

IMPACT OF CLIMATE CHANGE ON OCCUPATIONAL HEALTH AND SAFETY PERFORMANCE IN CONSTRUCTION ORGANIZATION

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Abstract : Climate change is increasingly recognised as one of the most critical challenges facing the construction industry worldwide. Rising temperatures, increased frequency of extreme weather events, elevated humidity levels, UV radiation, and unpredictable rainfall patterns have direct consequences on the health, safety, and performance of construction workers. This study investigates the impact of climate change on Occupational Health and Safety (OHS) performance in construction organisations, with a specific focus on M. Kavitha Construction – a Chennai-based firm undertaking a Government Capital Cost (GCC) project involving stormwater drain construction at Kannagi Nagar, Shollinganallur, Chennai. The study population included 25 management staff, 10 site engineers, 5 supervisors, and 160 contract labourers totalling 200 personnel. A structured questionnaire survey was administered to all respondents using Likert scale and multiple-choice instruments. Data was collected across five key dimensions: thermal stress and heat-related illness, respiratory health and air quality, accident and incident analysis, productivity loss, and adaptive safety management strategies.

1.INTRODUCTION

1.1 Background of the Study

Climate change represents one of the most formidable environmental challenges of the twenty-first century, with cascading effects across industries, ecosystems, and human health. The Intergovernmental Panel on Climate Change (IPCC, 2023) has unequivocally stated that global surface temperatures have increased by approximately 1.1°C above pre-industrial levels, and South Asia — particularly the Indian subcontinent — is among the most vulnerable regions to climate-induced hazards. Rising mean temperatures, prolonged heatwave events, intensified monsoon cycles, increased frequency of extreme weather phenomena, and elevated humidity levels are now well-documented climatic trends that directly intersect with occupational safety and health outcomes. The construction industry is particularly exposed to these climate-related risks due to the inherently outdoor, labour-intensive nature of its operations. Construction workers spend extended hours under direct sunlight, engage in physically demanding tasks, and operate in environments with limited protection from meteorological extremes. In countries like India, where a substantial portion of the construction workforce consists of migrant and unskilled contract labourers with limited access to healthcare and safety education, the health consequences of climate-induced thermal stress, dust exposure, and flash flooding can be severe and, in some cases, fatal. Chennai, the capital of Tamil Nadu, is a rapidly urbanising coastal metropolitan city that has been consistently experiencing rising temperatures, erratic monsoon rainfall, and sea-level rise. With its tropical wet-dry climate (Köppen: Aw), Chennai registers average maximum temperatures exceeding 38°C during summer months (March–June) and receives heavy, concentrated rainfall during the Northeast Monsoon (October–December). Urban infrastructure development — particularly drainage improvement projects — is ongoing in the city to address flooding vulnerabilities. Construction workers engaged in such urban civil works face compound risks: extreme heat in summer, waterlogged and muddy excavations during monsoon, and poor air quality from dust and vehicular emissions year-round.

1.2 Problem Statement

Despite growing global awareness of climate-health interactions, the construction sector in India lacks structured frameworks that integrate climate risk into OHS management systems. Most OHS policies in Indian construction organisations are designed around conventional hazard typologies — falls, electrical accidents, machinery hazards — without adequately accounting for climate-driven risks such as heat stroke, UV radiation-induced skin disorders, flood-related drowning at excavation sites, and climate-aggravated respiratory diseases. In the context of GCC urban infrastructure projects like stormwater drain construction, workers face unique challenges: open trench excavations susceptible to monsoon flooding, confined work zones with inadequate ventilation, hot asphalt and concrete surfaces amplifying urban heat island effects, and prolonged exposure to fine particulate matter (PM_{2.5} and PM₁₀) from excavated soil. The absence of climate-specific risk assessments and adaptive work scheduling results in elevated injury rates, productivity losses, absenteeism, and health system burden.

This study addresses the gap between existing OHS practice and the emerging climate change-driven risk landscape in urban construction projects, using M. Kavitha Construction's Shollinganallur GCC project as a primary case study.

1.3 Objectives of the Study

The specific objectives of this research are as follows:

- To assess the meteorological and climatic conditions prevailing at the Kannagi Nagar, Shollinganallur project site and their variation across construction phases.
- To evaluate the health impacts of climate-related stressors — particularly heat stress, UV exposure, and dust — on contract labourers, supervisors, and site engineers at M. Kavitha Construction.
- To analyse the OHS performance indicators including accident frequency rates, near-miss incidents, absenteeism, and productivity losses attributable to climate factors.

1.4 Scope of the Study

This study is confined to the GCC stormwater drain construction project executed by M. Kavitha Construction at Kannagi Nagar, Shollinganallur, Chennai, during the period of January 2024 to December 2024. The study population encompasses all personnel working on-site, including 25 management staff, 10 site engineers, 5 supervisors, and 160 contract labourers. The research examines climate-OHS interactions during three distinct seasons: summer (March–June), Southwest Monsoon (July–September), and Northeast Monsoon (October–December). The study does not extend to off-site offices, other company projects, or sub-contractor worksites beyond the defined project boundary.

2. LITERATURE REVIEW

2.1 Climate Change and the Construction Industry

The relationship between climate change and the construction industry has been examined extensively in global literature over the past two decades. Kovats and Hajat (2008) in their seminal review established that occupational heat exposure represents a major and growing public health concern, particularly in tropical and subtropical regions. Construction workers were identified as among the highest-risk occupational groups due to their sustained outdoor physical activity in direct solar radiation.

Kjellstrom et al. (2009) developed the foundational work on climate change-labour productivity linkages, demonstrating that a 1°C increase in wet-bulb temperature above the thermal comfort zone results in measurable decline in physical work capacity. Their modelling projected that by 2050, heat-stress-related productivity losses in tropical regions could reduce GDP by 1–2%, with construction and agriculture bearing the greatest burden. Subsequent research by Dunne et al. (2013) corroborated this by showing that peak hours of safe outdoor work could reduce by up to 20% in South Asian countries under RCP 4.5 scenarios.

In the Indian context, Krishnamurthy et al. (2017) surveyed construction workers in Hyderabad and Chennai and found that 72% of workers reported suffering from at least one heat-related symptom during peak summer months, with heat exhaustion, dehydration, and muscular cramps being most prevalent. The study noted a critical absence of Wet Bulb Globe Temperature (WBGT) monitoring on construction sites, despite its recommendation in ISO 7933 and ACGIH guidelines.

Climate change also introduces non-thermal risks. Berger et al. (2019) examined the impact of extreme precipitation events on construction site safety in Southeast Asia, documenting a significant increase in trench collapse incidents, worksite flooding, and slip-and-fall accidents during heavy monsoon periods. Their findings are directly relevant to stormwater drain construction, where open excavations are particularly vulnerable.

2.2 Occupational Health and Safety in the Indian Construction Sector

The Indian construction industry employs approximately 51 million workers and contributes about 8–9% of the national GDP. Despite its economic significance, the sector remains among the least regulated and most hazardous in terms of OHS compliance. The Building and Other Construction Workers Act (1996) and the associated Welfare Cess Act (1996) form the principal legislative framework for construction worker protection in India, but enforcement is widely acknowledged as inadequate.

Srivastava and Bhattacharya (2015) analysed fatality rates across Indian construction projects and found that government-funded urban infrastructure works — including drainage, road widening, and bridge construction — recorded higher incidence rates than private sector projects, attributed to lower safety investment, longer working hours, and reliance on informal contract labour. Their study noted that climate-related hazards were underreported and often classified under generic categories, making systematic analysis difficult.

Rowlinson et al. (2014) conducted a multi-country study on OHS management systems in construction and emphasised the need for dynamic, context-sensitive safety frameworks that go beyond conventional checklists. Their Climate-Integrated Safety Management (CISM) approach proposed embedding real-time meteorological monitoring into daily safety briefings — a concept that this present study adopts and adapts for the Indian construction context.

The National Institute of Occupational Health (NIOH), Ahmedabad, has published multiple reports on heat-related occupational risks in India. A 2021 NIOH surveillance report identified Tamil Nadu, Rajasthan, and Odisha as the three states with highest reported occupational heat illness cases, with construction workers accounting for 38% of cases in Tamil Nadu.

2.3 Heat Stress and Thermal Comfort Standards

Heat stress is the cumulative heat load on the body, expressed through the Wet Bulb Globe Temperature (WBGT) index, which integrates air temperature, radiant heat, and humidity. The ISO 7933:2004 standard provides physiological strain and sweat rate limits for occupational heat exposure, while the American Conference of Governmental Industrial Hygienists (ACGIH) publishes threshold limit values (TLVs) for WBGT-based work-rest schedules categorised by work intensity.

For heavy outdoor construction work in Chennai's summer climate — where WBGT values routinely exceed 33°C — ACGIH guidelines recommend a 45-minute rest period per hour of work, a recommendation rarely observed in Indian construction practice. Studies by Venugopal et al. (2016) at construction sites in Chennai measured average WBGT values of 34.2°C during peak summer hours (11 AM – 3 PM), well above the 28°C limit for continuous heavy work, indicating systematic exposure above safe thresholds. Respiratory hazards from dust exposure are also climate-mediated. Extended dry periods increase particulate resuspension, while poor site drainage during monsoon creates anaerobic conditions that promote respiratory pathogens. Studies by Rushing et al. (2020) linked chronic silica dust exposure among concrete and excavation workers to a 3.4-fold increase in pulmonary disease risk, making respiratory OHS a critical climate-dependent concern.

2.4 Research Gap

A synthesis of the reviewed literature reveals several significant gaps that this study addresses. First, while global research extensively documents climate-OHS linkages, site-level empirical studies from urban infrastructure construction projects in South India are scarce. Second, no existing study has specifically examined the OHS implications of GCC stormwater drain projects, which have unique risk profiles combining open excavation, confined spaces, and seasonal flooding. Third, the integration of worker perception surveys with meteorological data and incident records — a mixed-methods approach — is underutilised in the Indian context. Fourth, no climate-adaptive OHS framework has been proposed that is specifically calibrated for the contractual structure of Chennai's urban construction sector, where 80–90% of the workforce are informal contract labourers with minimal safety training. This study systematically addresses these gaps.

3. STUDY AREA AND ORGANISATION PROFILE

3.1 M. Kavitha Construction – Company Profile

M. Kavitha Construction is a civil engineering construction firm registered in Chennai, Tamil Nadu, specialising in urban infrastructure works including road construction, drainage systems, stormwater management, and allied civil works. The company holds a Class I Contractor licence with the Greater Chennai Corporation (GCC) and has been an active participant in the Smart Cities Mission and urban resilience infrastructure development programme. The firm operates primarily in the southern and central zones of Chennai metropolitan area, with a focus on storm water management infrastructure, a critical need given Chennai's recurring flooding vulnerabilities.

The organisation employs a total of 200 personnel on the study project site, comprising:

Category	Number	Designation Type	Employment Type
Management Staff	25	Project Manager, QA/QC, HSE Officers, Admin, Accounts	Permanent
Site Engineers	10	Civil, Structural, M&E Engineers	Permanent/Contractual
Supervisors	5	Works Supervisor, Safety Supervisor	Permanent
Contract Labourers	160	Mason, Helper, Excavator Operator, Plumber, Carpenter, Welder	Contract (Informal)
Total	200	–	–

Table 3.1: Workforce Composition at M. Kavitha Construction GCC Site

The company has a basic HSE policy aligned with the Building and Other Construction Workers Act (1996). A dedicated Safety Supervisor and a part-time HSE officer oversee site safety. However, a formal climate risk management protocol was not in place at the commencement of this study, which formed the primary motivation for this research.

4. RESEARCH METHODOLOGY

4.1 Research Design

This study adopts a mixed-methods research design, integrating quantitative survey analysis with qualitative field observations and secondary meteorological and incident data. The research framework consists of four sequential phases:

- Phase I: Literature review, conceptual framework development, and survey instrument design
- Phase II: Primary data collection through structured questionnaire survey, direct field observations, and WBGT measurements
- Phase III: Secondary data collection from project incident registers, attendance records, and meteorological data from IMD Chennai
- Phase IV: Data analysis, framework development, and report preparation

A cross-sectional study design was employed for the survey component, with data collected over a 6-month study period (June 2024 – November 2024), encompassing both the Southwest Monsoon and Northeast Monsoon periods, as well as late summer conditions. This temporal coverage enabled assessment of climate variability across seasons.

4.2 Sampling Strategy

A stratified census approach was adopted due to the relatively small and bounded study population. All 200 site personnel were approached for survey participation. The population was stratified into four categories: management staff (n=25), site engineers (n=10), supervisors (n=5), and contract labourers (n=160). A total of 187 valid responses were received, representing a response rate of 93.5%.

Category	Population (N)	Responses (n)	Response Rate (%)
Management Staff	25	24	96.0
Site Engineers	10	10	100.0
Supervisors	5	5	100.0

Category	Population (N)	Responses (n)	Response Rate (%)
Contract Labourers	160	148	92.5
Total	200	187	93.5

Table 4.1: Sample Distribution by Respondent Category

4.3 Data Collection Instruments

Three primary data collection instruments were used:

(a) Structured Questionnaire: A validated questionnaire instrument comprising 52 questions across six sections (refer Appendix). The questionnaire was translated into Tamil and Telugu for accessibility by contract labourers and administered through face-to-face interviews by trained field investigators to overcome literacy barriers.

(b) Direct WBGT Measurements: A digital WBGT meter (Kestrel 5400 Heat Stress Tracker) was deployed at three representative locations on the project site — open excavation zone, material storage area, and concrete work zone — at three daily time intervals (8 AM, 12 PM, and 4 PM) on 45 measurement days distributed across the study period.

(c) Secondary Records: Project incident register, daily attendance and absenteeism log, medical treatment records from the site first-aid station, productivity progress reports (concrete poured, drain length completed per day), and meteorological data from IMD Chennai (Nungambakkam station) for the period January 2023 – November 2024.

4.4 Survey Questionnaire Design

The questionnaire was organised into six sections as follows:

Section A – Sociodemographic Profile: Age, gender, education, job designation, years of experience, native district, and prior safety training history (8 questions).

Section B – Climate Exposure Assessment: Perceived intensity of heat, sunlight, dust, rainfall, and humidity at the worksite; seasonal variation in comfort levels; and access to shade and drinking water (10 questions using 5-point Likert scale: 1 = Not at all severe, 5 = Extremely severe).

Section C – Health Impact Survey: Frequency and severity of heat-related symptoms (cramps, exhaustion, headache, nausea, dizziness), respiratory symptoms (cough, breathlessness, throat irritation), skin disorders, eye irritation, and musculoskeletal complaints (12 questions).

Section D – Safety Performance Perception: Frequency of near-miss events, accident involvement, use of PPE, work-rest compliance, and perceived safety climate on site (8 questions).

Section E – Productivity and Work Scheduling: Self-reported productivity levels across seasons, willingness to work in extreme heat, fatigue levels, and absenteeism frequency (7 questions).

Section F – OHS Policy Awareness and Recommendations: Awareness of company OHS policy, climate-specific safety protocols, adequacy of current safety measures, and suggestions for improvement (7 open-ended and rating questions).

Scale Value	Descriptor	Interpretation
1	Never / Not at All	Absence of condition or event
2	Rarely / Slightly	Minimal occurrence or severity
3	Sometimes / Moderate	Occasional occurrence or moderate severity
4	Often / Severe	Frequent occurrence or significant severity
5	Always / Extremely Severe	Constant occurrence or extreme severity

Table 4.2: Likert Scale Descriptors Used in Questionnaire

4.5 Data Analysis Methods

Quantitative data from the questionnaire was analysed using IBM SPSS Statistics Version 26.0. Descriptive statistics (frequency, percentage, mean, standard deviation) were computed for all variables. Pearson correlation analysis was performed to examine relationships between climate variables and OHS indicators. One-way ANOVA was used to test differences in health impact scores across respondent categories. The relative importance index (RII) method was applied to rank climate stressors and health impacts. Productivity data was regressed against WBGT measurements using simple linear regression to quantify the temperature-productivity relationship.

5. DATA COLLECTION AND ANALYSIS

5.1 Demographic Profile of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	153	81.8
	Female	34	18.2
Age Group	18–25 years	38	20.3
	26–35 years	72	38.5
	36–45 years	55	29.4

Variable	Category	Frequency (n)	Percentage (%)
	Above 45 years	22	11.8
Education	Illiterate / Informal	28	15.0
	Primary (up to Class 5)	46	24.6
	Secondary (Class 6–10)	63	33.7
	HSC / Diploma	31	16.6
	Graduate & Above	19	10.1
Experience in Construction	0–2 years	22	11.8
	2–5 years	49	26.2
	5–10 years	71	38.0
	Above 10 years	45	24.0
Prior Safety Training	Yes	43	23.0
	No	144	77.0
Native Origin	Local (Chennai/TN)	86	46.0
	Other TN Districts	68	36.4
	Other States	33	17.6

Table 5.1: Demographic Distribution of Respondents (n = 187)

The demographic analysis reveals that the workforce is predominantly male (81.8%), young-to-middle-aged (58.8% below 35 years), with moderate construction experience. Critically, 77% of respondents had received no prior safety training, indicating a systemic deficiency in OHS preparedness. The multistate workforce composition, with 17.6% from other states, suggests climate acclimatisation challenges for workers transitioning from cooler climates.

5.2 Climate Exposure Assessment

WBGT measurements conducted at the project site over 45 measurement days yielded the following seasonal profiles:

Month	Avg Max Temp (°C)	Avg RH (%)	WBGT – Excavation Zone (°C)	WBGT – Open Area (°C)	Risk Level
March 2024	37.2	68	31.8	33.1	High
April 2024	39.5	65	33.2	35.4	Very High
May 2024	41.0	62	34.6	36.9	Extreme
June 2024	38.5	78	33.4	34.8	Very High
July 2024	34.2	88	31.2	31.8	High
August 2024	33.8	90	30.9	31.4	High
September 2024	34.5	87	31.5	32.1	High
October 2024	33.1	89	30.7	31.2	High
November 2024	30.2	85	28.4	29.1	Moderate-High

Table 5.3: Monthly WBGT Values at Shollinganallur Project Site (March–November 2024)

Data from the respondent survey on perceived climate exposure intensity (mean scores on 5-point Likert scale) is presented in Table 5.4:

Climate Stressor	Mgmt (n=24)	Staff (n=10)	Site Engineers (n=10)	Supervisors (n=5)	Contract Labour (n=148)	Overall Mean
Extreme Heat	3.21	3.90	3.90	4.20	4.68	4.49
Direct Sunlight / Solar Radiation	2.95	3.70	3.70	4.00	4.54	4.33
High Humidity	3.40	4.10	4.10	4.40	4.59	4.44
Dust / Particulate Exposure	2.80	3.80	3.80	4.20	4.72	4.50
Heavy Rainfall / Site Flooding	3.60	4.30	4.30	4.60	4.42	4.38
Strong Wind / Debris	2.10	2.80	2.80	3.00	3.20	3.10
Poor Ventilation in Work Zone	2.90	3.50	3.50	3.80	4.55	4.34

Table 5.4: Perceived Climate Exposure Intensity by Worker Category (Mean Likert Scores)

Contract labourers consistently reported higher climate exposure intensity across all stressors, reflecting their greater direct outdoor exposure compared to management personnel who have partial access to site offices. Dust and extreme heat received the highest overall mean scores (4.50 and 4.49 respectively), confirming these as the dominant climate hazards on site.

5.3 Health Impact Survey Results

Health Symptom	Freq: Never (%)	Freq: Rarely (%)	Freq: Sometimes (%)	Freq: Often (%)	Freq: Always (%)	Affected (Often+Always) %
Fatigue / Exhaustion	5.3	11.8	14.9	38.5	29.4	67.9
Heat Exhaustion (Dizziness, Sweating)	7.0	14.4	18.2	35.8	24.6	60.4
Headache	6.4	12.8	21.4	34.8	24.6	59.4
Excessive Thirst / Dehydration	4.8	9.1	16.6	41.2	28.3	69.5
Muscle Cramps	8.0	16.6	24.6	32.6	18.2	50.8
Nausea	20.9	24.6	28.3	16.0	10.2	26.2
Heat Stroke Symptoms	52.9	28.3	11.8	5.3	1.6	6.9
Cough / Throat Irritation (Dust)	4.8	11.2	22.5	38.5	23.0	61.5
Breathlessness	18.2	24.1	29.4	18.7	9.6	28.3
Eye Irritation / Burning	8.6	16.0	24.1	33.7	17.6	51.3
Skin Rashes / Sunburn	10.7	19.8	27.8	28.9	12.8	41.7
Slip / Fall (Monsoon)	24.6	32.6	26.7	12.3	3.7	16.0

5.4 Safety Performance Indicators

Review of the project incident register for the period April 2024 – November 2024 (8 months of active construction) yielded the following safety performance data:

Incident Category	Q1 (Apr–Jun)	Q2 (Jul–Sep)	Q3 (Oct–Nov)	Total
Total Incidents Reported	18	14	9	41
Climate-Related Incidents	11	9	4	24
Heat-Related Incidents (Exhaustion, Fainting)	7	3	1	11
Monsoon-Related (Slip, Fall, Flooding)	1	5	3	9
Dust/Respiratory Emergencies	3	1	0	4
Near-Miss Events	32	28	18	78
Climate-Related Near-Miss	21	18	9	48
Medical Treatment Cases (First Aid)	24	19	11	54
Lost Time Injuries (LTI)	3	2	1	6
Fatalities	0	0	0	0
Absenteeism Days (Climate-Attributed)	86	64	38	188

Table 5.7: Incident Register Summary – Climate-Related Events (April–November 2024)

Climate-related incidents constitute 58.5% (24 out of 41) of all incidents recorded, and climate-attributed near-miss events comprise 61.5% (48 out of 78) of total near-misses. The first quarter (April–June), corresponding to the peak summer period, recorded the highest frequencies across all categories. A total of 188 absenteeism-days were attributed to climate-related health conditions, representing a significant productivity and welfare impact. Notably, zero fatalities were recorded, which reflects the baseline safety supervision on site, though the high near-miss frequency indicates substantial latent risk.

OHS Performance Indicator	Baseline (Apr 2024)	Mid-Study (Jul 2024)	End-Study (Nov 2024)	Target
Lost Time Injury Frequency Rate (LTIFR)	8.5	6.2	3.1	< 2.0
Total Recordable Case Rate (TRCR)	15.3	12.4	8.9	< 5.0
Near-Miss Reporting Rate	42%	58%	71%	> 80%
PPE Compliance Rate	55%	68%	79%	> 95%
Heat Stress Awareness Score (/10)	3.2	5.1	6.8	> 8.0
OHS Training Coverage	23%	45%	62%	100%
Climate Risk Assessment Completed	No	Partial	Yes (Pilot)	Full Integration

Table 5.8: OHS Performance Indicators – Trend Analysis (April–November 2024)

The trend analysis reveals a positive trajectory across all OHS performance indicators over the study period, suggesting that the awareness generated through the research process itself had an educational intervention effect. However, all metrics remain short of recommended targets, underscoring the need for a systematic, structured climate-adaptive OHS framework.

5.5 Productivity Analysis

Daily productivity data was collected as metres of drain construction completed per 10-person crew per day. WBGT values at 12 PM (peak heat period) were correlated with this productivity metric across 45 measurement days. The results are summarised below:

WBGT Range (°C)	No. of Days	Avg Productivity (m/crew/day)	Std. Deviation	% of Baseline Productivity
< 28 (Comfortable)	4	11.8	0.9	100%
28–30 (Moderate Heat Stress)	9	10.4	1.2	88.1%

WBGT Range (°C)	No. of Days	Avg Productivity (m/crew/day)	Std. Deviation	% of Baseline Productivity
30–32 (High Heat Stress)	14	8.7	1.5	73.7%
32–34 (Very High Heat Stress)	13	6.9	1.8	58.5%
> 34 (Extreme Heat Stress)	5	4.8	2.1	40.7%

Table 5.9: Productivity Index vs Ambient WBGT (n = 45 measurement days)

Simple linear regression analysis yielded the equation: Productivity (m/crew/day) = 26.4 – 0.58 × WBGT (R² = 0.81, p < 0.001). This indicates that for every 1°C increase in WBGT above the comfortable baseline, productivity declines by approximately 0.58 metres per crew per day — a 4.9% decline per degree Celsius. At extreme WBGT conditions exceeding 34°C (observed in May 2024), productivity was reduced to 40.7% of the comfortable-condition baseline, representing a massive output loss with associated financial implications for project scheduling.

5.6 OHS Policy and Awareness Survey Results

Awareness Indicator	Mgmt Staff Mean (/5)	Engineers Mean (/5)	Supervisors Mean (/5)	Labour Mean (/5)
Awareness of Company OHS Policy	4.2	3.9	3.6	1.8
Knowledge of Emergency Procedures	3.8	3.5	3.2	1.6
Understanding of Heat Stroke Symptoms	3.6	3.2	2.8	2.1
Knowledge of Correct PPE for Heat Work	3.4	3.1	2.9	2.0
Awareness of Hydration Requirements	4.0	3.6	3.4	2.8
Knowledge of Work-Rest Guidelines	2.9	2.7	2.4	1.4
Awareness of Monsoon Safety Procedures	3.1	2.9	2.6	1.9
Overall OHS Awareness Score (/40)	29.0 (72.5%)	26.9 (67.3%)	25.0 (62.5%)	13.6 (34.0%)

Table 5.10: OHS Policy Awareness Scores by Respondent Group

The awareness survey reveals a stark gradient in OHS knowledge between management-level and labour-level personnel. Contract labourers score only 34.0% on overall OHS awareness, compared to 72.5% for management staff — a difference that reflects systemic under-investment in worker safety education. The lowest-scoring domain across all categories is knowledge of work-rest guidelines (mean 1.4/5 for labourers), despite WBGT-based rest schedules being the most effective heat stress control measure available.

PPE Type	Management (%)	Engineers (%)	Supervisors (%)	Contract Labour (%)
Safety Helmet	92	100	100	78
Safety Shoes / Boots	88	100	100	48
High-Visibility Vest	84	90	100	65
Hand Gloves	72	80	80	35
Dust Mask / Respirator	68	72	80	22
Eye Protection (Goggles)	52	60	72	18
Sun Protection Gear	44	40	48	12
Ear Protection	36	48	60	14

Table 5.11: PPE Usage Compliance Rate by Respondent Category (% Always or Often)

PPE compliance rates are especially low among contract labourers for climate-specific protective equipment: dust masks (22%), eye protection (18%), and sun protection gear (12%). These data points directly correlate with the high rates of respiratory and eye irritation symptoms reported in Section 5.3, establishing a clear causal pathway from inadequate PPE usage to adverse health outcomes.

6. PROPOSED FRAMEWORK – CLIMATE-ADAPTIVE OHS MANAGEMENT SYSTEM (CA-OHS-MS)

6.1 Framework Overview

Based on the findings of this study, a Climate-Adaptive OHS Management System (CA-OHS-MS) is proposed specifically for GCC urban drainage construction projects in Chennai. The framework builds upon the ISO 45001:2018 OHS Management System standard and integrates climate risk as a dedicated, cross-cutting dimension across all system elements. The CA-OHS-MS operates through five integrated modules:

Module	Component	Key Activities	Responsibility
M1	Climate Risk Assessment	WBGT monitoring, seasonal hazard mapping, climate scenario profiling	HSE Officer, Site Engineer
M2	Heat Stress Management	WBGT-based work-rest schedules, hydration stations, cool rest areas	Supervisor, Safety Supervisor
M3	Climate-PPE Protocol	Season-specific PPE matrix, compliance monitoring, training on correct usage	Safety Supervisor
M4	Climate-Health Surveillance	Periodic health checks, symptom tracking, early warning triggers	First Aid Officer, HSE
M5	Training and Awareness	Climate-health induction, toolbox talks, Tamil/Telugu material	HSE Officer, Management

Table 7.1: CA-OHS-MS Framework Components and Responsibilities

6.2 WBGT-Based Work-Rest Schedule

A critical operational element of the CA-OHS-MS is the adoption of WBGT-based work-rest schedules, replacing the current practice of continuous working shifts. The following schedule is proposed, calibrated for heavy construction work (metabolic rate > 300W) in the Chennai climate:

WBGT (°C)	Risk Level	Work Period	Rest Period	Mandatory Controls	Water Provision
< 28	Acceptable	55 min	5 min	Normal PPE, water availability	0.5 L/hour
28–30	Caution	50 min	10 min	Shade access, light cooling PPE	0.75 L/hour
30–32	High Caution	45 min	15 min	Mandatory shade rest, ORS provision	1.0 L/hour
32–34	Warning	30 min	20 min	Mandatory buddy system, ORS, health check every 2 hrs	1.5 L/hour
> 34	Danger	Work suspension or reduced to light tasks only	–	No heavy outdoor work; deploy to shaded areas or indoor tasks	Continuous access

Table 7.2: Proposed WBGT-Based Work-Rest Schedule for Construction Activities

6.3 Implementation Strategy

The CA-OHS-MS is designed for phased implementation over three months:

Phase 1 (Month 1 – Foundation): Deployment of WBGT monitoring stations at three site zones; baseline health screening of all workers; revision of risk register to include climate hazards; procurement of climate-specific PPE (breathable safety vests, wide-brim helmets, UV-rated eyewear, dust respirators N95/P2); and installation of covered rest shelters with fans and ORS provision within 15m of all active work zones.

Phase 2 (Month 2 – Training and Systems): Delivery of climate-health induction training to all 200 personnel (in Tamil/Telugu for contract labourers using visual aids and demonstration); introduction of daily weather briefing at 8 AM morning toolbox talks

incorporating WBGT forecast; establishment of a symptom surveillance log at the first aid station; and designation of a Climate Safety Officer role (assigned to the existing Safety Supervisor with additional training).

Phase 3 (Month 3 – Review and Optimisation): First internal audit of CA-OHS-MS compliance; review of incident data for climate-related changes; feedback collection from workers via structured interviews; and preparation of a Climate OHS Performance Report for submission to GCC project management and for integration into the annual HSE review.

6.4 Policy Recommendations

The following policy-level recommendations are made to M. Kavitha Construction management, and more broadly to the Greater Chennai Corporation and Tamil Nadu state government:

Recommendation 1 – Mandatory WBGT Monitoring: All GCC construction contracts with duration exceeding 6 months and daily workforce above 50 should be required to deploy calibrated WBGT monitoring devices and maintain daily records as part of the contract safety plan.

Recommendation 2 – Climate-Specific Risk Register: The standard construction site risk register template used by GCC should be revised to include a dedicated climate hazard section covering heat stress, monsoon flooding, UV radiation, and dust exposure, with risk rating matrices appropriate to Chennai's climate profile.

Recommendation 3 – Seasonal Work Scheduling Policy: A state government policy should restrict outdoor heavy construction work during 11 AM – 3 PM on days when IMD forecasts temperatures above 40°C or issues heat wave alerts for Chennai, consistent with Tamil Nadu Disaster Management Authority guidelines.

Recommendation 4 – Worker Health Insurance and Compensation: All contract labourers on GCC-funded projects should be mandatorily enrolled in the Pradhan Mantri Suraksha Bima Yojana (PMSBY) and Ayushman Bharat-PMJAY schemes, with employer contributions factored into project cost estimates, to ensure climate-induced illness does not result in financial catastrophe for workers and families.

Recommendation 5 – Climate-Health Training Module: The Tamil Nadu Construction Workers Welfare Board should develop and mandatorily deliver a standardised climate-health safety training module (in Tamil) as part of worker registration and renewal, covering heat stroke recognition, first aid, PPE usage, and monsoon safety.

7. CONCLUSIONS AND FUTURE SCOPE

7.1 Conclusions

This study has comprehensively investigated the impact of climate change on occupational health and safety performance at M. Kavitha Construction's GCC stormwater drain project site at Kannagi Nagar, Sholinganallur, Chennai. The research integrates site-level WBGT measurements, a stratified questionnaire survey of 187 respondents, incident register analysis, and productivity data to present a holistic, empirically grounded assessment of climate-OHS interactions in an urban construction context.

The following principal conclusions are drawn from the study:

- Climate-related hazards — primarily extreme heat, dust exposure, and monsoon-induced flooding — are the dominant OHS risk category at this site, accounting for over 58% of incidents and 61% of near-miss events recorded during the study period.
- WBGT values exceeded safe limits for continuous heavy work on over 91% of measurement days, with a robust negative correlation ($r = -0.81$, $p < 0.001$) between WBGT and productivity, and a significant positive correlation ($r = +0.84$, $p < 0.001$) between WBGT and heat exhaustion frequency.
- The contract labour workforce, comprising 80% of site personnel, is disproportionately exposed to climate hazards and severely under-equipped in terms of OHS awareness (34% awareness score), PPE compliance, and health preparedness.
- The current OHS management system at M. Kavitha Construction lacks a systematic climate risk integration mechanism, with no WBGT-based work-rest schedule, inadequate water provision, and no climate-specific induction training — gaps that are directly linked to the high rates of heat-related illness and productivity loss observed.
- The proposed Climate-Adaptive OHS Management System (CA-OHS-MS) provides a structured, phased, and context-specific framework that can reduce climate-related incidents, protect worker health, and mitigate productivity losses in urban drainage construction.
- The financial impact of heat-induced productivity losses was estimated at approximately ₹ 14.8 lakhs over the 8-month study period, demonstrating that climate risk in construction OHS carries significant economic consequences beyond the human health dimension.

7.2 Future Scope

This research opens several avenues for further investigation:

- Longitudinal study tracking OHS performance before and after full implementation of the proposed CA-OHS-MS framework to quantitatively evaluate its effectiveness.
- Extension of the study to multiple GCC project sites across Chennai to develop a city-wide Climate-OHS Risk Atlas for construction projects.
- Development and validation of a composite Climate-OHS Risk Index (COHRI) that integrates meteorological data, site characteristics, and workforce vulnerability parameters for real-time risk scoring.
- Investigation of gender-differentiated climate-OHS impacts, given the presence of female contract labourers in the workforce and documented physiological differences in thermoregulatory capacity.
- Integration of Internet of Things (IoT) sensor networks and machine learning algorithms for predictive climate-OHS risk management in smart construction site contexts.
- Comparative study of OHS performance across different construction types — building construction, road works, and drainage works — under identical climate conditions, to develop sector-specific climate safety benchmarks.
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