et al., 2021). While resilience reduces the cost of government borrowing, climate change vulnerability has a major impact on government bond rates and spreads (Cevik & Jalles, 2022). The metropolitan near of Kelani River, Colombo is prone to regular floods because of the high rainfall and humid climate. Also, with higher positive values of frequency of droughts, households are affected (Thathsarani & Gunaratne, 2018).

2.3 IMPORTANCE OF CLIMATE DATA FOR MITIGATING CLIMATE CHANGE IMPACT ON BUILT ENVIRONMENT

Organisations strive to enhance the quality of climate data for decision making processes and used to derive climate indicators to address issues linked to climate system and humans (Camarillo-Naranjo et al., 2019). Climate data is essential for risk assessment, seasonal prediction, and the design of buildings and accurate sizing of the building systems (Rao & Rastogi, 2020). According to Brown et al. (2022) when selecting assets facility managers need to consider the manufacturers who can provide the best asset performance for the climate zone of assets going to operate. As Sri Lanka is identified as a country with a high degree of climate preparedness vulnerability, it is recommended that national climate monitoring and warning systems be strengthened (Escap, 2016).

2.4 CLIMATE DATA REQUIRED FOR FACILITIES MANAGEMENT FUNCTIONS

By considering the importance of data-driven decision making and the requirement of reliable data, facilities managers are advised to maintain a sufficient data management system (Assaf & Srour, 2021). In data-driven energy load profiling, building automation systems and smart meters are in use to track the exterior temperature and humidity (Zhu et al., 2019). Najjar et al. (2019) claimed that solar radiation, humidity, temperature, heat, precipitation, GHG emissions, are all climate data characteristics that are related to energy consumption. The climate variables including sunlight, humidity and temperature was examined to assist the facility managers in selecting the climate-responsive asset manufacture (Brown et al., 2022). In order to operate and maintenance planning of building systems, NASA time series data such as temperature, humidity, precipitation are utilised (Stackhouse et al., 2023). In addition, climate data including CO_2 concentration, humidity, temperature, cloud cover and aerosol are used to study the effects on building materials (Lacasse et al., 2020). Foreman et al.(2023) listed out safety indicators includes temperature and wind speed average. Further, heat indices such as Humidex are defined using air temperature and vapor pressure. In flood detection systems, sensors are using for measure water level along with water speed, temperature and humidity (Hsu et al., 2020). Amarathunga and Rajapaksha (2016) investigated the micro-climatic behaviour and thermal environment in different levels of a high rise building by measuring air temperature, relative humidity, natural lightning levels and wind velocity data.

2.5 CLIMATE DATABASE AVAILABILITY AND ACCESSIBILITY ISSUES

Despite advancements in Earth Observations and Internet of Things technologies, converting collected data into insights remains challenging due to the complexity of evaluating climate change (Hsu et al., 2020). Weerasekara et al. (2021) attempted to create a specific disaster database using data collected from the Meteorological Department of Sri Lanka. Climate Change Knowledge Portal (CCKP) is a hub created by the World Bank and it provides trends of temperature variations and rainfall variations (Hettiarachchi et al., 2019). Most climate databases are available to the expert users under open-licenses and complex due to technical file formats. Integrated Surface Database (2018) provides online search access and it is composed of location-based surface observational data. Energy analysts use weather files such as IMF (Input Macro Files), DDY (Design Day Files) and EPW (EnergyPlus Weather File) for simulation purposes. These files contain statical values such as thermal comfort index, relative humidity, wind speed, and solar radiation (Rao & Rastogi, 2020). Apart from that, Sea level, seismic, and deep ocean sensor data are evaluated by the Regional Integrated Multi-Hazard Early Warning System (RIMES) for Africa and Asia. A central climate data database with a standard model ensures consistency, reduces costs, and is crucial for analyses, reducing the need for costly web infrastructure (Rao & Rastogi, 2020). However, as climate database management is limited to the expert users, it is vital to release easily accessible tools for non-expert users (Camarillo-Naranjo et al., 2019). Climate databases require for study purposes in various spatial scales such as district, region or country wise (Bastidas-Arteaga et al., 2022).

3. METHODOLOGY

A comprehensive literature review was conducted to identify the climate change impact on the built environment and FM functions, climate data requirement for the FM functions and about climate data availability and accessibility. An expert survey was conducted to gather data from facilities management and built environment related professionals who were having vast knowledge and expertise in built-environment, sustainability, energy management and climate science aspects. Eight experts with over 7 years of experience, including those conducting research and practical work related to climate change impacts, provided their valuable insights to this research. The profiles of the experts are listed in Table 1.

Table 1: Profile of experts

Expert	Designation	Overall experience
E1	Facilities Engineer	09 years
E2	Energy Manager	11 years
E3	Senior Facilities Manager	12 years
E4	Sustainable design engineer	11 years
E5	Assistant Facilities manager	08 years
E6	River and Tsunami Simulation Engineer	07 years
E7	Programme coordinator	15 years
E8	Senior Facilities Manager	13 years

Semi-structured interviews were conducted as primary data collection which is a part of qualitative approach and it allows to explore participant knowledge in flexible manner. In climate researches expert interviews will address the uncertainty and enhance the relevance of climate data in decision making (Dessai et al., 2018). In order to analyse expert survey data, thematic analysis was selected. Pre-established themes, categories and codes are created based on the literature survey.

4. DATA ANALYSIS AND RESEARCH FINDINGS

4.1 IDENTIFY CLIMATE DATABASE REQUIREMENTS TO MITIGATE THE IDENTIFIED CLIMATE CHANGE IMPACTS ON BUILDINGS

The study analysed the awareness of facility managers and building professionals about climate change impacts, finding a medium level of understanding among these professionals about the impacts of climate change on buildings. E2 stated that, "*there is a medium concern, everything was focused or driven by the market itself. they requested the facilities designed to be very sustainable*". Similarly, E5 mentioned that there is definitely have more focused on climate change and all sustainability initiatives. According to E4 "*there's awareness among most of the professionals within the industry at the moment, because it's like hot topic at the moment*". On the other hand, E8 highlighted that "*but it's questionable, how practically they are working towards to mitigate climate change impacts in their day-to-day jobs".* E1 stated the awareness of Sri Lankan FM sector is low because there is no observed season effect in Sri Lanka. However, it was noted that there is a potential for climate change. However, E7 believed that, "*particularly the development planning and construction professionals not adequately consider the factors contribute for climate change and the impacts*."

4.1.1 Experience in Climate Change Impacts on Built Environment

Built environment professionals and FM experts have experienced direct and indirect impacts on their building facilities, built-infrastructures and lands. All experts agreed that there is a high energy consumption in buildings due to climate change impacts. In terms of overheating and high energy usage, E1 stated that "*it's a positive relationship. High heat means its energy consumption is high*". E2 further explained that "*I was involved in some energy audits and noticed that there's a huge impact on HVAC*". Regarding the health issues, E2 explained "*increased extreme heat events over the past few years, there has been several, and caused even deaths in vulnerable persons*". E2 claimed that, there is a huge mould growth impact for wood products in buildings. In addition to that, E3 highlighted that, due to increase of storm water volume there can be floods and maintenance teams have to manage unexpected situations. E8 pointed out about the soil cracks and the foundation damages due to low rains depends upon the region of the country. E1 highlighted that, "*the waterproofing tightness is required, otherwise it will reduce the lifetime of the material*." According to E4, the maintenance frequency of the HVAC systems is increased due to climate changes.

Regarding the built infrastructure, experts mentioned the climate impacts on urban drainage systems, transportation, water supply systems, electricity and information and communication systems. E6 stated that, "*urban planners must be addressed the future expected changes of rainfall intensity when designing drainage systems"*. According to E1, "*Sri Lankan electricity generation mainly based on water sources, in March mostly vulnerable for power failures."* In terms of information and communication systems E1 also stated, "*I managed a data centre, in the April, high thundering is very much critical. Once, we had a loss due to electrical surge come through the telephone lines and it affects some servers."* Further, E3 stated there is an increase of the insurance premium and that cause increase the operational costs. In terms of land use, E7 stated that, "*erosion and sedimentation is a huge impact due to high rain flow*. According to E4, overflooding impacts on water wells and creates other sanitary problems. E5 stated that, *"there can be heat islands in adjacent roads and land surfaces, and can be impacted on temperature rises in the buildings*".

4.1.2 Climate Change Impact on Facilities Management Functions

Almost all the professionals mentioned there is a climate impact on energy management. E7 stated that, "*there is huge requirement of selecting appropriate electrical devices which must be energy efficient*." E3 expressed that there is a risk of reducing the life span of the assets and increasing the maintenance frequency. E7 stated that, "*as disasters impacts have increased due to climate change, there is need for more actions on disaster preparedness and climate resilient development*." Additionally, E2 highlighted that "*facility managers would involve in design stage of buildings so that they can request the designing engineers to consider future climate events and climate data*." Further, E7 mentioned there is an impact on development projects and fails due to climate changes.

4.1.3 Climate Data Requirement in Facilities Management Functions

Almost all the experts mentioned the use of climate data for decision making process in their relevant fields. According to E2 "*we develop protocols for extreme heat and cold events considering climate data"*. E3 stated that facilities managers have to use climate data for risk mitigation. E6 mentioned that, "*I used climate data for flood modelling in Kelani River basin for disaster management*. "Further, E4 mentioned, "*we're using* *climate data to energy modelling and analyse the building performance*". According to E5, climate data would require to identify monsoon seasons and have to clean their gullies and roofs before it starts. E2 further explained that, short term weather data are used to train the building automation system. In construction stage, they have to adjust the working schedule if it is expected to have high rains. Majority of experts definitely agreed on climate data usage is an essential requirement to mitigate climate change implications on buildings. According to E4 "*we can use climate data to model certain scenarios and see how these changes or measures are going to reduce the climate change impact*." However, according to E5 opinion, even though the climate data are required, climate data monitoring is not a function of FM.

When considering the climate data types used in decision making, experts are using temperature as measure to design HVAC systems and use in maintaining thermal comfort. E1 stated that humidity is a measure that they almost checking due to water condensation of HVAC systems. Regarding precipitation data, E4 stated that, "*we are doing rainwater harvesting system sizing or calculations using the precipitation data*". E2 pointed out that wind speed data require to passive cooling of buildings and structural considerations. According to E8, "*solar radiation is used in specially for the installation of tilt mounted of roof surfaces, which facing to north-east directions*". E1 stated that solar gain data was used to tinted glass applications. In terms of CO_2 constraints E3 expressed that there is a standard to maintain CO_2 level below 800 ppm. Few of the experts are using cloud cover, land use and water level data. Table 2 presents the need of climate data in FM.

Table 2: Need of climate data in facilities management

Experts		E1	E2	E3	E4	E5	E6	E7	E8
Climate data usage									
Use of decision making in FM /built-environment sectors		✓	✓	✓	✓	✓	✓	✓	✓
Essentially use of mitigating climate change impacts on built environment		✓	✓	✓	✓	✓	✓	✓	✓
Types of climate data in use									
i.	Temperature	✓	✓	✓	✓	✓	✓	✓	✓
ii.	Precipitation	✓	✓	-	✓	✓	✓	✓	-
iii.	Humidity	✓	✓	✓	-	✓	✓	✓	✓
iv.	Wind speed	-	✓	-	✓	-	✓	✓	✓
v.	Solar radiation	✓	✓	-	✓	-	-	-	✓
vi.	Co2 emissions	✓	✓	✓	-	-	-	-	✓
vii.	Vapor pressure	-	-	-	-	-	-	-	-
viii.	Water level	-	✓	-	-	-	✓	✓	-
ix.	Cloud Cover	-	✓	-	✓	-	-	-	-
x.	Land use	-	-	-	-	-	✓	✓	✓

4.1.4 Assess Climate Data Sources

The climate data sources were assessed based on easy accessibility, high availability, convenience for non-expert usage, and difficulties faced. Majority of the experts are using climate data issued by Department of Meteorology, Sri Lanka. Further, few of them are relied on commercial data bases like AccuWeather and Weather Underground. Only few of the experts are using Climate change knowledge portal and Energy Plus weather data. Rather than the mentioned climate data sources, experts have used different other sources specifically for their usage. E2 explained that, "*in Sri Lanka, we've used Typical Meteorological Year data and I've used a software called eQuest to model energy and, we used a software called Red Screen, it takes climate data from NASA directly*". E4 have used National Oceanic and Atmospheric Administration database to obtain wind data. E6 has used Global Circulation and Regional Climate Model for retrieve climate data for the disaster management. Majority of experts have used in-situ climate data measures and E3 explained that, "*we have use sensors in to maintain temperature, Indoor Air Quality measurements and take spot measurements of Relative Humidity.*"

Majority of experts mentioned that there is a high availability or moderate availability of existing climate databases and these climate databases are not convenient to use for non-expert users such as facilities mangers. Further, experts have suggested to use climate data for the areas including water proofing, chiller upgrades, risk mitigation and capital projects. E4 stated that *"if we can use climate data to digital twin and simulate the energy models with actual data before implement."* E2 suggested to improve accessibility of climate data for facilities managers, it is a good initiative to create a visualisation tool and then facilities managers can convince the management on budget requirements. According to E8 "*it will be good to have a tool, that can use to connect the actual weather data and see some quick information rather than very detail analysis*". Table 3 summarises the use of existing climate data sources in built environment sector.

Table 3: Use of climate data sources

	Experts	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
Use of existing climate data	Easy Accessibility	✓						✓	
	High Availability	✓	✓	✓		✓	Mod*	Mod*	Mod*
	Convenience to use non climate experts	✓				n/a	Mod*		
	Any Difficulties occurred			✓	✓	n/a	✓		✓

[Mod*- Moderately agreed; n/a *- not answered]

5. DISSCUSSION

Literature findings and expert interview findings both confirmed that there is a huge climate change impact on built environment sector in both global and Sri Lankan context. It is notable that the awareness and the experience of experts towards climate change impacts on buildings is considerably high. When comparing the global built-environment sectors, Sri Lankan industry experts give less attention to mitigate the climate change impacts on built-environment. Organisations are typically taken into account for climate change initiatives because of market forces, sustainability, or green building considerations. Considering the mitigation of climate impacts on built environment scholars highlighted the importance of using climate data. Experts validated the literature by stating that climate data usage an essential requirement for mitigate the climate change impacts on built environment. All most all the experts have used climate data in decision-making in their fields of expert. Apart from the identified FM areas in literature, experts have mentioned that climate data are using in developing protocols for extreme weather events, flood modelling, energy modelling, identifying monsoon periods for pre-maintenance, water proofing, storm water runoff designs and HVAC upgrading. Considering the climate data types in use, Sri Lankan FM industry is mostly using temperature, humidity, precipitation, wind speed, CO_2 level and solar radiation. Scholars suggested the need of central climate database and it is vital to release freely available climate data for non-expert users (Rao & Rastogi, 2020). Even though literature have identified some other freely available climate data sources very few experts have mentioned the use of them. Experts are using some commercial climate databases such as Weather Underground, AccuWeather as NOAA climate data, eQuest, TMY data and Red Screen. Considering the climate data sources, scholars identified that even though there is limitless data, converting data into knowledge or insights was an issue. Similarly, majority of experts agreed that even though the availability of the climate data sources is high, converting them to actionable insights and informed decision making is an issue. Further, both literature and expert interview analysis found that using climate data from existing sources is complex for non-expert users, especially facilities managers do not have climate science knowledge and less engineering knowledge. Scholars suggested the need of central climate database and it is vital to release freely available climate data for non-expert users as well. FM and built-environment experts suggested to have freely available recent years' climate data records including visualisation tools to make informed decisions quickly rather than detailed analysis. Furthermore, experts stated that the climate database for facilities managers will be a good initiative. Experts also stated that it is a challenging task due to unpredictability of climate changes and not having proper base sources. Table 4 summarises the key points from the discussion on literature and expert interview findings.

Table 4: Literature and expert interview findings

	Literature Findings	**Expert Interview findings**
Availability	Highly available	Highly available
Accessibility issues of existing climate databases	Complex due to technical file formats Climate database management is limited to the expert users Converting collected data into insights is challenging Complexity of evaluating climate change involving geophysical, biological, and social systems	Complexity of accessing climate data Not user friendly for non-climate experts for effective decision making. Unawareness of user-friendly tools. Associated licensing agreements and payments. Require specific permissions. Response delays. Lack of expertise of FMs in climate science is a barrier to interpret and use climate data.
Needs of climate databases for FM	Need of central climate database Need freely available climate data for non-expert users	Need to use in building services designing, risk mitigation, maintenance. Need visualisation tools for climate databases. Easily understandable tool for non- expert users. Need of quick information without detailed analysis. Need of centralised database for all, and separate tool for FMs to visualise the data.

6. CONCLUSIONS

The comprehensive literature review identified that there are different climate change impacts on different sectors in global and Sri Lankan contexts and specifically on built-environment sector. Built environment categories including buildings, built-infrastructure and land-use areas have largely affected by the climate changes. In built environment sector, facility managers have responsibilities on mitigating climate change impacts on their facilities. The FM functions were further investigated across energy management, building maintenance, building performance, OSH and disaster management and found that each FM function has a direct and significant impact through climate changes. Experts validated the literature findings during the expert interview rounds. Climate data has been used for the decision-making purposes of built-environment fields and that it is an essential requirement to mitigate the climate change implications on built-environment. Further, different types of climate data are used in facilities management functions and different climate data sources were identified However, there were different availability and accessibility issues associated with these sources. And also, there is a less awareness of climate change impacts and use of climate data sources in Sri Lanka when comparing to the global. It was identified that there is an actual need of freely available and easily accessible user-friendly climate database for non-expert users such as facilities managers with simplified decision-making tools and visualisation tools.

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