SUSTAINABLE LIVING LAB

CLIMATE RISK ASSESSMENT

Climate-related Impacts and Adaptation Strategies for the Muthiyor Nanban Home

2025

Risk Analytics Data Support

CLIMADA
Technologies

Disclaimer

SL2 was engaged by the Anna Unna Charitable Trust (AUCT) to conduct a Climate Risk Assessment for the Muthiyor Nanban Home.

In preparing this document (the "Climate Risk Assessment"), SL2 has relied upon data gathered during the on-site visit, including environmental sensor readings, consultations with facility stakeholders (staff, residents, and management), information provided by AUCT, and data from third-party sources such as CLIMADA Technologies (collectively, the "Supporting Information"). SL2 reserves the right to revise any analyses, observations, or recommendations referred to in this Report if additional Supporting Information becomes available after the date of this Report's release.

SL2 has assumed the supporting Information to be accurate and complete for the purposes of this Report. The data and information provided by AUCT and third parties were not audited or independently verified for accuracy or completeness. Accordingly, SL2 expresses no opinion or other form of assurance regarding the Supporting Information. This report has been prepared for the exclusive use of the Anna Unna Charitable Trust, and SL2 does not assume responsibility for errors, omissions, or damages resulting from any person's reliance on this Report for any purpose other than the one for which it was prepared.

About the Author

Sustainable Living Lab

We are an ecosystem of organisations that design and implement solutions to navigate climate, societal, and digital transitions. Active across Asia, Europe and the US, with a footprint across 40 countries, we combine foresight, technology, and grassroots engagement to turn complex challenges into real-world outcomes where sustainability can be lived out.

SL2’s climate adaptation work will guide organisations through every stage of their climate adaptation journey, starting with helping them anticipate future climate scenarios through strategic foresight workshops and location-based risk analytics. We help assess specific climate vulnerabilities with tailored climate risk assessments. To align stakeholders, we develop collaborative adaptation strategies through target-setting, stakeholder-engagement sessions, and adaptation planning. We close the loop and adapt by implementing measurable climate solutions, offering on-ground implementation support, community programmes, and comprehensive training and capacity building.

At the core of SL2’s approach is the use of technology as a lever for sustainability, combined with a strong community-driven implementation model. SL2 builds resilient ecosystems by connecting data, innovation, and people, ensuring climate adaptation strategies are not only technically sound, but locally grounded, inclusive, and actionable.

Acknowledgment

We extend our sincere appreciation to all individuals and organisations who contributed to the successful completion of this assessment.

We are grateful to the management of the Anna Unna Charitable Trust for placing their trust in SL2 to undertake this important work, and for their continued support and transparency throughout the project. We also thank the nurses, staff, and residents of the Muthiyor Nanban Home for their generous cooperation, hospitality, and willingness to share their experiences, which provided invaluable insights for this study.

We wish to acknowledge CLIMADA Technologies for generously providing us with the required climate risk analytics data. The data played a crucial role in quantifying the potential climate impacts from heat and floods and went on to help us develop targeted recommendations and decisions to enhance the resilience of the home.

Finally, we recognise the dedication and professionalism of the SL2 project team and thank our colleagues whose ongoing support and contributions made this report possible. This work represents a collective effort, and we are deeply appreciative of all who played a part.

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1.Executive Summary

The Muthiyor Nanban Home in Pudukkottai, Tamil Nadu, is operated by Anna Unna Charitable Trust, a non-profit organisation based in central Tamil Nadu. They provide residential care for a highly climate-vulnerable elderly population. The facility faces escalating threats from prolonged periods of extreme heat, high humidity, and periodic flash flooding triggered by intense rainfall. These environmental challenges are compounded by the advanced age and health susceptibilities of the residents, making climate adaptation an operational priority.

Project Objective:

The primary objective of this project was to conduct a climate risk assessment for the Muthiyor Nanban Home, commissioned by the Anna Unna Charitable Trust. The assessment aimed to evaluate site-specific vulnerabilities to extreme heat and flooding, and to develop a targeted adaptation strategy to safeguard the long-term health, safety, and well-being of its residents.

To achieve this, a comprehensive site assessment was carried out, including a detailed site reconnaissance, stakeholder consultations, and environmental data collection. Specialised sensors were deployed to capture key metrics such as Wet Bulb Globe Temperatures (WBGT) and Heat Index, to accurately quantify thermal stress levels within the facility.

Through this process, the project seeks to generate the necessary insights to inform a practical and context-specific adaptation plan that strengthens the facility's resilience to future climate-related risks.

Methodology:

Our methodology was designed to provide a holistic picture of climate risks by combining three key approaches: on-site environmental measurements, direct stakeholder interviews (with residents, staff, and management), and future climate risk analysis.

The first approach, on-site measurement, involved a two-day site visit to establish a baseline of current conditions. We utilised specialised sensors to collect environmental data, including three handheld Wet Bulb Globe Temperature (WBGT) sensors to measure heat stress and a thermal imaging camera to identify **specific structural areas that contribute to heat retention**.

This data was then supplemented by our second approach, stakeholder interviews, which we gathered through health and comfort surveys with staff, residents, and higher management of the home.

Finally, to ensure our recommendations are forward-looking, our third approach was to incorporate future climate analysis, using established projections for the region to forecast how heat and rainfall patterns are expected to intensify and harm the health of residents.

The methodology for this assessment was designed to provide a holistic understanding of the asset's climate risks by integrating three key approaches:

1. Physical site inspection and data collection
2. Stakeholder engagement
3. Future climate risk analysis

The first step involved a two-day site visit to the care home, to establish a baseline of existing environmental conditions. The project team used specialised instruments, including handheld Wet Bulb Globe Temperature (WBGT) sensors to assess levels of heat stress, and a thermal imaging camera to identify structural features contributing to heat retention within the facility.

This was complemented by focused stakeholder engagement. Through structured interviews and health and comfort surveys with staff, residents, and management, the team gathered qualitative insights into lived experiences of heat exposure and related vulnerabilities.

The third component involved analysing future climate risk. Drawing on high-resolution climate data, the assessment sought to project how extreme heat and rainfall patterns may intensify over time, and to evaluate the potential impacts on residents' health and safety. These insights supported the formulation of targeted and context-specific adaptation strategies.

Assessment Highlights:

The assessment uncovered several critical findings that underscore the facility's heightened vulnerability to both present and future climate risks. These findings point to a system where specific operational and infrastructural gaps amplify the impacts of environmental stressors.

The most urgent and severe concern is the frequent and sustained exposure of residents to unsafe indoor heat levels. On-site measurements confirmed that thermal conditions in multiple rooms, particularly on the first floor, consistently exceeded recognised health and safety thresholds. This poses a substantial risk to a highly vulnerable population, many of whom experience impaired thermoregulation due to age and chronic medical conditions.

Data from the assessment revealed that two first-floor rooms, AF15 and AF21, recorded Wet Bulb Globe Temperatures (WBGT) exceeding 30°C - a threshold classified as "Extreme Risk." Notably, these rooms are occupied by some of the facility's most elderly and medically frail residents. This finding raises serious health and safety concerns, including a heightened risk of heat exhaustion, heatstroke, and worsening of pre-existing cardiovascular or respiratory conditions.

Inadequate cooling measures and operational limitations further worsen the indoor heat risk. Feedback from staff and residents indicated ongoing discomfort and symptoms associated with heat stress. The current cooling setup, mainly small wall-mounted fans, was widely reported as ineffective.

Poor ventilation compounds the issue. Although the building has windows near the ceiling, these are often kept closed to prevent wildlife intrusion, causing heat and humidity to build up and remain trapped. This is most severe during afternoon and evening hours, creating thermal conditions that hinder residents’ ability to cool down and recover overnight.

Climate projections indicate that these heat-related challenges are expected to significantly intensify. The analysis indicates a sharp rise in the number of days per year when the heat index is expected to exceed 41°C - a level classified by the U.S. National Weather Service as “Danger,” where heat exhaustion is likely and heatstroke becomes probable with prolonged exposure. By 2050, projections show 250 to 278 such days annually, across all emissions scenarios. For residents with limited thermoregulation capacity, this presents a sustained health risk, with prolonged periods of physiological stress and minimal recovery time.

Although the facility is not exposed to coastal or riverine flooding, the analysis confirms a high risk of localised surface flooding due to increasing extreme rainfall events. The site has commendable physical mitigation features, including rainfall concentration pipes (RCPs) and a surrounding green buffer.

However, the absence of a formal flood response plan weakens overall preparedness. While the hybrid solar-grid energy system offers some resilience to power outages, the lack of documented procedures increases the risk of disorganisation during flood events, potentially affecting resident safety, food security, and continuity of care.

2.Introduction

Project Context:

The Muthiyor Nanban Home, managed by the Anna Unna Charitable Trust, offers essential residential care to the elderly population in Pudukkottai, Tamil Nadu. This demographic is inherently vulnerable to the adverse effects of climate change. The physiological processes of aging diminish the human body's ability to regulate temperature effectively, a vulnerability that is often compounded by the chronic health conditions prevalent among older adults.[1] The regional climate, characterised by prolonged periods of intense heat and high humidity, therefore poses a significant and direct health risk to these residents. Furthermore, the area's increasing susceptibility to flash floods triggered by extreme rainfall events introduces a secondary layer of risk that complicates the safe operation of the facility and the well-being of its residents.

This report presents an in-depth assessment of these climate-related vulnerabilities.

One of the key focuses of the analysis is the effectiveness of the existing building envelope, which was constructed using Glass Fiber Reinforced Gypsum (GFRG) panels. This modern composite material, renowned for its high thermal insulation properties, was specifically selected to create a passively cooled and comfortable indoor environment by reducing the transfer of external heat into the building.

This report explores the home's structure and daily operations, checking climate related safety levels for residents. Based on findings, it recommends an adaptation strategy with short-term, medium-term, and long-term actions to protect residents and better prepare the facility for the climate challenges ahead.

Operational (Site) Overview:

The Muthiyor Nanban Home is situated on a two-acre, roughly rectangular-shaped parcel of land located on the outskirts of Pudukkottai town, Tamil Nadu. The facility's main building features a distinctive octagonal design, which houses 20 rooms for its residents, distributed across two levels: eight on the ground floor and twelve on the first floor. At the center of this structure is an open courtyard that serves as the primary communal space where residents gather for meals and social activities.

The day-to-day operations of the home are managed by a dedicated team. Resident care is provided by nine nurses who are available around the clock, 24x7. An on-site kitchen staffed by three employees prepares three meals daily for all residents & staff. Seven cleaning staff members maintain the facility, while seven additional personnel handle administrative tasks and oversee safety and security.

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[1] Heat and Older Adults (Aged 65+) | Heat Health | CDC.

The site incorporates several key infrastructural features designed to support its operations and enhance resilience. An on-site kitchen, adjacent to the courtyard, facilitates the preparation of three daily meals for all residents. The property benefits from significant vegetation and extensive tree cover, which provides natural shading to the area, controls the slowdown of floodwater, and contributes to a more moderate local microclimate. To manage risks associated with heavy rainfall, the compound is equipped with twenty-seven Rainfall Concentration Pipes (RCPs) around its periphery. It is designed to collect and filter rainwater during intense storms, with the collected water then made available for use by the local community.

Energy resilience is an important component of the facility's infrastructure. The home operates on a hybrid energy system, sourcing approximately half of its power from on-site solar panels coupled with a battery backup. At the same time, the electrical grid supplies the remaining 50%. This shared reliance ensures that essential services, including lighting and cooling appliances, can remain operational during the power interruptions that often accompany severe weather.

While the building’s layout and materials reflect a deliberate effort to moderate indoor temperatures, a significant conflict has emerged between the design's intent and its day-to-day operational reality. The octagonal shape is theoretically well-suited for promoting cross-ventilation; however, this function is nullified mainly because windows are frequently kept closed as a necessary precaution against intrusion by local wildlife. This lack of natural airflow results in the trapping of heat and moisture/humidity within the building. The internal cooling is currently limited to numerous small, wall-mounted fans, which, according to feedback from some residents and staff, are insufficient to provide adequate relief, particularly on the demonstrably warmer first floor.

Image 1: The Muthiyor Nanban Home

Image 2: Screenshot from Google Maps showing the 2-acre plot

Image 3: Inside the Muthiyor Nanban Home

Image 4: Rooftop solar installation

Image 5: Building Layout - Ground Floor

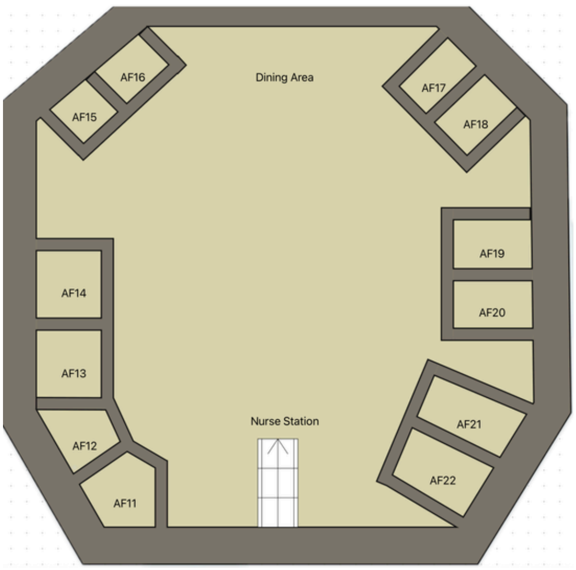

Image 6: Building Layout - First Floor

The Challenge:

Pudukkottai's climate is characterised by prolonged periods of excessive heat combined with high relative humidity, conditions that substantially increase thermal discomfort and health risks for elderly individuals.[1] During the summer months (March to July), daily maximum temperatures frequently reach 39°C, with nighttime temperatures remaining elevated above 25°C, preventing adequate nocturnal cooling. Humidity levels ranging from 50% to 60% exacerbate the perception of heat, increasing the risk of heat exhaustion, dehydration, sleep disturbances, and exacerbation of existing medical conditions among residents.[2]

The facility's use of GFRG (Glass Fiber Reinforced Gypsum) in its construction aimed to reduce indoor heat gain through enhanced insulation and thermal buffering. While GFRG panels can lower internal temperatures by about 2°C compared to conventional materials,[3] sensor data indicated that many rooms, especially on the first floor, regularly exceed Wet Bulb Globe Temperature (WBGT) thresholds associated with heat danger and extreme risk. Some demonstrated WBGT values surpassing the extreme danger level of 30°C.

Compounding the risk is the building's limited ventilation windows are often kept closed to prevent intrusion by monkeys, significantly reducing cross-ventilation and causing heat to be trapped and radiated back into living spaces during the evening. Staff and residents reported substantial heat-related discomfort, and existing cooling measures, such as small wall-mounted fans, were found to be inadequate.

Future climate models project a troubling increase in the number of days per year when the heat index exceeds dangerous levels.

[1] Heat and Older Adults (Aged 65+) | Heat Health | CDC.
[2] Climate & Weather Averages in Pudukkottai, Tamil Nadu, India
[3] Comparison of Residences using GFRG as a Building Material with Conventional Residences in Kerala

Under low, moderate, and high emission scenarios, residents can expect to experience over 250 days of severe heat stress conditions annually by 2030, increasing to nearly 280 days by 2050 in the worst-case scenario. This trend signals a growing, compounded health hazard for an already vulnerable population, necessitating urgent and adaptive heat resilience strategies.

Project Objectives:

This project was commissioned to assess the climate-related vulnerabilities of the Muthiyor Nanban Home, with the goal of developing a targeted and practical adaptation strategy. The focus was on identifying specific heat and flood-related risks affecting the facility and its residents, particularly those that arise due to building design, operational practices, and projected climate changes. The following objectives guided the assessment:

- **Conduct a detailed diagnostic assessment** to understand how and why the Muthiyor Nanban Home is vulnerable to specific climate risks, moving beyond general assumptions to generate evidence-based insights into the facility's current condition.

- **Conduct an indoor thermal analysis** to identify specific hotspots, determine which rooms and floors are subject to higher heat exposure, and investigate the causes of heat retention. This includes evaluating construction materials, building orientation, and operational factors such as ventilation.

- **Assess the facility's preparedness for localised flooding**, particularly the risks associated with extreme rainfall events, and evaluate the effectiveness of current mitigation measures.

- **Analyse future climate projections** for the site to anticipate how risks from extreme heat and rainfall may evolve under different scenarios.

- **Develop a targeted adaptation strategy** for AUCT's Muthiyor Nanban Home, including practical and context-specific recommendations to address the identified vulnerabilities and ensure the long-term safety and well-being of residents.

Methodology

3.1 Baseline Data Collection Framework

The initial phase of the project involved a scoping exercise to determine which climate hazards posed the greatest risk to the Muthiyor Nanban Home. Rather than narrowing the focus from the outset, the team began with a broad review of potential threats, including cyclones, various forms of flooding, and extreme heat. This approach ensured that the assessment targeted the most relevant risks.

The scoping process followed a three-part method. First, historical meteorological data for the region were reviewed to understand patterns of past extreme weather events. This was followed by structured engagement with the facility's management to document their experiences of climate-related disruptions. Lastly, future climate projections were analysed across multiple emissions scenarios to assess likely trends.

Based on this integrated assessment, extreme heat and localised flash flooding due to intense rainfall were identified as the two most critical hazards. These were prioritised due to their potential to significantly impact resident health and disrupt facility operations.

A two-day site visit to the home was conducted on 11 and 12 May 2025, timed to coincide with the peak summer period to assess the severity of heat stress under typical high-temperature conditions.

Indoor Thermal Assessment

To establish an empirical baseline of the facility's thermal performance during extreme heat, a structured data collection protocol was implemented. The process began with cross-verification of all sensors to ensure consistency and accuracy within acceptable error margins. All operational guidelines outlined in the respective user manuals were strictly followed during the site visit.

Sensors were deployed in nine rooms selected to provide a representative sample across the facility. These included rooms on both the ground and first floors, and on different orientations of the building to account for variation in sun exposure. Additional sensors were placed in key common areas such as the kitchen and central courtyard. An outdoor reference sensor was positioned on the roof to enable direct comparison with external conditions. Environmental data was recorded hourly from 10 AM until 8 PM throughout the monitoring period.

The analysis focused on two key metrics for assessing heat stress: Wet Bulb Globe Temperature (WBGT) and Heat Index.

Wet Bulb Globe Temperature (WBGT)

WBGT is considered the gold standard for measuring heat stress on the human body because it is a standard and globally recognised metric that provides a more holistic assessment than standard temperature readings. Unlike a simple thermometer, the WBGT measurement accounts for four key environmental factors simultaneously: ambient air temperature, humidity, wind speed, and radiant heat. This last component is particularly important as it measures the heat radiating from sun-exposed surfaces like walls and roofs, which can significantly increase the heat load on an individual.

Due to its comprehensive nature, the WBGT is utilised by occupational health and safety bodies to establish safety standards for heat exposure.

For the WBGT ratings, we referenced scientific literature, which typically indicates 30°C as a significant heat stress threshold for healthy adults. However, given that a significant portion of the home's residents are over 70 and have various health conditions that compromise their ability to regulate body temperature, a more conservative threshold was established for this assessment. We defined a WBGT of **28-30°C as the 'Danger' zone** and any reading **above 30°C as the 'Extreme' zone** to reflect the heightened vulnerability of the residents better.[4]

While acknowledging that the standard threshold values for the Heat Index are based on U.S. NOAA data and are not specifically calibrated for the elderly, they served as a valuable and widely understood anchor point for risk communication. It is assumed that the health impacts at each threshold would be more severe for the elderly residents.

To ensure a holistic analysis, this quantitative sensor data was integrated with qualitative information. Key resident data, including age, room assignment, and pre-existing health conditions, was taken into account. Furthermore, detailed interviews were conducted with nurses and management to gather direct feedback on observed health impacts and operational challenges related to heat

Flood

A focused vulnerability assessment was conducted for extreme rainfall. This involved a thorough on-site evaluation of the facility's existing flood preparedness measures, which was then analysed in the context of future extreme rainfall projections. This enabled us to identify specific gaps and inform the targeted recommendations necessary to enhance the site's resilience

Table 1: Technical Specifications of the Sensors

Sensor Name / Model	Primary Use / Purpose	Key Specifications	Image
HTC HD-01 Heat Stroke Meter	Used for personal heat exposure monitoring. This wearable sensor measures Air Temperature, Humidity, and Wet Bulb Globe Temperature (WBGT) in accordance with the ISO 7243 standard.	- Air Temp Accuracy: ±0.6°C- Humidity Accuracy: ±5%RH- WBGT Accuracy: Based on a ±3.6°F variance- Sampling Rate: Every 20 seconds	

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[4] Investigating wet-bulb globe temperature on heat-related illness in general population for alerting heat exposure: A time-stratified case-crossover study - ScienceDirect.

Sensor Name / Model	Primary Use / Purpose	Key Specifications	Image
UNI-T UTi260B Thermal Camera	Used to measure radiant heat from surfaces. This handheld camera identified and quantified thermal hotspots like machinery.	- Temperature Range: -20°C to 550°C- Accuracy: ±2°C- Thermal Sensitivity: <50mK- IR Resolution: 256×192 pixels	
UNI-T UT333 Digital Thermo-Hygrometer	Used to measure outdoor ambient conditions. This provided a baseline for outdoor temperature and humidity to compare against indoor measurements.	- Temperature Range: -10 to 60°C- Temperature Accuracy: ±1.0°C- Humidity Accuracy: ±5%RH	

3.2 Future Heat Risk Analysis & Modelling

To ensure that the adaptation strategy for the Muthiyor Nanban Home is not just a solution for today's climate but is also resilient to future changes, a forward-looking risk analysis was conducted. Using data from CLIMADA Technologies, this analysis estimated the future risks for both extreme heat and flooding at the Pudukkottai location.

The analysis was based on three distinct and globally recognised scenarios known as Shared Socioeconomic Pathways (SSPs). These SSPs are used by climate scientists to model a range of possible futures based on how society and the global economy are expected to evolve. For this report, we selected three pathways to represent optimistic, moderate, and pessimistic outcomes:

- **SSP1-2.6 (Sustainability Pathway):** This is considered an optimistic scenario that projects a future with a strong global focus on sustainability and international cooperation. It represents a world with low greenhouse gas emissions that is compatible with the goal of limiting global warming to under two degrees Celsius.

- **SSP2-4.5 (Middle-of-the-Road Pathway):** This scenario represents a future that follows current trends, with moderate progress on climate action and moderate greenhouse gas emissions and warming.

- **SSP5-8.5 (Fossil-Fueled Development Pathway):** This is a pessimistic, high-emissions scenario characterised by a continued reliance on fossil fuels and significant global warming by 2100, with projected temperature increases between 3.3 and 5.7 degrees Celsius.

By analysing the potential heat and flood risks associated with each of these distinct futures, this report can provide recommendations that are robust and adaptable, thereby preparing the facility for a range of possible climate outcomes.

Image 7: Shared Socioeconomic Pathways (SSPs)

Use of Third-Party Risk Analytics: CLIMADA Technologies

This climate risk assessment incorporates third-party climate risk data and analytics provided by CLIMADA Technologies. CLIMADA Technologies supported the assessment by providing asset-level risk analytics data for the Muthiyor Nanban Home. Their data was instrumental in evaluating potential exposure and impact from climate-related hazards under various future climate scenarios.

Background of CLIMADA Technologies

CLIMADA Technologies is a global climate risk analytics data provider originating from the academic research group on Weather & Climate Risk at ETH Zurich. The company is dedicated to transforming climate risk into opportunity through data-driven adaptation planning.

Their technology is based on CLIMADA, a global, open-source, multi-hazard model designed to quantify the socioeconomic impacts of weather and climate events. The model is actively developed at ETH Zurich in collaboration with international research groups.

CLIMADA Technologies provides analytics for both acute and chronic climate hazards, including tropical cyclones, river floods, heat, drought, wildfires, sea level rise, storm surge, and European winter storms. The company leverages high-resolution probabilistic event sets for both current and future climate scenarios. By integrating these hazard sets with asset-level and vulnerability data, CLIMADA Technologies delivers comprehensive physical risk assessments that account for both direct and indirect impacts of climate change.

Overview of Data and Methodology

The risk data applied in this assessment include hazard maps, risk ratings, and climate indicators related to acute and chronic hazards including heat waves, flooding, tropical cyclones, and windstorms. These outputs were generated using downscaled climate projections and asset exposure data, in combination with standardised vulnerability assumptions.

The methodology employed by CLIMADA Technologies reflects established best practices in scenario-based climate risk assessment. Key features of the approach include:

- Use of downscaled, bias-corrected climate data derived from CMIP6 models (e.g. NASA NEX-GDDP-CMIP6)
- Alignment with officially recognised IPCC scenarios (SSP1-2.6, SSP2-4.5, SSP5-8.5) for the years 2030, 2050, and 2080
- Application of over 170 climate indicators to assess hazard frequency, intensity, and change over time
- Generation of standardised risk ratings to support cross-hazard and cross-scenario comparison
- Estimation of financial impacts for selected hazards using vulnerability functions and metrics such as Average Annual Loss and Return Period Loss

Transparency, Limitations, and Replicability

The scope of CLIMADA Technologies’ analytics is defined by the resolution and availability of climate projection data, coverage of hazard types, and model structure as of 2025. While the detailed computational framework remains proprietary, the approach is consistent with international standards such as those outlined by the Task Force on Climate-related Financial Disclosures (TCFD).

Due to the confidential nature of certain modelling components, full replication of the results is not possible. However, steps have been taken to promote transparency and support interpretation, including:

- Documentation of key data inputs, climate scenarios, and assumptions used in this report (see Appendix)
- Clear statement of analytical boundaries and time horizons
- Cross-validation of selected results against available public datasets and sector benchmarks, where feasible

3.3 Adaptation Strategy Development:[7]

A core objective of this project was to develop an adaptation strategy that is both effective and informed by the experiences of residents and staff at the Muthiyor Nanban Home. As technical data alone provides an incomplete picture, stakeholder engagement was used to contextualise the findings.

A two-day site visit was conducted where the team spoke with nursing staff, support personnel, residents, and senior management.

Structured questionnaires were used to collect information on room occupancy, resident health conditions, heat-related challenges, comfort levels, and ventilation issues.

These discussions revealed practical, day-to-day difficulties and provided direct suggestions for operational improvements. The qualitative data added important context to the sensor-based environmental measurements, identifying priority areas and uncovering risks not captured by the instruments.

Ultimately, the final adaptation strategy presented in this report is the product of an integrated approach that synthesises quantitative findings with subjective, experiential accounts. This methodology not only allowed for the identification of actionable risks but also ensured that proposed solutions are feasible, responsive to daily realities, and crafted with a nuanced understanding of the facility's operating context.

Image 8: Interview With Nurse

Baseline Vulnerabilities

4.1 Heat Related Vulnerabilities

Building Materials and Design

The facility is constructed with Glass Fiber Reinforced Gypsum (GFRG), which offers strong insulating properties and is intended to reduce the amount of heat entering the building. Its octagonal architectural design was selected to support cross-ventilation to ensure effective cooling under optimal conditions. In practice, however, this potential remains largely unrealised due to day-to-day operational constraints.

Ventilation and Indoor Climate Challenges

Despite the geometric design, nearly all windows remain closed to prevent entry by wildlife, particularly monkeys. This has led to minimal natural airflow and reduced cross-ventilation by a significant margin. As a result, indoor areas, especially during the evening hours, can become warmer and more humid than the outdoor environment, intensifying occupant discomfort and elevating heat risks.

Cooling Infrastructure

Cooling within the facility predominantly relies on small, wall-mounted fans. Feedback from residents and staff consistently indicates that these fans are insufficient, particularly on the first floor and in corridor spaces, where fans are absent. This lack of effective cooling is further exacerbated during periods of peak heat.

Thermal Risk by Room

Temperature sensor data reveal that first-floor rooms, especially AF15, AF11 and AF21, experience the highest and most frequent levels of heat stress. These rooms exceed the “Extreme Risk” threshold on the Wet Bulb Globe Temperature (WBGT) scale during the hottest parts of the day, placing residents at increased risk for heat-related illness.

Staff Capacity and Training

Currently, nursing and facility staff have not received formal training to recognise or manage heat-related illnesses. There are no established protocols or quick-access resources in place for actively managing heat related health incidents among residents, highlighting an important gap in risk preparedness.

Resident Coping Strategies

Residents often congregate in porch areas to take advantage of marginally cooler microclimates. There is 24/7 access to clean drinking water but not to chilled water.

4.2 Flood Related Vulnerabilities

Rainwater Management

The facility’s perimeter is equipped with 27 Rainfall Concentration Pipes (RCPs) designed to divert and store runoff during periods of heavy rain exceeding 10mm. This system has proven effective not only in reducing the immediate risk of surface flooding but also in capturing water used by the surrounding community.

Green Buffer

Lush vegetation encircles the facility, serving to provide both natural shade (which helps moderate temperatures) and additional capacity to absorb and delay stormwater runoff. This reduces the likelihood and severity of surface flooding in and around the compound.

Power and Energy Resilience

The facility is supplied equally by the main electricity grid and on-site renewable solar panels with battery storage. This hybrid system ensures that important services, such as lighting and cooling, remain operational during periods of grid failure, which are often associated with extreme weather events.

Food Security

All meals are cooked on-site, with food supplies stocked one week in advance to support uninterrupted operations, even during times when access to groceries may be threatened by flooding or other disruptions.

Flood Response Planning

The facility currently lacks a formal flood response plan. During interviews, management indicated that ground-floor residents would be moved to the first floor in the event of flooding. However, the approach is informal and lacks detailed procedures. It also fails to address critical concerns such as food security, given that the kitchen is located on the ground floor. The absence of a documented protocol leaves a significant gap in the facility’s overall flood preparedness.

Image 9: One of the 27 RCPs on site

Current Risk Assessment

5.1 Facility Thermal Analysis

The facility's thermal performance was assessed through a multi-dimensional analysis of sensor data, aimed at identifying spatial and temporal patterns of heat stress beyond basic temperature readings.

To locate areas of highest concern, maximum Wet Bulb Globe Temperature (WBGT) values were analysed for each occupied room. This helped identify specific 'hotspots' with the most severe short-term heat exposure.

Average WBGT values over the monitoring period were also examined to highlight rooms with sustained thermal loads, where residents are exposed to prolonged heat stress with potential health impacts.

Hourly WBGT data were used to track temporal trends, revealing daily heat cycles. The analysis identified critical periods, particularly in the late afternoon and evening, when indoor heat risk intensified.

A floor-by-floor comparison was conducted to assess spatial differences in thermal load. This helped identify structural or design factors contributing to uneven heat distribution.

The Heat Index was used as a complementary metric, classifying rooms based on established risk thresholds. This provided an additional layer of assessment to support clear communication of thermal risks to stakeholders.

Maximum WBGT Levels:

Analysis of maximum Wet Bulb Globe Temperature (WBGT) data showed that the first floor faces the most severe heat-related risks. Rooms AF15 and AF21, both housing highly vulnerable residents, recorded peak WBGT values of 30.2°C, placing them in the "Extreme Risk" category. Room AF11 also reached a high WBGT of 29.8°C, just below the threshold, but still indicative of hazardous conditions.

In contrast, the nurse station on the same floor recorded a lower maximum WBGT of 28.9°C. This difference is likely due to its open layout, which allows better air circulation compared to the enclosed resident rooms where heat is more easily trapped. The station's design and ventilation appear to mitigate heat build-up to some extent.

Overall, the elevated WBGT values across first-floor rooms suggest a common exposure to heat accumulation, likely influenced by their proximity to the roof and limited ventilation.

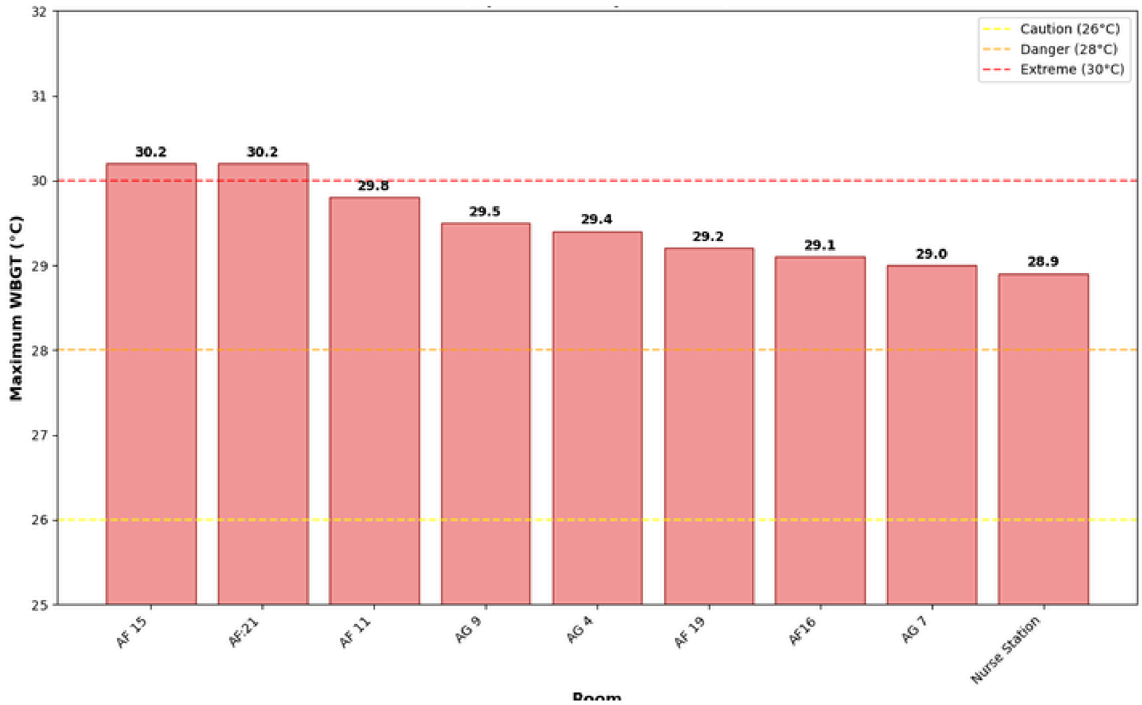

Figure 1: Maximum WBGT Levels (9 Rooms)

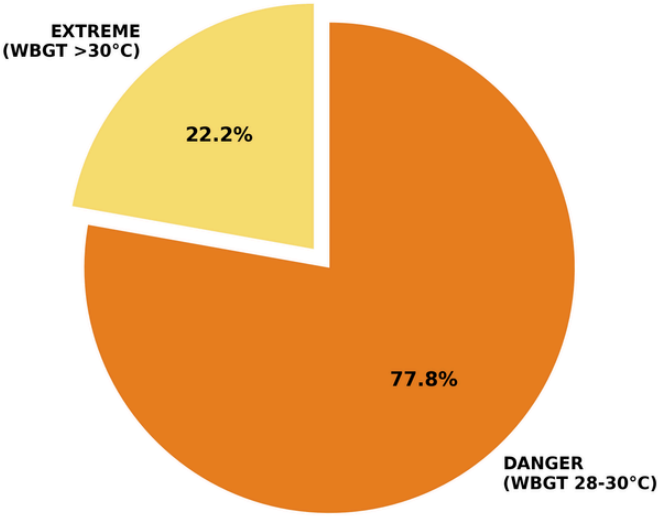

Figure 2: Percentage of rooms under heat risk

Sustained heat loads (WBGT Average)

Assessing average daily Wet Bulb Globe Temperature (WBGT) is essential for understanding prolonged thermal stress on residents, beyond short-term peaks. The data shows that hazardous heat exposure persists throughout the day, rather than occurring in isolated periods (see Figure 3).

Analysis indicates that 77.8% of monitored rooms fall within the ‘Danger’ category based on average daily WBGT, while the remaining 22.2% are in the ‘Caution’ zone. No room maintained a consistently safe thermal environment.

Rooms AF21 and AF15 recorded the highest sustained heat loads, with average daily WBGT values of 28.96°C and 28.93°C, respectively. These results highlight the continuous nature of heat exposure, which limits residents' ability to recover and poses an ongoing risk to health.

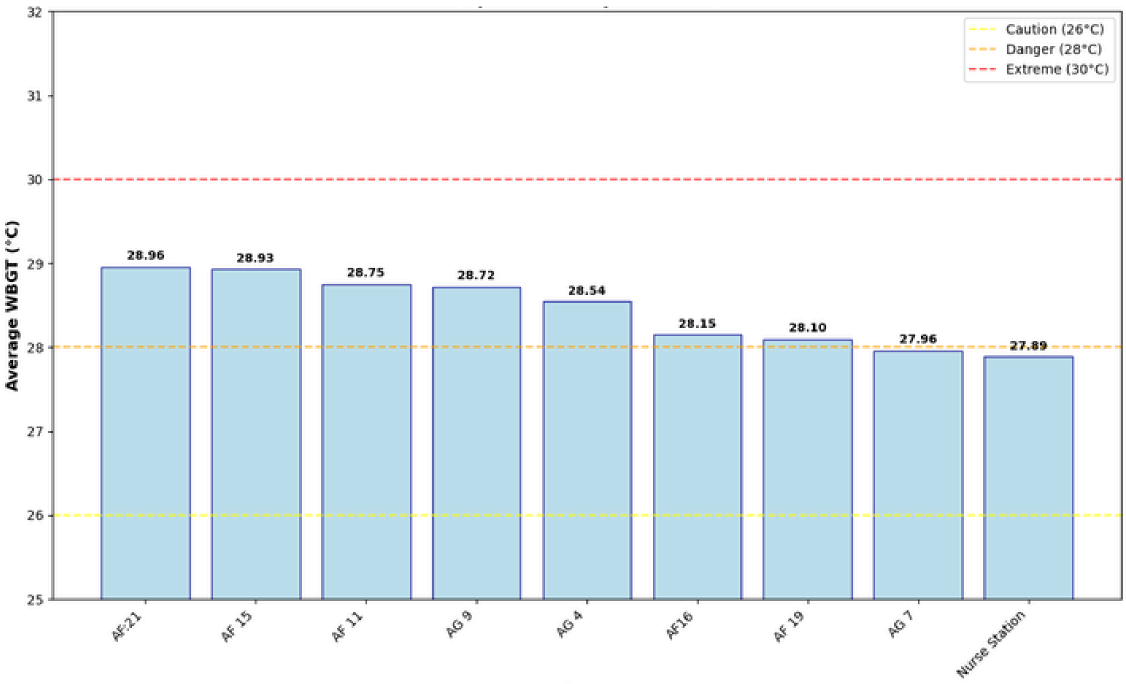

Figure 3: Sustained Heat Loads (Average WBGT Values)

Temporal Analysis (By Time of Day)

An analysis of hourly heat risk was conducted to identify periods of peak thermal exposure and to better understand the building's daily thermal behaviour. This assessment is critical for determining the timing of interventions and assessing whether heat buildup results from direct sunlight or structural retention.

As shown in Figure 4, WBGT values increased steadily throughout the day across all monitored rooms. First-floor rooms, in particular, showed a sharp rise in the afternoon. The highest risk period occurred between 16:00 and 19:00, during which several rooms entered the upper 'Danger' zone. Hotspot rooms AF15 and AF21 exceeded the 30°C 'Extreme Risk' threshold during this window.

This late-day peak indicates significant heat retention within the building's structure, leading to extended exposure for residents into the evening hours.

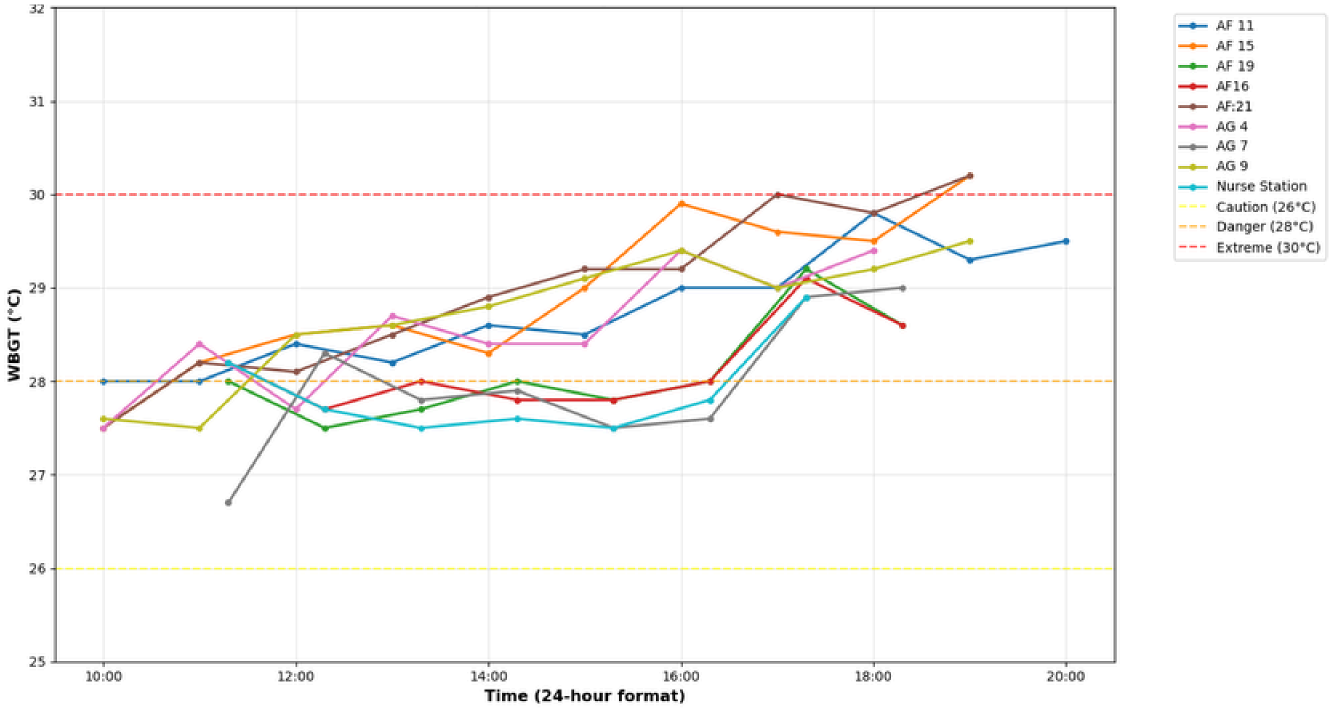

Figure 4: Temporal Analysis of Rooms (By Time of Day)

Spatial Analysis (By Floor)

The spatial analysis of heat exposure within the facility shows clear patterns with direct implications for resident safety and facility operations. Comparative data were collected from the ground floor, first floor, and terrace, with the terrace serving as a reference for outdoor conditions. This enabled a reliable assessment of how location within the building affects thermal stress.

Findings show that the first floor is consistently the most heat-affected area. From 17:00 onwards, WBGT levels on this floor often approach or exceed the 30°C 'Extreme Risk' threshold. Room-level data confirm this pattern, with AF11, AF21, and AF15 - all located on the first floor, recording the highest average WBGT values.

The terrace displayed a different trend: while it was the hottest area in the afternoon, temperatures declined during the evening. In contrast, both the ground and first floors retained heat, with the first floor showing the most significant rise, indicating greater thermal inertia and slower cooling.

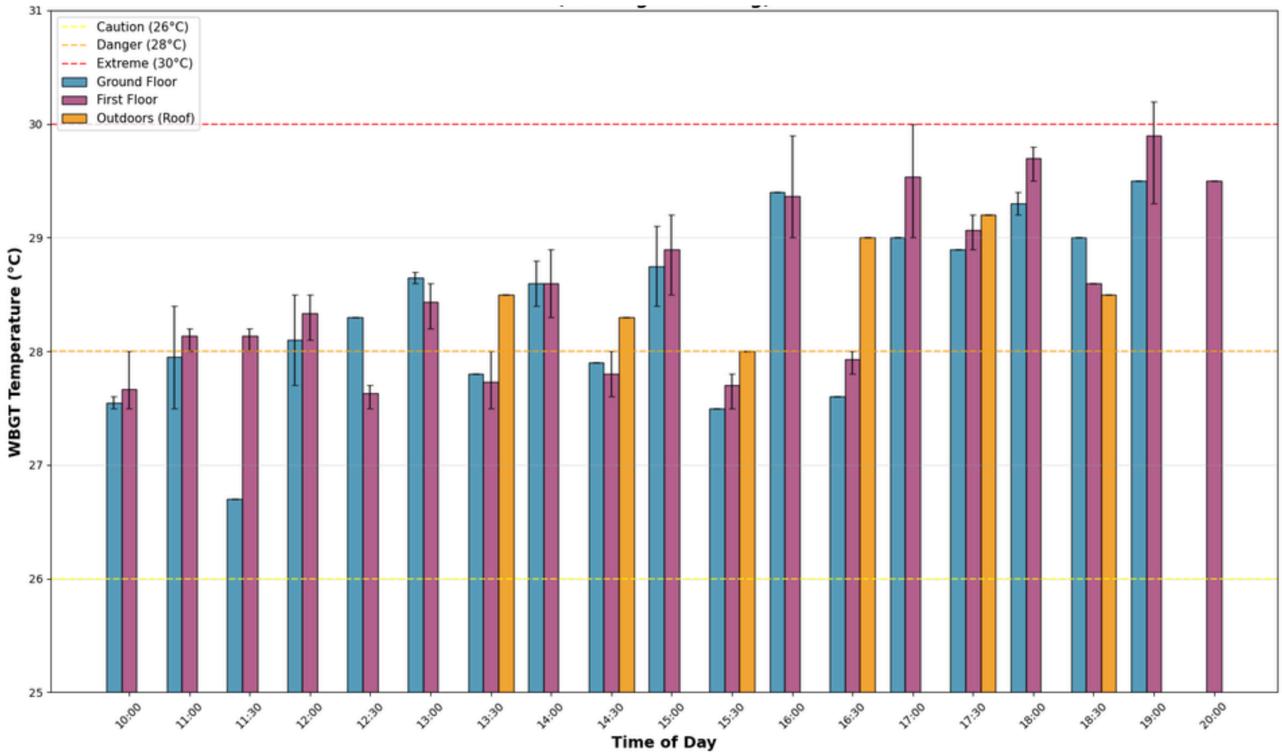

Figure 5: Spatial Analysis (By Floor)

Heat Index Levels: (Rooms & Outdoors)

The Wet Bulb Globe Temperature (WBGT) was used as the primary metric in this assessment due to its effectiveness in measuring human heat stress. To support risk communication with a broader audience, the Heat Index was also included as a supplementary measure.

While WBGT is standard in occupational and environmental health assessments, the Heat Index provides a more accessible reference point for non-technical stakeholders.

This analysis used official heat risk categories defined in the NOAA Heat Index Table.[5] The table below presents instances, based on hourly on-site data, where indoor Heat Index values exceeded thresholds for "Extreme Caution," "Danger," and "Extreme Danger." This approach supports a clear and systematic identification of high-risk periods and locations.

It should be noted that NOAA thresholds are based on average healthy adults. In the context of elderly residents, these categories likely underestimate the actual health risks.

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[5] https://www.weather.gov/ffc/hichart

Table 2: Heat Index Thresholds Based on NOAA

Heat Index	Below Caution (<27)	Caution (27-32°C)	Extreme Caution (32-41°C)	Danger (41-54°C)	Extreme Danger (>54°C)
Location/ Notes		Fatigue can occur with prolonged exposure to activity. Continuing activity could result in heat cramps.	Heat cramps and heat exhaustion are possible. Continuing activity could result in heat stroke.	Heat cramps and heat exhaustion are likely; heat stroke is probable with continued activity.	Heat stroke is imminent.
AF 11	0	0	3	8	0
AF 15	0	0	2	8	0
AF 19	0	0	4	4	0
AF16	0	0	5	2	1
AF:21	0	0	3	7	0
AG 4	0	0	4	5	0
AG 7	0	0	6	2	0
AG 9	0	0	6	4	0
Nurse Station	0	0	6	1	0
Outdoors (Roof)	0	0	4	11	1

Data shows a consistent pattern of elevated heat risk across most monitored rooms. The first floor was the most affected, with rooms such as AF11 and AF15 each recording eight instances in the “Danger” category, where heat exhaustion is likely. Notably, room AF16 crossed into the “Extreme Danger” category at least once, indicating an imminent risk of heat stroke for the residents.

A key finding is the discrepancy between outdoor and indoor heat patterns. While outdoor Heat Index values peaked in the afternoon and then declined, indoor readings continued to rise, reaching peak levels in the evening. This lag is linked to the building’s heat retention, particularly on the first floor, which leads to prolonged exposure and higher thermal stress for occupants. The results confirm that first-floor rooms are subject to greater and more sustained heat risk than those on the ground floor.

Stakeholder Engagement: Heat Stress

To complement the environmental data, structured interviews were conducted with residents and nursing staff to assess the direct effects of thermal conditions on health and comfort. The qualitative feedback reinforced the sensor findings, highlighting the significant human impact of the building’s heat retention.

Both staff and residents consistently reported a noticeable rise in heat over the course of the day, with evenings and nights described as particularly uncomfortable. This aligns with sensor data showing persistent heat buildup. Reported health issues included symptoms such as swelling around the eyes in nurses, and mouth ulcers and disrupted sleep among residents.

The interviews also revealed gaps in preparedness. Nursing staff reported a lack of formal training on recognising and responding to heat-related illnesses, including heatstroke. Additionally, chilled drinking water was not readily accessible to residents, reducing options for hydration. Half of the respondents noted that existing wall-mounted fans were inadequate for effective cooling.

5.2 Stakeholder Engagement: Flood Resilience Assessment

In addition to the primary heat risk, an assessment of the facility's resilience to localised flooding was conducted. Interviews with management confirmed that while the site is not exposed to coastal or riverine flooding, it does experience occasional surface flooding from heavy rainfall.

The investigation identified commendable proactive measures for water management and operational continuity. The site is equipped with 27 Rainfall Concentration Pipes (RCPs) to manage stormwater runoff, and a secure supply chain is in place for food and groceries to ensure self-sufficiency. However, the assessment revealed a significant vulnerability: the absence of a formal, documented flood response plan. While an informal concept for relocating residents exists, the lack of a detailed plan creates significant risk regarding logistical execution, resident safety, and food security, as the facility's kitchen is located on the ground floor.

Future Risk Assessment

To ensure the facility is prepared for the challenges ahead, a future risk analysis was conducted to see how heat and flood risks might evolve by 2030 and 2050. This analysis considered a range of possibilities, from a low-emissions, sustainable future (SSP1-2.6) to a high-emissions, fossil-fuel-driven world (SSP5-8.5).

6.1 Future Risk: Heat

Maximum Heat Index

The analysis focused on the "Max Heat Index" - the single hottest reading of the year. To put the future projections in context, the on-site assessment recorded a current maximum heat index of approximately 61.3°C on the roof. It is important to note that any reading above 54°C is considered "grave danger," a level at which heat stroke is imminent. For the home's elderly residents, many with existing health complications, exposure to such conditions poses a severe threat to their well-being

Table 3: Maximum Heat Index in 2030 and 2050

Year	SSP1-2.6 (Low Emissions)	SSP2-4.5 (Moderate Emissions)	SSP5-8.5 (High Emissions)
2030	~64	~64	~64
2050	~66	~65	~68

Although from a current perspective, the estimated future values may not seem too significant. But the Average days per year of higher heat index are significantly increasing, and that's what causes compounded dangers.

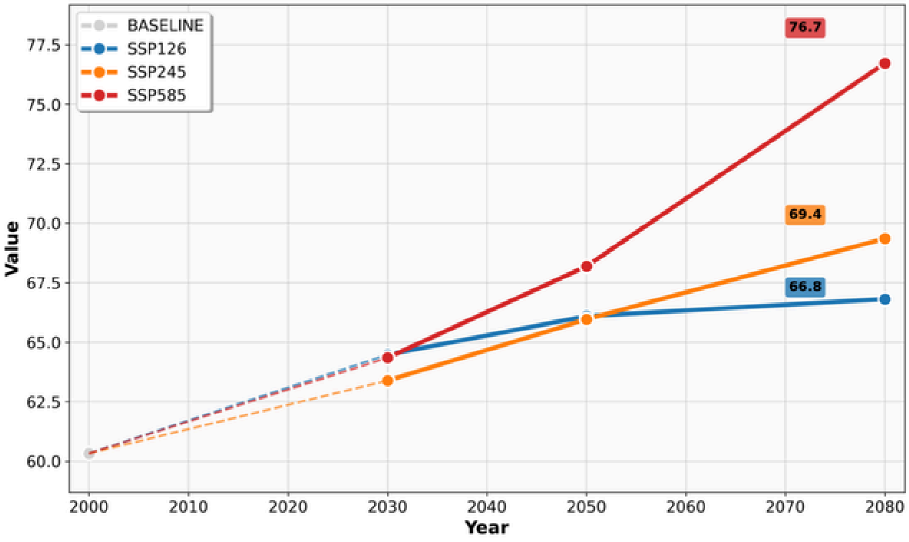

Figure 6: Maximum Heat Index in 2030 and 2050

Projected Frequency of High Heat Index Days (<41)

The report highlights the significant risk posed by the increasing number of days where the Heat Index (HI) exceeds 41°C - a level at which heat cramps and exhaustion are likely, and heat stroke is probable with continued exposure. A high frequency of such days signals a persistent and dangerous thermal environment.

Under all three emissions scenarios, the number of days crossing this threshold is projected to reach into the hundreds. By 2030, both low- and moderate-emission scenarios show approximately 250 such days per year, while the high-emission scenario projects over 255 days.

By 2050, this upward trend intensifies. The low-emission scenario projects around 262 days, the moderate-emission scenario 267 days, and the high-emission scenario over 278 days annually with HI levels above 41°C. These projections point to a future of near-constant exposure to hazardous heat, particularly for vulnerable populations.

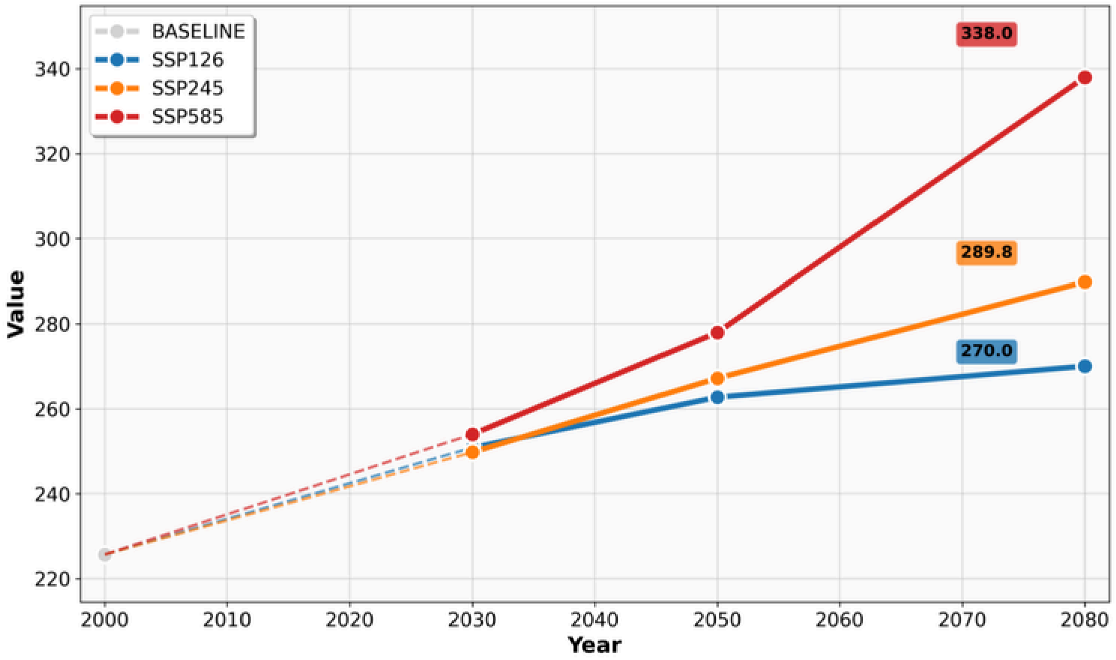

Figure 7: Projected Frequency of High Heat Index Days (<41)

Table 4: Projected Frequency of High Heat Index Days (<41)

Year	SSP1-2.6 (Low Emissions)	SSP2-4.5 (Moderate Emissions)	SSP5-8.5 (High Emissions)
2030	~250 Days	~250 days	~254
2050	~262	~267	~278

6.2 Future Risk: Floods

The assessment for Pudukkottai district confirms that its inland location offers strong protection against coastal and riverine flooding. Hydrological and topographical analyses indicate that the facility is not exposed to large-scale inundation from sea level rise or river overflow under any projected scenario.

However, shifting rainfall patterns present a growing concern. Forecasts show that extreme rainfall events are expected to become more frequent. By 2030, the wettest days may bring up to 77 mm of rain under a low-emission scenario, 73 mm under a moderate scenario, and 76 mm under a high-emission scenario.

By 2050, these figures rise further - up to 85 mm, 81 mm, and 94 mm, respectively. While the site is not at risk of large-scale flooding, such intense rainfall increases the likelihood of localised surface flooding. Existing drainage systems may be insufficient to cope with these heavier downpours, raising the risk of flash flooding around the facility. Although some flood mitigation infrastructure is in place, it may not be adequate as rainfall intensity increases.

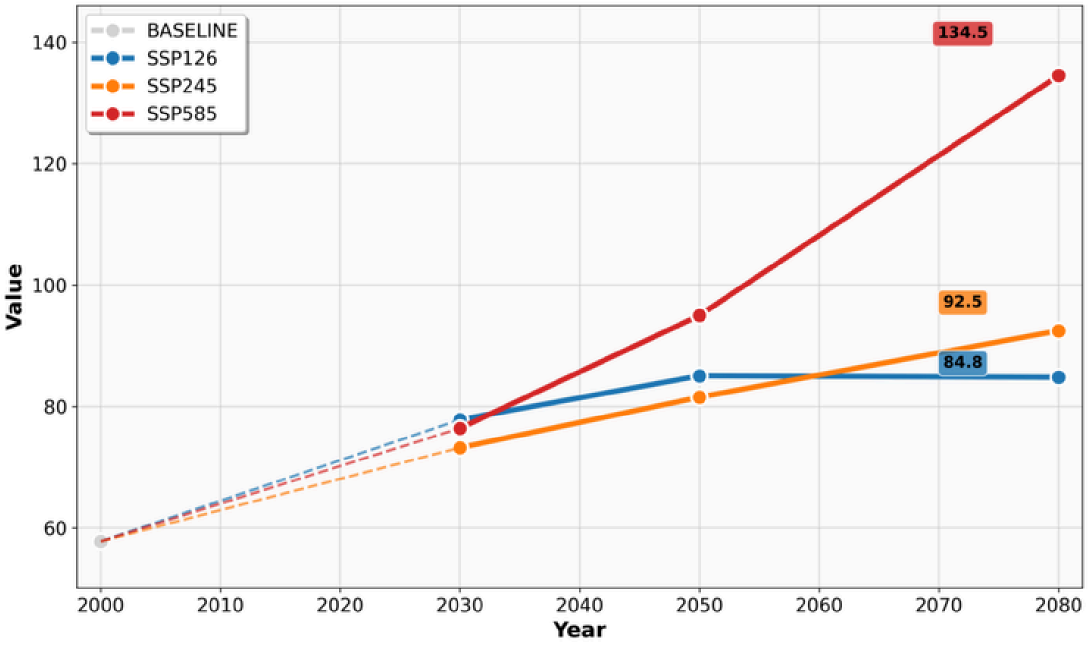

Figure 8: Extreme Precipitation (mm)

Table 5: Extreme Precipitation (mm)

Year	SSP1-2.6 (Low Emissions)	SSP2-4.5 (Moderate Emissions)	SSP5-8.5 (High Emissions)
2030	77mm	73mm	76mm
2050	85mm	81mm	94mm

Heat Adaptation Strategy & Recommendations

Proposed Interventions:

Immediate and Short-term Interventions

- **Room Reallocation for Vulnerable Residents:** Relocate the most heat-vulnerable elderly residents - especially those who are bedbound or have chronic illnesses, from first-floor hot spots (rooms AF15, AF21, AF11 in particular) to cooler ground-floor rooms where measured WBGT values remain consistently lower.

- **Upgrade Internal Cooling Infrastructure:** Replace or supplement small wall-mounted fans with high-capacity ceiling fans on the first floor and in corridors. Ensure all communal lounges and dining areas have adequate fan coverage for group cooling.

- **Enhance Natural Ventilation:** Develop protocols to open windows to enable cross-ventilation. Where possible, install secure mesh window screens to reduce wildlife intrusion while allowing airflow.

- **Staff Training and Heat Health Protocols:** Implement mandatory training for all staff to recognise and respond rapidly to signs of heat-related illness in the elderly (such as heat exhaustion, heat stroke, dehydration, confusion, or swelling). Clear written protocols for emergency action should be displayed in staff areas.

Medium-term Adaptation Measures

- **Cross-Ventilation Enhancements:** Install mechanical cross-ventilation fans or louvered vents across the building's external and internal walls to improve airflow, especially on the first floor and in corridors.

- **Roof and Building Envelope Interventions:** Pilot advanced measures such as applying thermal reflective coatings and green roofs (planting vegetation) on the first-floor slab, particularly above AF15 and AF21. This can reduce heat absorption and lower indoor temperatures during the afternoons and evenings.

- **Passive and Active Cooling Integrations:** Explore partnerships to implement Thermally Activated Building Systems (TABS), which combine water-based radiant cooling with GFRG structural panels. Such hybrid systems significantly enhance indoor comfort while maintaining energy efficiency.

Long-term Strategies

- **Build a Flood Response Plan:** This ensures all residents (especially those with limited mobility) and staff know precisely the action steps needed to be taken.

- **Scalable Pilot Programs:** Expand successful roof and ventilation pilots (e.g., reflective coatings, rooftop gardens, TABS) across all first-floor rooms

- **Early Warning and Monitoring Systems:** Institute digital in-home heat alert monitors for staff and residents. Such systems notify users to increase hydration or move to cooler areas during forecasted heat events. These should be based on core body temperatures, which are a more comprehensive measurement method.

- **Landscape & Site Modifications:** Enhance shading through the addition of trees, vines, and pergolas adjacent to building facades. Consider cool-paved surfaces or reflective tiles in outdoor walkways to reduce heat radiance further

Table 6: Summarised Interventions & Expected Benefits

Priority Timeline	Specific Recommendation	Expected Impact/Benefit
Urgent/Immediate (0-3 mo)	Relocate Bed-ridden, extremely old & Vulnerable residents from AF11, AF15 and AF21 to ground floor	Immediate exposure reduction to extreme heat
Urgent/Immediate (0-3 mo)	Replace small wall fans with high-capacity ceiling fans on the first floor and corridors	Improved air circulation, personal cooling
Urgent/Immediate (0-3 mo)	Open windows early evening with secure mesh to enable ventilation	Enhanced natural ventilation; reduction in indoor heat build-up
Urgent/Immediate (0-3 mo)	Provide consistent access to chilled drinking water	Increased hydration and heat stress relief
Urgent/Immediate (0-3 mo)	Conduct formal staff training on heat stroke recognition and emergency protocols	Faster response to heat stress; improved resident safety
Medium (6-12 mo)	Install mechanical cross-ventilation fans and exhausts in corridors, the kitchen, and the bathrooms	Continuous airflow management; decrease heat and humidity
Medium (6-12 mo)	Pilot thermal reflective coatings and/or green roofs and/or Thermally activated building system (TABS) on AF15, AF21 rooftop	Passive cooling, roof heat absorption reduction

Priority Timeline	Specific Recommendation	Expected Impact/Benefit
Medium (6-12 mo)	Add fans in first first-floor corridors and corridors	Improved resident comfort during peak heat times
Long Term (>12 mo)	Build a Flood Response Plan	Minimises confusion/delays during flooding and ensures food supply for the residents
Long Term (>12 mo)	Regularly clean and maintain RCPs/drains (self cleans)	Prevents drain clogging; reduces flood water accumulation
Long Term (>12 mo)	Expand the thermally activated building system (TABS) and rooftop greening based on pilot results	Integrated passive cooling; energy-efficient temperature control
Long Term (>12 mo)	Implement digital in-home heat alert monitors linked to staff response based on more comprehensive core body temperatures	Early heat risk alerts, proactive adjustments

Evaluation & Improvement Plan:

1. **Baseline Data Reference:**
    - Utilise pre-intervention sensor data (e.g., WBGT values, indoor temperature/humidity) and resident/staff feedback to compare against post-implementation conditions.

2. **Data Collection Metrics:**
    - Indoor temperature and humidity levels, focusing on critical rooms previously identified as heat hotspots (especially AF15, AF21, AF11).
    - WBGT readings compared to established heat risk thresholds.
    - Resident and staff reported thermal comfort and any heat-related symptoms.

3. **Performance Evaluation:**
    - Analyse whether indoor temperatures and WBGT have decreased sufficiently to move rooms from the extreme risk category to a lower risk category.
    - Evaluate improvements in ventilation and resident comfort.

4. **Decision Criteria:**
    - If goals are met, maintain and optimise short-term measures; initiate planning for medium-term improvements as needed to ensure sustainability.
    - If goals are not met, proceed with the roll-out of medium-term interventions (mechanical ventilation, reflective roofing, and green roofs) and reassess following their completion.
    - Following a medium-term evaluation, if the situation remains inadequate, implement long-term solutions (e.g., TABS, heat alert systems).

5. **Continuous Feedback Loop:**
    - Maintain ongoing environmental and health monitoring, coupled with regular feedback from residents and staff, to adapt and refine strategies in response to changing climatic conditions and emerging challenges.

Annexure

Table 7: Flood risk in future scenarios (25, 50, 100, 250 year return periods).

Scenario	Time period	Description of indicator	Depth in meters (Inundation)
baseline	2000	river flood depth with 1-in-100 year return period	0
ssp126	2030	river flood depth with 1-in-100 year return period	0
ssp126	2050	river flood depth with 1-in-100 year return period	0
ssp126	2080	river flood depth with 1-in-100 year return period	0
ssp245	2030	river flood depth with 1-in-100 year return period	0
ssp245	2050	river flood depth with 1-in-100 year return period	0
ssp245	2080	river flood depth with 1-in-100 year return period	0
ssp585	2030	river flood depth with 1-in-100 year return period	0
ssp585	2050	river flood depth with 1-in-100 year return period	0
ssp585	2080	river flood depth with 1-in-100 year return period	0
baseline	2000	river flood depth with 1-in-250 year return period	0
ssp126	2030	river flood depth with 1-in-250 year return period	0
ssp126	2050	river flood depth with 1-in-250 year return period	0
ssp126	2080	river flood depth with 1-in-250 year return period	0
ssp245	2030	river flood depth with 1-in-250 year return period	0
ssp245	2050	river flood depth with 1-in-250 year return period	0
ssp245	2080	river flood depth with 1-in-250 year return period	0
ssp585	2030	river flood depth with 1-in-250 year return period	0
ssp585	2050	river flood depth with 1-in-250 year return period	0

Scenario	Time period	Description of indicator	Depth in meters (Inundation)
ssp585	2080	river flood depth with 1-in-250 year return period	0
baseline	2000	river flood depth with 1-in-25 year return period	0
ssp126	2030	river flood depth with 1-in-25 year return period	0
ssp126	2050	river flood depth with 1-in-25 year return period	0
ssp126	2080	river flood depth with 1-in-25 year return period	0
ssp245	2030	river flood depth with 1-in-25 year return period	0
ssp245	2050	river flood depth with 1-in-25 year return period	0
ssp245	2080	river flood depth with 1-in-25 year return period	0
ssp585	2030	river flood depth with 1-in-25 year return period	0
ssp585	2050	river flood depth with 1-in-25 year return period	0
ssp585	2080	river flood depth with 1-in-25 year return period	0
baseline	2000	river flood depth with 1-in-50 year return period	0
ssp126	2030	river flood depth with 1-in-50 year return period	0
ssp126	2050	river flood depth with 1-in-50 year return period	0
ssp126	2080	river flood depth with 1-in-50 year return period	0
ssp245	2030	river flood depth with 1-in-50 year return period	0
ssp245	2050	river flood depth with 1-in-50 year return period	0
ssp245	2080	river flood depth with 1-in-50 year return period	0
ssp585	2030	river flood depth with 1-in-50 year return period	0
ssp585	2050	river flood depth with 1-in-50 year return period	0
ssp585	2080	river flood depth with 1-in-50 year return period	0

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