International Labour Organization

Impacts of heat stress on jobs and productivity in Sri Lanka

Quantitative and qualitative employment estimates for evidence-based decision-making



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These studies are authored by Andreas D. Flouris, Leonidas G. Ioannou and Konstantinos Mantzios.

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1. Background

In 2015, the ILO Guidelines for a just transition towards environmentally sustainable economies and societies for all were adopted. The preamble of the Paris Agreement on climate change, also adopted in 2015, underscores close links between climate action, sustainable development and a just transition, with Parties to the Agreement "taking into account the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities". In 2023, the International Labour Conference adopted the Resolution concerning a just transition towards environmentally sustainable economies and societies for all, which endorsed the ILO Just Transition Guidelines as the central reference for policymaking and a basis for action. Ideally, any climate change policy process [such as the Nationally Determined Contributions (NDC), National Adaptation Plans (NAPs) or the Long-Term Low Emission Development Strategies, LT-LEDS] should be informed by an assessment of the employment impacts—both positive and negative—as well as an indication of the measures that will be taken to ensure a just transition for workers and enterprises drawing on the ILO Just Transition Guidelines and the 2023 ILC Resolution. Against this backdrop, it is crucial to evaluate how environment and climate policies affect job creation or destruction (particularly for women and youth), income distribution, skills development, and overall economic growth. Providing quantitative and qualitative employment estimates for evidence-based decision-making is essential for maximizing positive and mitigating or buffering negative social and employment outcomes.

Heat stress, exacerbated by rising global temperatures and more frequent heatwaves, poses a significant challenge to occupational safety and health (OSH). According to a recent report published by the International Labour Organization (ILO),[1] excessive heat impacts more than 70% of the global workforce, exposing over 2.41 billion workers annually to hazardous conditions. The consequences are profound, with heat stress contributing to approximately 22.85 million non-fatal injuries and 18,970 fatalities every year across the world.[1] The economic and productivity costs are equally alarming, as heat stress leads to billions of productivity losses and healthcare costs annually.[1] These losses undermine economic stability and exacerbate inequalities in jobs and/or regions with high exposure to excessive heat.

1.1. Scope of this study

The available evidence underlines the urgent need to integrate heat stress mitigation strategies into national and workplace OSH frameworks. As a result of the ILO's work with the Climate Vulnerable Forum, the present study builds on the available data to provide just transition input to Climate Prosperity Plans (CPPs). It evaluates the implications of heat stress in Sri Lanka's labour market and proposes evidence-based strategies to enhance worker safety and economic resilience. It also assesses employment data scenarios linked to green transitions and global warming, with a particular focus on productivity losses due to heat stress.

1.2. ILO in Sri Lanka

Sri Lanka is an island nation located in the Indian Ocean, just off the southeast coast of the Indian subcontinent (Figure 1). The country boasts a diverse geography, ranging from expansive coastal plains and sandy beaches to rugged central highlands and dense tropical forests. Its central plateau, characterized by cooler temperatures and mist-covered mountains, contrasts sharply with the warm, humid conditions of the coastal regions. This varied topography not only contributes to Sri Lanka's rich biodiversity but also underpins its agricultural and cultural heritage.

Sri Lanka has been grappling with a severe economic crisis since 2022, driven by deep-rooted structural issues which were exacerbated by external shocks, such as the COVID-19 pandemic and rising global commodity prices. The crisis has led to a sharp contraction of the economy, with GDP declining by approximately 9.5% over 2022

[1] ILO (2024). Heat at work: Implications for safety and health. A global review of the science, policy and practice. A. D. Flouris, M. Azzi, H. Graczyk, B. Nafradi and N. Scott. Geneva, Switzerland, International Labour Organization.

and 2023 due to shortages of essential goods, high inflation, and a steep depreciation of the Sri Lankan Rupee.[2] Public debt surged to unsustainable levels, reaching 119.2% of GDP in 2022. Inflation peaked at 46.4% that same year, while the local currency depreciated by over 80%, exacerbating the cost-of-living crisis. Consequently, poverty rates have doubled, with around 25% of the population now living below the international poverty line of $3.65 per day. Food insecurity and malnutrition have escalated as households struggle with declining incomes and rising costs of living.[3]

In response to the crisis, Sri Lanka has undertaken significant structural reforms, supported by international institutions such as the International Monetary Fund and the World Bank. These reforms include new fiscal measures, restructuring of state-owned enterprises, and efforts to improve debt management. Despite these efforts, the path to recovery remains challenging, with GDP projected to contract by 3.8% in 2023 before achieving modest growth of 1.7% in 2024. This outlook is highly dependent on the successful implementation of reforms and debt restructuring. The high levels of poverty and inequality present significant challenges to achieving inclusive growth.

Figure 1. Sri Lanka physical map.[3]



The ILO has been actively engaged in supporting Sri Lanka's efforts to stabilize its labour market and enhance social protection, especially in light of the recent economic crisis. The ILO's work in Sri Lanka includes technical assistance and policy advice aimed at promoting decent work and fair labour standards. Key ILO initiatives focus on strengthening occupational safety and health (OSH), supporting skills development, and improving labour rights for vulnerable groups, including informal workers and women. The ILO also collaborates with the Sri Lankan government to address child labour and enhance workplace safety, particularly as workers face additional risks related to economic hardship and environmental hazards.

As part of its mandate, the ILO has been working with national stakeholders to develop Decent Work Country Programmes that align with Sri Lanka's national development priorities. These programmes aim to foster job creation, enhance social protection systems, and promote equitable and sustainable economic growth. Through its collaboration with government agencies, employers, and trade unions, the ILO is helping to build resilience in Sri Lanka's labour market amid the current economic and environmental challenges.

Sri Lanka is also highly susceptible to climate change impacts and natural disasters,[4] with approximately 87% of the population living in areas considered moderate or severe climate hotspots. Projections indicate that by 2050, climate change could result in an annual GDP loss of up to 1.2% due to increasingly frequent and intense natural disasters.[4]

Until recently, the most frequent climate hazards were considered to be floods, droughts, landslides, storm surges, and cyclones.[4] However, the fact that Sri Lanka is one of the hottest countries in the world is often neglected. Also, in recent years, Sri Lanka has experienced a rise in average temperatures of about 0.8°C per decade, which is much higher than the global average.[5] This trend has led to more frequent and severe

[2] World Bank (2023). Sri Lanka Development Update. Mobilizing Tax Revenue for a Brighter Future. Washington DC, USA.
[3] The map was made using http://www.maps-for-free.com
[4] World Bank Group (2021). Sri Lanka Climate Change Action Plan. In: The South Asia Climate Roadmap 2021-2025. Washington DC, USA.
[5] Saeed F., Schleussner C., Ashfaq M. (2021). Deadly heat stress to become commonplace across South Asia already at 1.5°C of global warming. Geophysical Research Letters, 48(7). doi:10.1029/2020gl091191.

heatwaves, particularly affecting low-elevation areas from April to June.[5] Also, the number of days reaching "extreme heat caution" level is on the rise, posing significant risks to public health and labour productivity.[6]

Urban areas, such as Colombo, are especially vulnerable due to the urban heat island effect, where human activities and infrastructure contribute to higher temperatures compared to rural regions.[7] This exacerbates heat stress for urban populations and workers, highlighting the need for targeted adaptation strategies to mitigate the impacts of rising heat levels.

Climate adaptation initiatives, supported by both local and international organizations, aim to enhance Sri Lanka's resilience to these hazards. The government, with support from agencies like the World Bank, has implemented programs focused on climate-resilient infrastructure, water management, and community-based disaster preparedness. However, addressing climate risks remains critical to protecting both the economy and communities that are particularly susceptible to extreme weather.

In this context, addressing the labour market implications of climate policies—such as those aimed at reducing heat stress in workplaces—becomes even more urgent. It is vital to ensure a just transition that safeguards the rights and livelihoods of workers, particularly those in sectors such as agriculture and construction, where exposure to heat stress is high.

[6] Jayawardena I.M., Darshika D.W., Herath H.M. (2018). Recent trends in climate extreme indices over Sri Lanka. American Journal of Climate Change, 07(04), 586-599. doi:10.4236/ajcc.2018.74036.

[7] Simath S., Emmanuel R. (2022). Urban thermal comfort trends in Sri Lanka: the increasing overheating problem and its potential mitigation. Int J Biometeorol 66, 1865–1876. https://doi.org/10.1007/s00484-022-02328-9.

2. Current and future heat exposure and climate change

2.1. Current weather and climate overview

Sri Lanka has a tropical climate characterized by significant regional variation and two primary monsoon seasons: the Maha season, influenced by the northeast monsoon (September to March), and the Yala season, associated with the southwest monsoon (May to August). With an average temperature of around 27-28°C, Sri Lanka ranks among the hottest countries globally. In Colombo, the country's commercial capital, average temperatures range from 28°C to 29°C, with minimal monthly variation throughout the year. Daily maximum temperatures hover around 31°C year-round. Altitude is the primary factor affecting temperature variation across the country, with significantly cooler temperatures found in the south-central mountainous regions. Average annual temperatures in coastal and lowland areas range from 27°C to 28°C, while higher elevations in the central hill country, such as Nuwara Eliya, experience cooler temperatures, averaging around 15°C to 20°C.

2.2. Choice of environmental indicators

To characterize the prevailing environmental conditions for work in Sri Lanka, the present study used two key indicators: the monthly average maximum temperature and the monthly average maximum Wet-Bulb Globe Temperature (WBGT). The rationale for selecting these indicators and the specific time constant is provided below:

Air temperature: Temperature is the standard metric used by weather and climate experts when referring to general atmospheric conditions. However, the working environment is more complex, as it often involves additional factors such as high humidity, low wind, and exposure to thermal radiation from the sun or machinery. Consequently, air temperature alone does not fully capture the thermal stress experienced by workers.[8]

Wet-Bulb Globe Temperature (WBGT): The WBGT is the most widely adopted indicator by scientists and occupational health and safety professionals to assess heat stress in the workplace and its effects on health and productivity.[8,9,10,11] Unlike air temperature, the WBGT integrates several factors – air temperature, humidity, wind speed, and thermal radiation – to provide a more comprehensive measure of the heat load on the human body. Importantly, WBGT-based guidance takes into account work intensity and the use of personal protective equipment, making it especially useful for evaluating the risk of heat-related illnesses in occupational settings.

A recent series of large-scale multi-country evaluations of all the available indicators found that the WBGT is the most effective for evaluating the risk of heat-related illnesses for people who work in the heat.[8,12,13,14] A recent ILO analysis of legislation from countries across the world found that the WBGT is the most widely-used indicator of heat stress in the workplace.[1] Due to its strengths, the WBGT has been recommended by a number of national

[8] Ioannou L.G., Tsoutsoubi L., Mantzios K., et al. (2022). Indicators to assess physiological heat strain - Part 3: Multi-country field evaluation and consensus recommendations. Temperature; 9(3): 274-291.
[9] NIOSH, Criteria for a recommended standard: occupational exposure to heat and hot environments, B. Jacklitsch, et al., Editors. 2016, Centers for Disease Control and Prevention. National Institute for Occupational Safety and Health. U.S. Department of Health and Human Services: Cincinnati, OH, USA.
[10] ISO, ISO 7243:2017 — Ergonomics of the thermal environment - Assessment of heat stress using the WBGT (wet bulb globe temperature) index. 2017, International Organization for Standardization: Geneva, Switzerland.
[11] ACGIH, Heat stress, TLVs and BEIs: threshold limit values for chemical substances and physical agents & biological exposure indices, ACGIH, Editor. 2020, ACGIH: Cincinnati.
[12] Ioannou L.G., Mantzios K., Tsoutsoubi L., et al. (2022). Indicators to assess physiological heat strain - Part 1: Systematic review. Temperature; 9(3): 227-262.
[13] Ioannou L.G., Dinas P.C., Notley S.R., et al. (2022). Indicators to assess physiological heat strain - Part 2: Delphi exercise. Temperature; 9(3): 263-273.
[14] Flouris A.D., Ioannou L.G., Nybo L. (2022). Working in a warming world: Translating thermal physiology to policy-relevant information. Temperature; 9(3): 223-226.

and international organizations for assessing heat stress including the ILO, the World Health Organization, and the World Meteorological Organization.[1,15] Detailed information regarding the methods used to estimate WBGT can be found in Annex 1.

Health and physical impacts of rising WBGT: As WBGT values increase, the human body experiences greater difficulty in dissipating heat, which can lead to a range of adverse effects. Elevated WBGT levels can cause:

- **Reduced physical performance:** Increased heat stress slows down movement and reduces overall work capacity, as the body prioritizes cooling over physical exertion.[16]
- **Cardiovascular strain:** The heart works harder to pump blood to the skin for cooling, which can lead to increased heart rate and long-term cardiovascular stress.[17]
- **Fatigue and cognitive impairment:** Higher WBGT levels are associated with quicker onset of fatigue and reduced cognitive function, impacting decision-making and coordination.[1,18,19]
- **Heat-related illnesses:** Prolonged exposure can result in dehydration, heat cramps, heat exhaustion, or even heat stroke, especially in high-intensity work environments.[1,17] Working in a hot environment for a significant part of the year can lead to acute/chronic kidney injury.[1,17]

Choice of time constant: The present analysis employs the monthly average maximum values for both temperature and WBGT because these values are typically observed between 12:00 and 14:00 – the period when most workers are active. This approach ensures that the indicators accurately represent the most challenging conditions encountered during the workday.

2.3. Current heat and environmental conditions

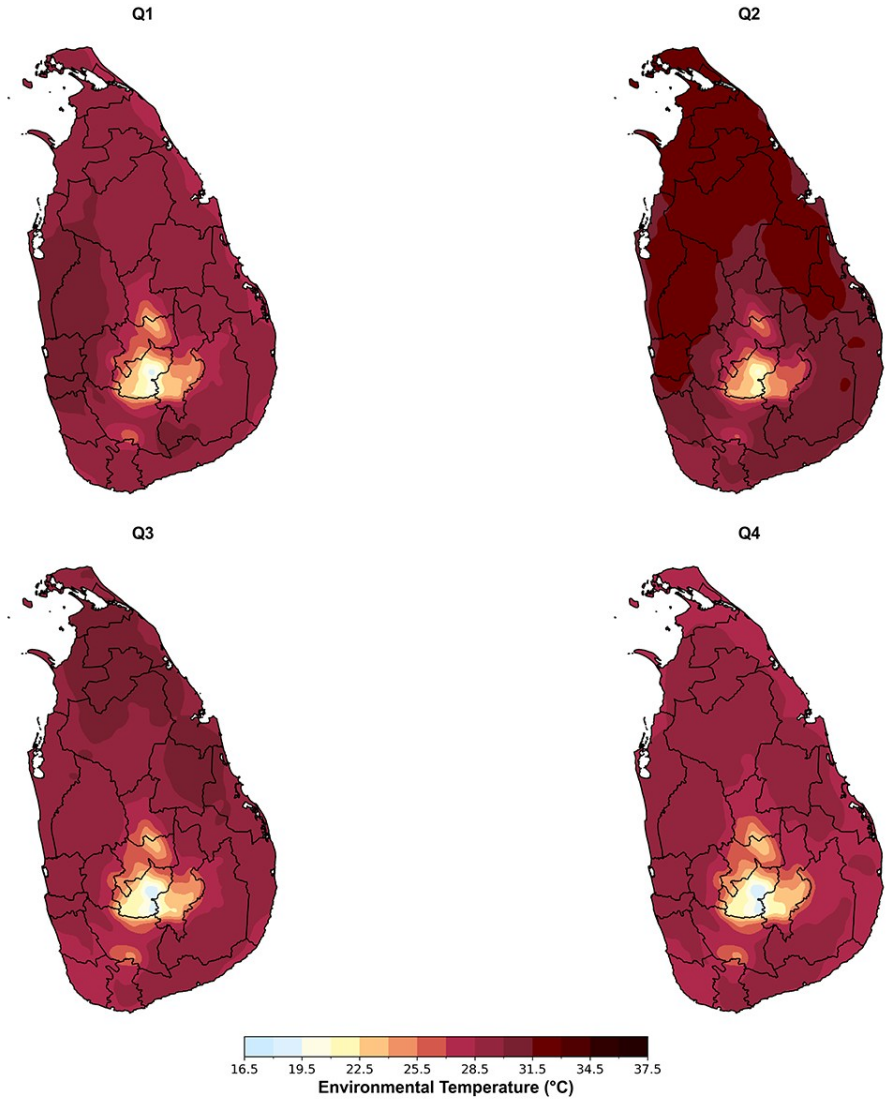
Figure 2 illustrates the quarterly average maximum environmental temperatures across Sri Lanka. The following patterns emerge:

Seasonality

- **Q2** is the hottest quarter nationwide. Most lowland districts sit in the 31-35 °C band, with very few areas below 30 °C.
- **Q1** is already hot across the plains, though a little milder than Q2.
- **Q3** remains hot over almost all lowlands with only small pockets of relief, so the mid-year monsoon does not translate into a strong daytime cooling of maximum temperatures.
- **Q4** shows the broadest moderation of the year, but large parts of the north and east still record maxima near or above 30 °C.

[15] World Health Organization and World Meteorological Organization (2025). Climate change and workplace heat stress: technical report and guidance. Geneva, Switzerland.
[16] Ioannou L.G., Foster J., Morris N.B., et al. (2022). Occupational heat strain in outdoor workers: A comprehensive review and meta-analysis. Temperature; 9(1): 67-102.
[17] Flouris A.D., Dinas P.C., Ioannou L.G., Nybo L., Havenith G., Kenny G.P., Kjellstrom T. (2018). Workers' health and productivity under occupational heat strain: a systematic review and meta-analysis. Lancet Planetary Health; 2(12): e521-e531.
[18] Flouris A.D. (2019). Human thermoregulation. in: Périard J., Racinais S., eds. Heat stress in sport and exercise: Springer.
[19] Flouris AD, Schlader ZJ. (2015). Human behavioral thermoregulation during exercise in the heat. Scandinavian Journal of Medicine and Science in Sports; 25 (S1): 52-64.

Figure 2. Quarterly average maximum environmental temperature across Sri Lanka during the reference historical period (1985-2014).



Spatial patterns

- The central highlands remain cool throughout the year. Quarterly maxima there mostly fall in the 19-26 °C range, reflecting elevation. This sharp temperature gradient between highlands and surrounding regions remains stable across all quarters.
- The coastal and interior lowlands are persistently hot in all quarters.
- The north, east and south-east are the most consistently warm zones, while the southwest is slightly less hot in Q3-Q4.

Implications for labour and OSH planning

- Plan for the highest occupational heat risk in Q2 across all lowland districts, with the rest of the year also requiring strong controls in outdoor and high-exertion work. While Q4 may offer some relief, many lowland areas still face high temperatures that will put workers at risk.
- Focus protection on the lowlands, as the central highlands provide the only consistent thermal relief for heat-exposed tasks.
- Urban centres and coastal hubs should expect added heat from built-up surfaces and low wind, so site-level monitoring is needed even when district averages suggest only modest change.

Figure 3 illustrates the quarterly average maximum WBGT across Sri Lanka. WBGT is an important measure of heat stress, taking into account not only temperature but also humidity, wind speed, and solar radiation, which makes it particularly useful in assessing the risk of heat stress for working people. The following observations were made:

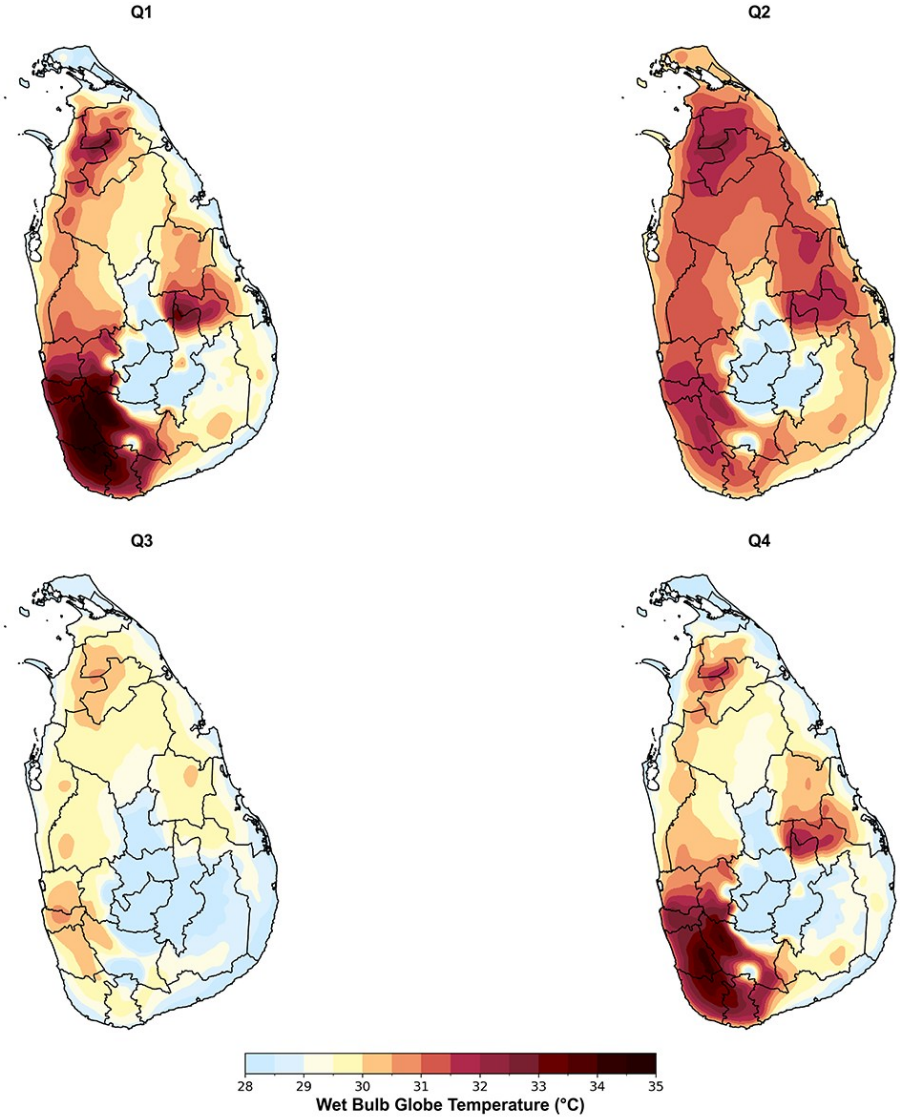
Seasonality

- **Q1** is already hot and humid for much of the country. The southwest low-country is the highest-risk area, with WBGT in the extreme 32-35°C range. Central highlands remain markedly lower.
- **Q2** shows the broadest and most intense heat stress of the year. WBGT rises across almost all lowland districts, with many coastal and inland plains in the 31-34°C band while the hill country remains cooler.
- **Q3** brings the clearest relief. Most regions shift into the 28-31°C range, especially the south and east, reflecting monsoon cloud cover and ventilation. Cooler pockets expand over the interior and around the highlands.
- **Q4** sees a rebound. Heat intensifies again in the southwest and along parts of the west and east coasts, while the central highlands and the southeast lowlands remain cool.

Spatial patterns

- A persistent elevation gradient is visible. The central highlands form a cool core in every quarter, surrounded by warmer lowlands.
- The southwest coastal-inland belt is the most consistently hot zone, peaking in Q1 and Q2 and returning in Q4.
- Northern and northwestern plains are warm in Q1-Q2, moderate in Q3, and mixed in Q4. Eastern districts swing from high WBGT in Q2 to lower values in Q3, then warm again in Q4.
- Island-wide, the highest WBGT occurs in low-lying, humid areas, while higher terrain and areas influenced by monsoon cloud show lower stress.

Figure 3. Quarterly average maximum WBGT across Sri Lanka during the reference historical period (1985-2014).



Implications for labour and OSH planning

- Plan for the highest occupational heat risk in Q2 across nearly all lowland districts, and in Q1 and Q4 for the southwest belt. At WBGT above about 32°C, continuous moderate or heavy work is unsafe without strong controls.
- Q3 offers some relief, but it is crucial to keep protections in place for specific hot pockets.
- Prioritise WBGT-based management rather than air temperature alone, as it is better suited to identify hotspots. Apply work-rest cycles, earlier shifts, shaded and ventilated rest areas, reliable hydration, and task rotation, with stricter measures in the southwest low-country and other coastal plains.
- Maintain site-level monitoring in urban centres and ports where low wind, paved surfaces, and crowding can elevate WBGT above surrounding areas.
- For outdoor agriculture, construction, and transport, align schedules with the seasonal pattern shown in these maps, and provide additional protections for workers in districts that regularly exceed 31-32°C WBGT in Q1, Q2, and Q4.

2.3.1. Findings from comparing temperature against WBGT

When comparing the maps showing environmental temperature against those illustrating the WBGT, the following key insights emerge:

Seasonality

- **Environmental temperature** is warm across most lowlands in every quarter. Q2 is the hottest island-wide, Q1 and Q4 remain very warm, while Q3 is relatively cooler but many lowlands still show maxima near 30-33°C. The central highlands stay markedly cooler all year, often 20-26°C.
- **WBGT** shows a much sharper seasonal cycle than temperature. Q2 shows island-wide peak, with most lowland districts near 31-34 °C WBGT. Q1 and Q4 are characterized by strong south-west and southern coastal hotspots reaching 33-35°C despite only moderate air temperatures. The broadest relief is observed during Q3, with much of the island falling to 28-30°C WBGT because of monsoon cloud and ventilation.

Overall, temperature suggests persistently hot conditions year-round, whereas WBGT reveals a pronounced risk peak in Q2 and secondary peaks in Q1 and Q4 on the south-west/south coasts, with true seasonal relief in Q3 that the temperature maps underplay.

Spatial patterns

- **Environmental temperature** is dominated by elevation. The central highlands form a cool core in all quarters, while coastal and interior lowlands are consistently warm to hot.
- **WBGT** is shaped by monsoon exposure, humidity, wind and sun. Q1 and Q4 show the highest WBGT along the south-west and southern lowlands (e.g., Gampaha-Colombo-Kalutara-Galle-Matara-Hambantota belt). In Q2, the high WBGT expands across most coasts and interior, not just the west. The highlands remain the most favorable WBGT pocket in every quarter.

Taken together, the spatial patterns indicate that, where elevation cools the air, it also lowers WBGT. But coastal humidity and weak winds can turn moderate temperature into high heat stress, a pattern most visible in the south-west in Q1 and Q4.

Key divergences between temperature and WBGT

- **Q1:** Temperature is at “moderate heat” levels in most regions, yet WBGT spikes to extreme 33-35°C in the south-west. Humid, low-wind conditions drive risk that temperature alone would miss.
- **Q2:** Both indices are high across most of the country, but WBGT shows severe heat stress in certain hotspots that temperature misses.
- **Q3:** Temperature still shows hot lowlands, primarily in the north, while WBGT drops to 28-30°C over large areas due to monsoon cloud cover and ventilation. Temperature alone would overstate risk during this quarter.
- **Q4:** Temperature moderates but WBGT again highlights south-west and southern hotspots, indicating persisting physiological stress late in the year.

The above suggests that the WBGT is a better decision metric for worker protection, especially in Q1 and Q4 when humidity and radiation amplify heat stress without extreme air temperatures.

Implications for labour and OSH planning

- **High-risk windows:** The primary is during Q2 (nationwide), while secondary windows are in Q1 and Q4 for south-west and southern lowlands. Localized hotspots also appear on the east coast.
- **Lower risk window:** Q3 across much of the island, especially outside the far south-west.
- **Priority locations:** Adaptation efforts should be strengthened in Colombo, Gampaha, Kalutara, Galle, Matara, Hambantota, and other coastal lowlands in Q1/Q4, and island-wide in Q2.

Operational guidance

- Use WBGT thresholds to trigger controls, not air temperature alone.
- In high-risk quarters/areas: adopt earlier work starts, longer mid-day breaks, task rotation, water-rest-shade, and ventilation/cooling for indoor and vehicle-based work.
- Plan seasonal work programs around the Q3 window where feasible, while retaining WBGT monitoring for local spikes.

In conclusion, air temperature maps and forecasts describe where it is hot. WBGT maps and forecasts show where workers' bodies face the highest physiological strain. For Sri Lanka, that strain peaks during Q2 across most regions and returns in Q1 and Q4 along the south-west and southern coasts. Policy and workplace protections should be timed and targeted accordingly.

2.4. Climate projections

2.4.1. Country overview

Sri Lanka's tropical climate, defined largely by two monsoon seasons and high humidity, underpins the country's agricultural output, energy production, infrastructure development, and public health outcomes.[20,21] Sri Lanka's key industries – agriculture, fisheries, tourism, and manufacturing – are closely tied to climate patterns and are increasingly strained by extreme weather and shifting climate conditions:

- **Agriculture:** Agriculture remains a vital sector, employing about a quarter of the workforce and contributing about 8% of GDP.[22,23] Rice is the major food crop grown in two main seasons (Yala from May-August and Maha from September-March) aligned with the monsoons.[21] This reliance on seasonal rains makes farming highly vulnerable to climate variability.[21] In recent years, delayed or irregular monsoon rains and longer dry spells have disrupted planting schedules and reduced yields.[21] Higher temperatures are also projected to suppress crop productivity. For example, rising heat could put downward pressure on rice yields, threatening national food security.[21] Droughts and floods already cause significant agricultural losses. A severe drought during 2016-2017 heavily affected 17 districts, undermining farmers' livelihoods and jeopardizing the rice-based food system.[24] Such climate shocks have left hundreds of thousands of rural households food-insecure in affected years, illustrating the sector's sensitivity to climate conditions.[25]
- **Fisheries:** The fisheries sector is another climate-sensitive industry, providing livelihoods for coastal communities and contributing to diets and exports. It directly and indirectly supports about 3.6 million people (roughly 17% of the population).[26] Marine and inland fisheries are heavily impacted by changes in the climate.[27] Warming ocean temperatures and coral reef degradation (from ocean warming and bleaching events) affect fish breeding grounds and stocks, potentially reducing catches available to

[20] UN Sri Lanka (2023). Climate impact - Sri Lanka. United Nations: Colombo, Sri Lanka.
[21] The World Bank Group and the Asian Development Bank (2021). Climate Risk Country Profile: Sri Lanka. The World Bank Group, Washington, DC.
[22] Statista.com. Sri Lanka: Distribution of employment by economic sector from 2013 to 2023. https://www.statista.com/statistics/728543/employment-by-economic-sector-in-sri-lanka. Accessed: 12/12/2024.
[23] International Trade Administration (2024). Sri Lanka - Country Commercial Guide: Agricultural Sector. U.S. Department of Commerce. https://www.trade.gov/country-commercial-guides/sri-lanka-agricultural-sector. Accessed: 12/12/2024.
[24] Copernicus (2017). Drought Surveillance in Sri Lanka. Copernicus Global Land Service Use Case. https://www.copernicus.eu/en/use-cases/drought-surveillance-sri-lanka. Accessed: 12/12/2024.
[25] Global Justice Program (2024). Climate Crisis, Displacement, and the Right to Stay. Othering and Belonging Institute, UC Berkeley. https://belonging.berkeley.edu/climatedisplacement/case-studies/sri-lanka. Accessed: 12/12/2024.
[26] World Bank (2021). Priorities for sustainably managing Sri Lanka's fisheries, coastal aquaculture, and the ecosystems that support them. Washington, DC.
[27] United Nations - Sri Lanka (2023). Turning the tide: charting a sustainable future for Sri Lanka's fisheries. Colombo, Sri Lanka. https://srilanka.un.org/en/253345-turning-tide-charting-sustainable-future-sri-lanka%E2%80%99s-fisheries. Accessed: 12/12/2024.

fishers. Altered monsoon wind patterns and more frequent storms can make fishing at sea more dangerous and unpredictable. Fishers face damage or loss of boats and gear during storms, and rough seas often force days-long interruptions in fishing activity.[28,27] These challenges threaten the sustainability of fish harvests and the income of fishing communities.[27] The government and agencies have noted that climate change poses a long-term threat to the marine environment and fishery livelihoods, calling for adaptation measures in this sector.[27]

- **Tourism:** Tourism is a major economic driver for Sri Lanka, and it too is vulnerable to climate variability and extremes.[21] A large portion of Sri Lanka's tourism is nature-based (beaches, coral reefs, wildlife, and scenic landscapes), all of which are sensitive to climate conditions. Beach erosion and coastal flooding caused by sea-level rise and stronger monsoon surges can damage beachfront hotels, resorts, and roads, directly impacting tourist areas. Indeed, coastal tourism infrastructure is already affected by rising sea levels and erosion.[29] Coral bleaching episodes linked to higher sea temperatures can degrade coral reefs (e.g., in the Pasikudah or Hikkaduwa areas), reducing the appeal of Sri Lanka's dive sites. Extreme weather events such as cyclonic storms, heavy rains, or landslides in hill country can disrupt travel plans, damage heritage sites, and deter visitors. For example, flooding or landslides in popular destinations have in the past led to tour cancellations and costly repairs. Overall, climate change introduces significant threats to the future of tourism through rising temperatures, extreme events, and environmental degradation,[30] potentially reducing tourist arrivals and earnings if adaptive actions are not taken.
- **Manufacturing:** Manufacturing (including agro-processing, textiles/garments, and light industry) contributes about 25% of GDP,[31] and while it is less directly weather-dependent, it still faces climate-related disruptions. Many industrial zones and factories are located in low-lying or coastal areas (for access to ports and cities), making them susceptible to floods and storms. Intense rainfall events have caused flooding of industrial areas. For instance, the May 2016 floods around Colombo inundated factories and warehouses, damaging equipment and inventory.[32] In that disaster, many manufacturing firms had to halt production for days to weeks, resulting in output losses and missed export orders. More broadly, climate disasters can damage infrastructure and machinery, leading to costly downtime in production.[33] Additionally, manufacturing depends on reliable power and water supplies. Droughts can diminish hydropower generation and water availability for industrial processes, leading to electricity shortages or rationing that hamper factory operations.[34] Extreme heat is another concern. While many larger factories are indoor and can mitigate heat, smaller workshops may see reduced worker efficiency on very hot days. Thus, even in manufacturing, climate conditions (especially extreme events) pose risks to stability and productivity.

Detailed climate change trends against natural variability are illustrated in Figure 4. The available evidence reveals a consistent upward trend in temperatures (Figure 4, top left graph) as well as that warming has become

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[28] SLYCAN Trust (2020). Climate Risk Management and Risk Transfer in Sri Lanka's Fisheries Sector. https://www.slycantrust.org/blog-posts-knowledge/climate-risk-management-and-risk-transfer-in-sri-lankas-fisheries-sector. Accessed: 12/12/2024.

[29] Buultjens J., Ratnayake I., Gnanapala W.K.A. (2017). Case Study Sri Lanka: Climate change challenges for the Sri Lankan tourism industry. In: Jones A., Phillips M. (eds) Global climate change and coastal tourism: recognizing problems, managing solutions and future expectations. pp. 200-211. CAB International, Wallingford, UK.

[30] Arachchi T.L. (2024). The impact of climate change on the tourism sector. SLYCAN Trust. https://www.slycantrust.org/post/the-impact-of-climate-change-on-the-tourism-sector. Accessed: 22/12/2024.

[31] Statista.com. Sri Lanka: Share of economic sectors in the gross domestic product (GDP) from 2013 to 2023. https://www.statista.com/statistics/728539/share-of-economic-sectors-in-the-gdp-in-sri-lanka. Accessed: 19/2/2025.

[32] Alianza Cooperativa International (2016). Appeal for support after May 2016 Sri Lanka floods. Brussels, Belgium. https://ica.coop/es/media/news/appeal-support-after-may-2016-sri-lanka-floods. Accessed: 22/12/2024.

[33] Arachchi T.L. (2024). Building Flood Resilience in Sri Lanka's Fashion and Apparel Sector: Insights from Biyagama. SLYCAN Trust. https://slycantrust.org/post/building-flood-resilience-in-sri-lankas-fashion-and-apparel-sector-insights-from-biyagama. Accessed: 22/12/2024.

[34] Hirji R., Nicol A., Davis R. (2017). South Asia climate change risks in water management. World Bank, Washington, DC. International Water Management Institute, Colombo, Sri Lanka.

more pronounced in Sri Lanka during the recent decades (particularly in the period 2005-2014) and during January-February as well as July-November (Figure 4, top right graph). In addition, the available evidence illustrates a shift in the distribution of average mean surface air temperatures in Sri Lanka in the 30-year period until 2014 (Figure 4, bottom left graph), as well as an increasing frequency and intensity of extreme temperature events (Figure 4, bottom right graph).

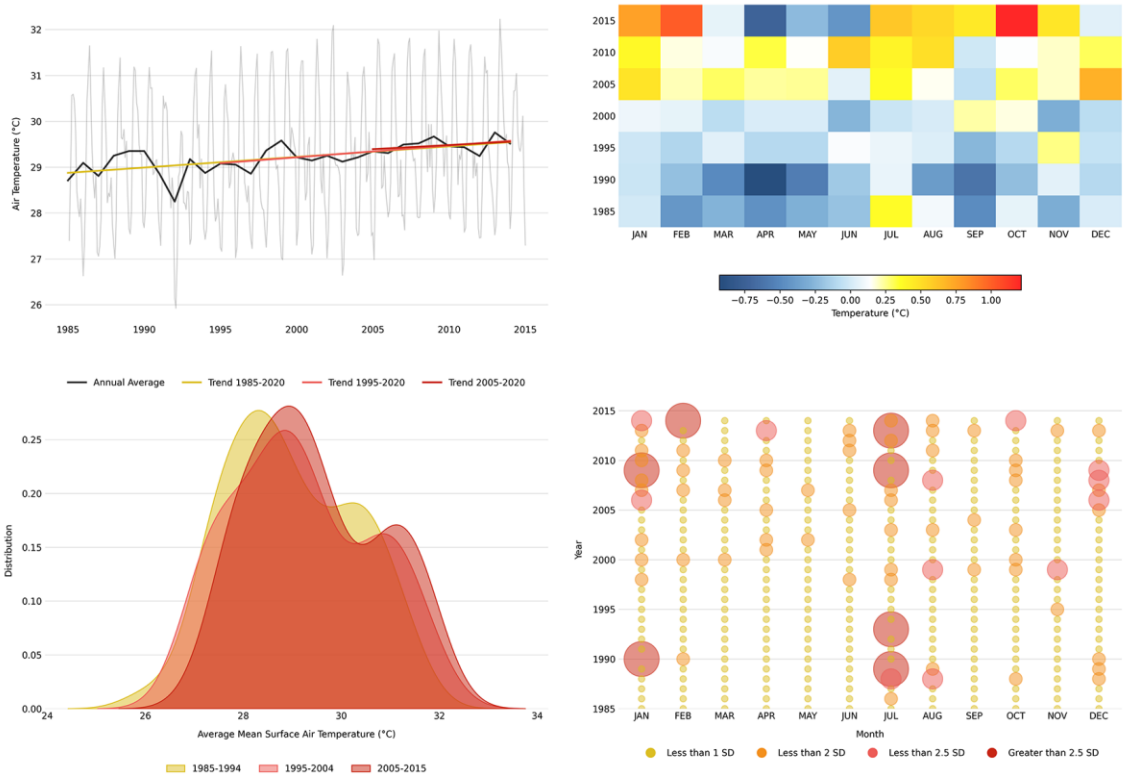
Collectively, the available evidence demonstrates a clear and accelerating warming trend in Sri Lanka in the 30-year period until 2014:

- Average maximum temperatures have increased significantly, as indicated by the rising annual temperatures over recent decades.
- The occurrence and intensity of extreme temperature events, particularly in the warmer months, have grown substantially since 2010.
- Monthly temperature trends reveal that warming is not limited to specific seasons but it occurs almost the entire year, except, perhaps, the period April-June.
- The trends highlight the growing impact of climate change in Sri Lanka, posing significant challenges to the environment, economy, and public health.

Taken together, these findings emphasize the urgent need for adaptive measures to address rising temperatures and extreme heat events, particularly given the Sri Lanka's vulnerability to climate change and its dependence on sectors such as tourism, which are highly sensitive to climatic variations.

The economic impact of climate change will not be uniform across Sri Lanka, with rural and low-income communities likely facing disproportionate challenges. Sectors such as agriculture, fisheries and tourism, which are central to Sri Lanka's economy, are particularly exposed to climate risks. The projected increase in extreme weather events, such as heatwaves, intense rains, and droughts, threatens to disrupt these sectors, potentially impacting employment and income for a significant portion of the population.

Figure 4. Climatological averages and trends of change against natural climate variability in Sri Lanka during the period 1985-2015: average mean surface air temperature with linear trend lines per decade (top left); average mean surface air temperature monthly trends (top right); change in distribution of average mean surface air temperature (bottom left); change in intensity of extreme daily maximum temperature events (bottom right).



2.4.2. Climate change scenarios

To understand how future heat conditions might affect work in Sri Lanka, the present study uses four "storylines" known as Shared Socioeconomic Pathways (SSPs). These scenarios were used by the IPCC Sixth Assessment Report[35] to describe different ways our society might evolve based on our choices about energy use, technology, and environmental policies. The scenario characteristics are summarized in Table 1.

Following standard practice,[35] the present analysis uses specific codes that combine the SSP number with an expected level of greenhouse gas influence – measured as radiative forcing in watts per square meter (W/m^2) – by the year 2100. The radiative forcing level indicates the strength of the warming effect observed at the end of the century, resulting in the following codes: SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5.

It is important to note that there are several other SSPs and radiative forcing combinations available.[35] However, the present study focuses only on these four scenarios because they represent a wide range of potential futures – from a highly sustainable pathway to one that relies heavily on fossil fuels – and provide clear contrasts in terms of expected climate impacts. This selection helps illustrate the range of possible outcomes in a straightforward manner while keeping the analysis accessible and focused.

[35] IPCC (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. V. Masson-Delmotte, P. Zhai, A. Pirani et al. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Intergovernmental Panel on Climate Change.

What are the SSPs?

The SSPs are narratives used by climate scientists to explore how different levels of greenhouse gas emissions might impact our world. In simple terms, they help us imagine a range of possible futures: from a sustainable world with clean energy to one that continues heavy use of fossil fuels.

The four scenarios of the future considered in the present study are as follows:

- **SSP1 – Sustainability (Taking the Green Road):** In this scenario, countries work together to adopt clean energy and sustainable practices. As a result, global warming is limited, with temperature increases by the year 2100 of about 1.3°C to 2.4°C above pre-industrial levels. The "2.6" added next to the SSP1 code indicates that the warming influence (radiative forcing) is expected to reach roughly 2.6 W/m^2 by 2100.

  On the development front, the world in this scenario shifts gradually, but steadily, toward a more sustainable path, characterized by more inclusive development and a respect for environmental issues. Investments in education, health, and social protection accelerate the demographic transition, while policy reforms internalise environmental costs and improve stewardship of global commons. Economic objectives broaden from pure GDP growth to human-well-being; material consumption grows slowly and becomes markedly less resource- and energy-intensive. As a result, both inter- and intra-country inequality decline.

- **SSP2 – Middle of the Road:** This scenario follows current trends with moderate improvements in technology and environmental policies. This results in a moderate temperature rise of approximately 2.1°C to 3.5°C by the year 2100. The "4.5" added next to the SSP2 code means the radiative forcing is projected to be around 4.5 W/m^2 by 2100.

  The socio-economic and technological trends in this scenario largely continue along the historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others perform below expectations. Moderate population growth levels off after mid-century and resource efficiency improves gradually, yet progress toward the Sustainable Development Goals (SDGs) is uneven. Environmental pressures ease in some areas but persist in others; vulnerability to shocks remains significant where institutions are weak. Income inequality persists or marginally improves, while the challenges for addressing vulnerability to societal and environmental changes persist.

- **SSP3 – Regional Rivalry (A Rocky Road):** In this pathway, countries tend to prioritize national interests over international cooperation, leading to slower progress on clean technologies and climate policies. This scenario could lead to higher warming of about 2.8°C to 4.6°C, due to a radiative forcing level near 7.0 W/m^2 by 2100, which is reflected in the SSP3 code used in the present study.

  In this scenario, geopolitical fragmentation, resurgent nationalism and concerns over security lead countries to prioritise domestic or, at most, regional self-sufficiency. Countries prioritize achieving energy and food security goals within their own regions at the expense of broader-based development. Trade barriers rise and investment in education, technology and cross-border cooperation declines. Economic development is slow, consumption is material-intensive, inequalities persist or worsen (particularly in emerging economies), and environmental degradation accelerates in several regions. Population growth stagnates in industrialized but rises fast in developing countries.

- **SSP5 – Fossil-Fueled Development (Taking the Highway):** This future envisions rapid economic growth powered largely by fossil fuels, with limited efforts to limit emissions. This pathway may lead to the highest warming, with temperature increases exceeding 5°C by the year 2100. The "8.5" added next to the SSP5 code reflects an expected radiative forcing of approximately 8.5 W/m^2 by 2100.

Integrated global markets and robust institutions foster technological breakthroughs in this scenario. There are also strong investments in health, education, and institutions to enhance human and social capital. The strong faith in markets and innovation drives rapid economic expansion and rising living standards. These factors lead to rapid global economic growth, while global population peaks and declines by the end of the century. However, growth is powered by abundant fossil fuels and energy-intensive lifestyles. Local environmental issues such as air pollution are successfully managed, and confidence grows in large-scale technological fixes, including potential geo-engineering.

Table 1. Characteristics of the global SSPs used in the present study.

SSP	Scenario	Estimated warming (2041-2060)	Estimated warming (2081-2100)	Very likely range in °C (2081-2100)
SSP1-2.6 (Sustainability Pathway)	**Low GHG emissions** CO_2 emissions cut to net zero around 2075	1.7	1.8	1.3 – 2.4
SSP2-4.5 (Middle of the Road Pathway)	**Intermediate GHG emissions** CO_2 emissions around current levels until 2050, then falling but not reaching net zero by 2100	2.0	2.7	2.1 – 3.5
SSP3-7.0 (Regional Rivalry Pathway)	**High GHG emissions** CO_2 emissions double by 2100	2.1	3.6	2.8 – 4.6
SSP5-8.5 (Fossil-fueled Development Pathway)	**Very high GHG emissions** CO_2 emissions triple by 2075	2.4	4.4	3.3 – 5.7

Note: Detailed information for the methods used to calculate the SSPs-related analyses can be found in Annex 1.

Key: GHG = greenhouse gas.

The IPCC Sixth report does not estimate the likelihood of the four tested scenarios. The rise in heat levels will depend on which mitigation pathway and policies countries collectively and independently pursue.[35]

The tested SSPs are not predictions but rather tools that help explore a range of possible futures. By comparing these outcomes, the present study illustrates how different policy and economic choices today could influence the working conditions and heat stress risks in Sri Lanka tomorrow.

Implications of SSPs for labour markets and policy interventions

From an ILO standpoint, the SSPs highlight differing socioeconomic and governance contexts that affect labour markets. For instance, SSP1's focus on sustainability and equity could spur the creation of green jobs and improved working conditions, while SSP3's emphasis on regional rivalries and weak collaboration might hamper labour standards and stifle investment in social protection. SSP5 suggests robust economic growth but continued dependency on fossil fuels, which could raise long-term occupational risks in certain industries.

Combining the SSPs with different greenhouse gas concentration trajectories allows for comprehensive assessments of future risks and opportunities. The SSPs are used to test labour policies, design social protection measures, and plan for just transitions to low-carbon industries. By anticipating how diverse SSPs shape workforce needs and climate challenges, stakeholders can develop strategies that safeguard workers' well-being and promote sustainable and inclusive growth.

Connecting global SSPs to national strategies for Sri Lanka

While the SSPs are developed as global scenarios, they provide critical insights for national decision-makers, including those in Sri Lanka. These scenarios illustrate how different paths in energy use, economic growth, and policy decisions could shape the climate and, consequently, the environmental conditions that affect daily life and work. For Sri Lanka, the varying outcomes depicted by the SSPs – ranging from sustainable pathways with limited warming (SSP1-2.6) to fossil-fueled development leading to severe warming (SSP5-8.5) – are directly linked to the country's future labour conditions, economic stability, and public health.

By considering these global SSPs, Sri Lankan policymakers can better understand the potential risks and opportunities that different climate futures may bring. For instance, adopting policies aligned with a more sustainable scenario (e.g., SSP1-2.6) could help mitigate the severity of heat stress, protect worker health, and reduce economic losses from reduced productivity. Conversely, inaction or insufficient adaptation measures (e.g., SSP5-8.5) may expose Sri Lanka to extreme heat conditions, with significant repercussions for labour productivity and overall economic resilience. In essence, the global SSPs are not abstract projections. They serve as practical tools that inform national strategies, enabling Sri Lanka to tailor its climate adaptation and economic policies to protect its citizens and secure a more stable, sustainable future.

2.4.3. Future heat conditions

The monthly maximum average environmental temperature and WBGT during the reference historical period (1985-2014) ranged between 28°C and 30°C (Figure 5). Across all SSPs, the analysis suggests a clear warming trend, with varying degrees of severity depending on the scenario. Even in the most optimistic scenarios (SSP1-2.6 and SSP2-4.5), Sri Lanka will face increases of 2°C environmental temperature and WBGT. The scenarios with high emissions (SSP3-7.0 and SSP5-8.5) suggest more significant warming of up to 6°C environmental temperature and 5°C WBGT. Without effective adaptation strategies, these would lead to significant health impacts and severely reduce the capacity to perform manual labour.

Figure 5. Average maximum environmental temperature (top) and WBGT (bottom) with 95% confidence intervals in the reference historical period (1985-2014) and until 2100 across the different SSPs.

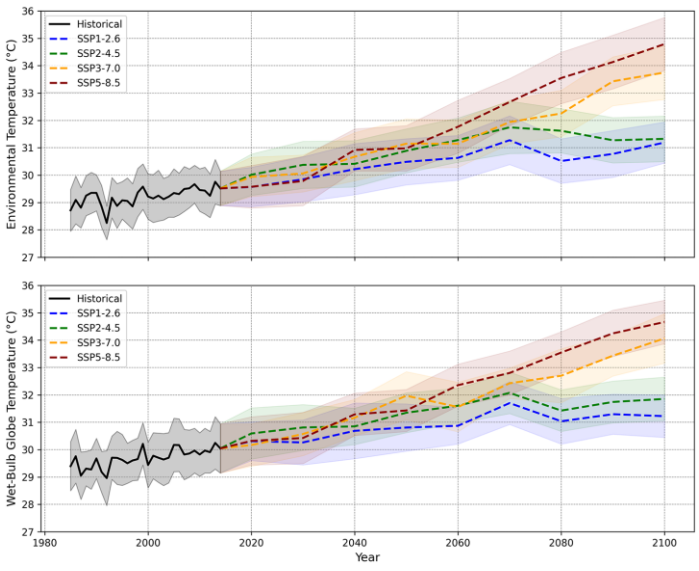


Figure 6 illustrates the change in environmental temperature compared to the reference historical period across the different SSPs and at different time points until the end of the century. According to SSP1-2.6, there will likely be a moderate temperature increase by 2040, generally around 0.5°C to 1°C. By 2080, the temperature increases could reach 1.5°C across most of Sri Lanka, while, by 2100, rises of up to 2.5°C are expected in many parts of the country. Based on the SSP2-4.5, a more significant increase in temperature is expected by 2060 with temperature rises of up to 2°C in southern areas, and smaller increases of 2°C in the north of the country. As global action on emissions reduction is slower in this pathway, these temperature increases will spread throughout the country by the end of the century. According to the SSP3-7.0, a more significant temperature rise of 2°C to 2.5°C is anticipated in many areas by 2060. After 2080, Sri Lanka could face severe temperature rises, with much of the country experiencing increases of up to 5°C, which would have significant impacts on water resources, agriculture, and heat stress. According to the SSP5-8.5, the initial temperature rise will be around 2°C across the country. With continued fossil fuel use and unchecked emissions (assumed in this scenario), Sri Lanka will see a substantial rise in temperatures, reaching 4°C to 4.5°C by 2080. By the end of the century, this pathway projects Sri Lanka's

temperatures increasing by 6°C across all regions. This would represent severe climate impacts, including unmanageable heatwaves, water shortages, and disruptions to daily life and agricultural systems.

The change in WBGT compared to the reference historical period across the different SSPs and at different time points until the end of the century is illustrated in Figure 7. The results follow closely those for environmental temperature, which are discussed above. In brief, across all scenarios, the analyses suggest a clear warming trend, with varying degrees of severity depending on the SSP. Even in the most optimistic scenario (SSP1-2.6), Sri Lanka will face WBGT increases of 2°C in many regions by 2100. Without strong climate mitigation (i.e., SSP3-7.0 and SSP5-8.5), by the end of the century, Sri Lanka could see WBGT rises of over 5.5°C, which would lead to significant heat-health impacts as well as drastic reductions in the capacity to perform manual labour. These projections underscore the importance of implementing adaptation strategies to mitigate the impacts of rising heat levels in Sri Lanka.

Figure 6. Change in the average maximum environmental temperature in Sri Lanka compared to the reference historical period (1985-2014) across the different SSPs and at different time points during this century.

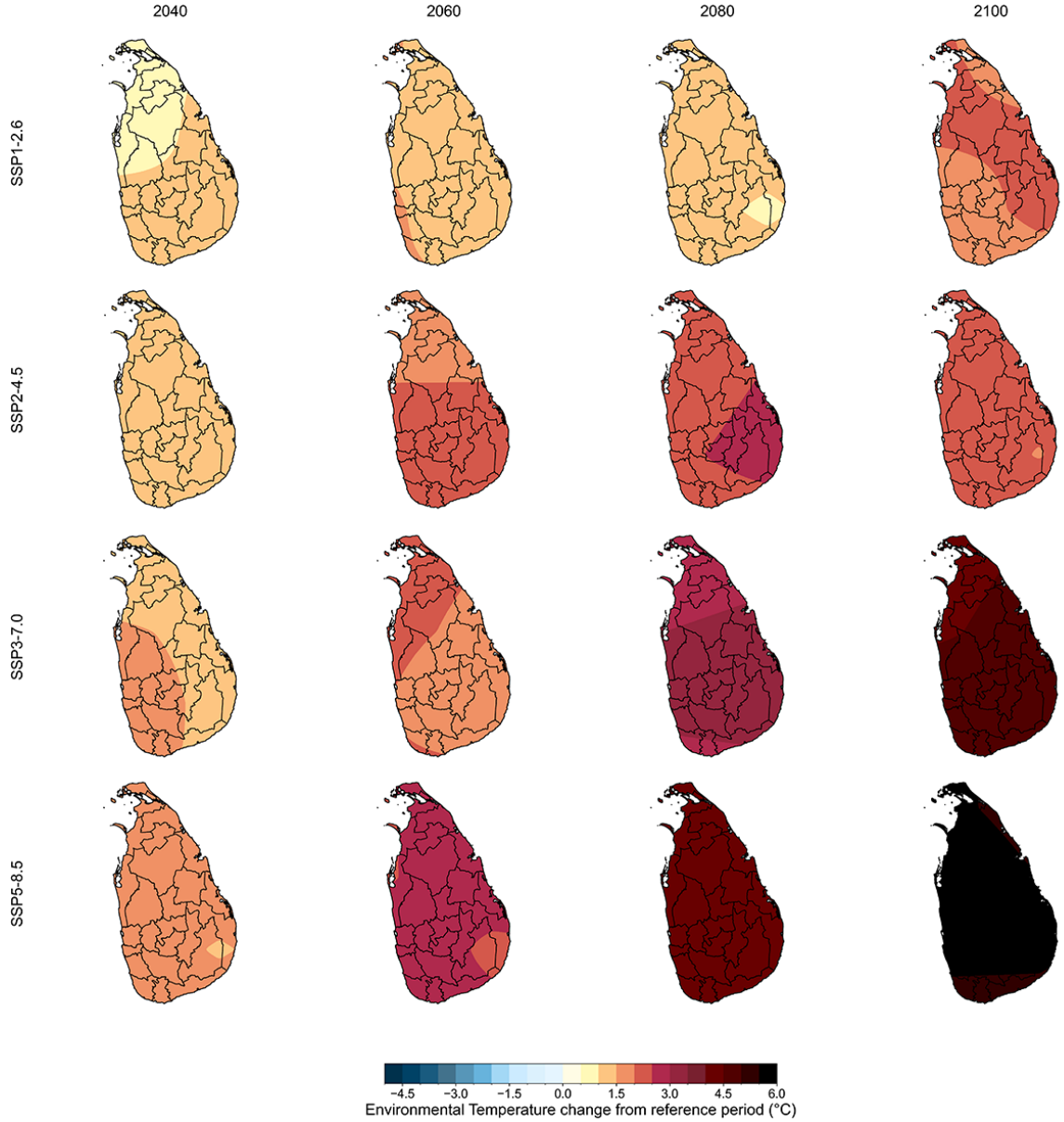
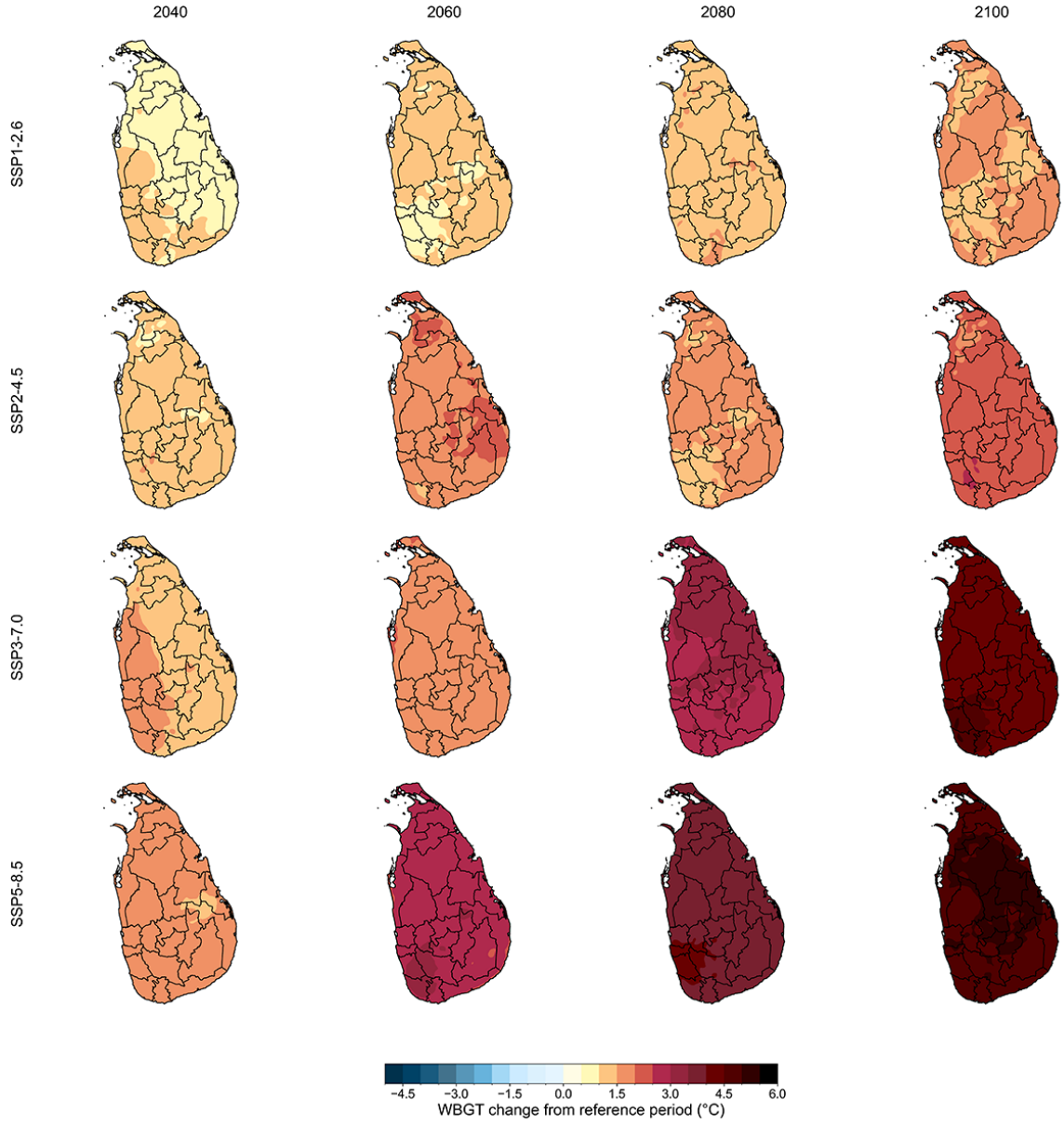


Figure 7. Change in the average maximum WBGT in Sri Lanka compared to the reference historical period (1985-2014) across the different SSPs and at different time points during this century.



3. Loss of work capacity by sector of activity

3.1. Overview of economic activity sectors

Sri Lanka's economy is diverse, with agriculture, industry, and services each playing significant roles. In 2023 the country's GDP was around 84 billion USD, with services contributing the largest share, followed by industry and agriculture.[31] Each sector's performance and challenges shape Sri Lanka's economic outlook. Below is a current overview of the key sectors, their contribution to GDP and employment, recent trends, and the major challenges and opportunities they face, with emphasis on data from reputable sources. Key sectors of the economy include:

1. **Agriculture:** Agriculture (including forestry and fishing) remains a foundation of Sri Lanka's economy, though its relative contribution has declined with diversification. As of 2023, agriculture accounted for about 8.2% of national GDP.[22,23,36] Despite this modest share of output, it is a vital source of livelihoods: roughly 25-30% of Sri Lanka's workforce is employed in agriculture.[22,23,37] The sector includes domestic staple crops (such as rice, fruits, and vegetables) and export-oriented plantation crops, particularly tea, rubber, coconut, and spices.[21] Sri Lanka is one of the world's leading tea producers, and tea remains a key agricultural export and source of foreign exchange earnings.[21] The fisheries and livestock sub-sectors are also important, with fisheries alone contributing about 1.3% of GDP as a subset of agriculture.[23]

2. **Industry:** The industrial sector (which includes manufacturing, mining and quarrying, utilities, and construction) is a key driver of Sri Lanka's economic output. Industry contributes about 25% of GDP, and about 28% of the labour force is employed in industrial activities.[31,37] Manufacturing, especially textile and apparel production, dominates this sector. Sri Lanka's garment industry is internationally competitive and has been the largest export earner, accounting for nearly 40-50% of merchandise exports in recent years.[38] Other manufacturing segments include food and beverage processing (e.g. tea packaging, milk products), rubber and plastics products, chemicals, and light engineering. The construction industry is another significant component, encompassing infrastructure development, housing, and commercial real estate projects. Construction saw a boom in the 2010s with large-scale road, port, and urban development projects. Although it was heavily affected during the economic downturn, construction remains crucial for employment of semi-skilled labour and for capital formation.

3. **Services:** The services sector is the largest segment of Sri Lanka's economy, reflecting the country's evolution toward a service-oriented market. In 2023, services accounted for 66% of GDP,[31] making it the dominant contributor to economic output. Services also provide 57% of all jobs, covering a range of activities from trade and transport to education and finance.[37] Major service industries include wholesale and retail trade, transportation, banking and finance, telecommunications, public administration, and importantly tourism. Tourism is often highlighted as a critical sub-sector given its foreign exchange earnings and community-level economic impact. Prior to the disruptions of 2019-2021, tourism had grown rapidly: it directly contributed about 5% of GDP in 2017 and accounted for approximately 11% of employment at its peak.[39] Hundreds of thousands of Sri Lankans work in hotels,

[36] Drought portal - Knowledge resources on integrated drought management: Sri Lanka. Food and Agriculture Organization of the United Nations. https://www.fao.org/in-action/drought-portal/preparedness/vulnerability-and-impact-assessment/national-case-studies/sri-lanka/en. Accessed: 3/12/2024.
[37] ILO (2022). Sri Lanka: The Employment - Environment - Climate Nexus. Employment and environmental sustainability factsheet. International Labour Organization. Geneva, Switzerland.
[38] Sri Lanka Export Development Board. Ministry of Industry and Entrepreneurship Development. https://www.srilankabusiness.com/apparel/exporter-information/export-potential.html. Accessed: 3/12/2024.
[39] ILO (2020). Platformization of the Tourism Sector in Sri Lanka. Impacts on labour market and decent work opportunities. International Labour Organization. Geneva, Switzerland.

travel services, and related industries connected to tourism. Other growing service areas include information technologies and software services (overlapping with information and communication technologies mentioned earlier) which are positioned as emerging export earners, as well as port services with the Port of Colombo being a busy global transshipment hub.

3.2. Impacts of heat stress on work capacity

3.2.1. Link between heat stress, work intensity, and capacity to perform work

The interplay between heat stress and work intensity is a critical factor in determining an individual's capacity to perform work. High work intensity exacerbates the physiological effects of heat, leading to quicker onset of fatigue, slower work pace, and increased safety risks. Understanding this relationship is essential for developing effective workplace policies and protective measures, such as adjusted work-rest cycles and hydration protocols, which aim to mitigate these impacts and maintain productivity even in challenging environmental conditions.

When the body cannot remove enough heat to ensure that its internal temperature remains stable, this leads to a range of adverse physiological responses.[17] These responses become particularly significant in occupational settings where physical work is required.

Heat stress and the human body

When exposed to intense heat, the human body struggles to maintain its normal internal temperature. As WBGT levels increase, the body directs more blood flow to the skin in an effort to cool down.[18] This physiological adjustment places additional strain on the cardiovascular system, leading to fatigue, reduced cognitive function, and an increased risk of heat-related illnesses such as heat exhaustion and heat stroke.[18,40]

Work intensity and metabolic heat production

The physical effort required for high-intensity work naturally produces metabolic heat.[18,41] When this internal heat generation combines with external (environmental) heat stress, the body's cooling mechanisms can be overwhelmed.[18] Workers engaged in high-intensity activities are, therefore, at a greater risk of experiencing the negative effects of heat. As the body becomes stressed by the combined internal and external heat loads, it responds by slowing down physical work as a protective mechanism. This slowdown is called "behavioural thermoregulation"[19] and it is a key factor in the observed loss of work time and, therefore, productivity.[42]

Loss of capacity to perform work

Reduced capacity to perform work under high heat stress is not only a matter of slower movement; it also includes reduced work output[42,43] and increased error rates.[44] This occurs because workers should take more

[40] Kenny G.P., Wilson T.E., Flouris A.D., Fujii N. (2018). Heat exhaustion. Handbook of Clinical Neurology; 157: 505-529.
[41] Poulianiti K.P., Havenith G., Flouris A.D. (2019). Metabolic energy cost of workers in agriculture, construction, manufacturing, tourism, and transportation industries. Industrial Health; 57(3): 283-305.
[42] Ioannou L.G., Tsoutsoubi L., Samoutis G., Bogataj L.K., Kenny G.P., Nybo L., Kjellstrom T., Flouris A.D. (2017). Time-motion analysis as a novel approach for evaluating the impact of environmental heat exposure on labor loss in agriculture workers. Temperature; 4(3): 330-340.
[43] Ioannou L.G., Tsoutsoubi L., Mantzios K., et al. (2025). The impact of workplace heat and cold on work time loss. Journal of Occupational and Environmental Medicine; doi: 10.1097/JOM.0000000000003332.
[44] Ioannou L.G., Mantzios K., Tsoutsoubi L., Panagiotaki Z., Kapnia A.K., Ciuha U., Nybo L., Flouris A.D., Mekjavic I.B. (2021). Effect of a simulated heat wave on physiological strain and labour productivity. International Journal of Environmental Research and Public Health; 18(6): 3011.

frequent breaks, reduce their pace, or even stop working to avoid heat-related health risks.[45] The cumulative effect of these adjustments is a measurable loss in work time and, therefore, productivity, as well as increased risks of accidents and long-term health impacts.[16,43]

3.2.2. Projected loss of work capacity due to rising heat stress from climate change

The impact of heat stress on the capacity to perform work in Sri Lanka was estimated using a response function for workability, based on previous methods.[46] The estimated work capacity loss in Sri Lanka's agricultural, construction, manufacturing, mining and quarrying, services, as well as transport and trade sectors are illustrated in Figures 8-10. The estimates were computed separately for different work intensity levels (high, moderate, and low) for the historical reference period (1985-2014) and up to 2100 based on the different SSPs. Also, they show work capacity loss during a given year as well as work capacity loss due to climate change (i.e., calculated as a change from the baseline historical period 1985-2014).

During the historical period, work capacity losses in **agriculture** and **construction** (Figure 8) fluctuated between 22-28% in high-intensity work, between 10% and 12% in moderate-intensity work, and between 4% and 6% in low-intensity work. Climate change will lead to significant work capacity losses beyond the levels observed in the historical period. Under SSP1-2.6 and SSP2-4.5, climate change will cause further work capacity losses of 15-20% in high-intensity work, 10-13% in moderate-intensity work, and 4-6% in low-intensity work, reflecting relatively mild impacts due to strong climate change mitigation. In SSP3-7.0 and SSP5-8.5, climate change will lead to additional work capacity losses reaching 30% in low-intensity work and exceeding 40% in high-intensity work by 2100, reflecting the severe impact of climate change and heat stress on work capacity. These are the most pessimistic emission scenarios, showing the highest projected losses, reflecting the severe impact of climate change and heat stress on work capacity.

In **manufacturing**, **mining and quarrying** (Figure 9), **services**, as well as **transportation and trade** (Figure 10), work capacity losses remained below 8% during the historical period. During this century, climate change is not expected to cause significant work capacity losses in low-intensity work beyond the levels observed in the historical period. This is also the case for moderate- and high-intensity work under scenarios SSP1-2.6 and SSP2-4.5, which assume sustainability-focused global action. However, in SSP3-7.0 and SSP5-8.5, climate change will lead to additional work capacity losses reaching 12% in moderate-intensity work and exceeding 25% in high-intensity work by 2100, suggesting significant heat stress impacts and underscoring the impact of high heat exposure and the need for adaptation measures.

Overall, the key findings of this analysis are as follows:

- **Intensity matters:** work capacity losses are directly linked to work intensity, with high-intensity work across all industries facing the greatest projected losses under all scenarios. Although the impact on moderate- and low-intensity work is less severe, even these activities will experience work capacity declines, particularly under higher-emission scenarios, highlighting the pervasive impact of rising heat levels.
- **Vulnerability is unequal:** agriculture and construction show the highest work capacity losses due to increased heat stress from climate change, reaching as high as 40% by the end of the century. Manufacturing, mining and quarrying, services, transportation, and trade are also heavily impacted, but at a lesser degree.
- **Scenario divergence:** under more optimistic scenarios (SSP1-2.6, SSP2-4.5), work capacity losses remain relatively low across all intensity levels. However, in scenarios where climate action is delayed or

[45] Flouris A.D., Ioannou L.D., Dinas P.C., et al. (2019). Assessment of occupational heat strain and mitigation strategies in Qatar – Key Findings. International Labour Organization, United Nations: Doha, Qatar.
[46] García-León D., Casanueva A., Standardi G., Burgstall A., Flouris A.D., Nybo L. (2021). Current and projected regional economic impacts of heatwaves in Europe. Nature Communications; 12(1): 5807.

absent (SSP3-7.0, SSP5-8.5), work capacity losses increase significantly, particularly for high-intensity work.

- **Long-term trends:** regardless of the SSP, work capacity losses generally increase towards the latter half of the century, reflecting the long-term effects of climate change on work capacity in Sri Lanka.

This analysis emphasizes the need for targeted adaptation strategies, particularly for high-intensity labour, to mitigate work capacity losses in the context of increasing heat levels and climate change impacts.

Figure 8. Average work capacity loss (%) in Sri Lanka during high- (top), moderate- (middle), and low- (bottom) intensity work in agriculture (left graphs) and construction (right graphs) during the reference historical period (1985-2014) and until 2100 across the different SSPs. Vertical axes in each graph show work capacity loss during a given year (right hand side axis) and work capacity loss due to climate change, calculated as a change from the baseline historical period 1985-2014 (left hand side axis). Shaded areas represent 95% confidence intervals.

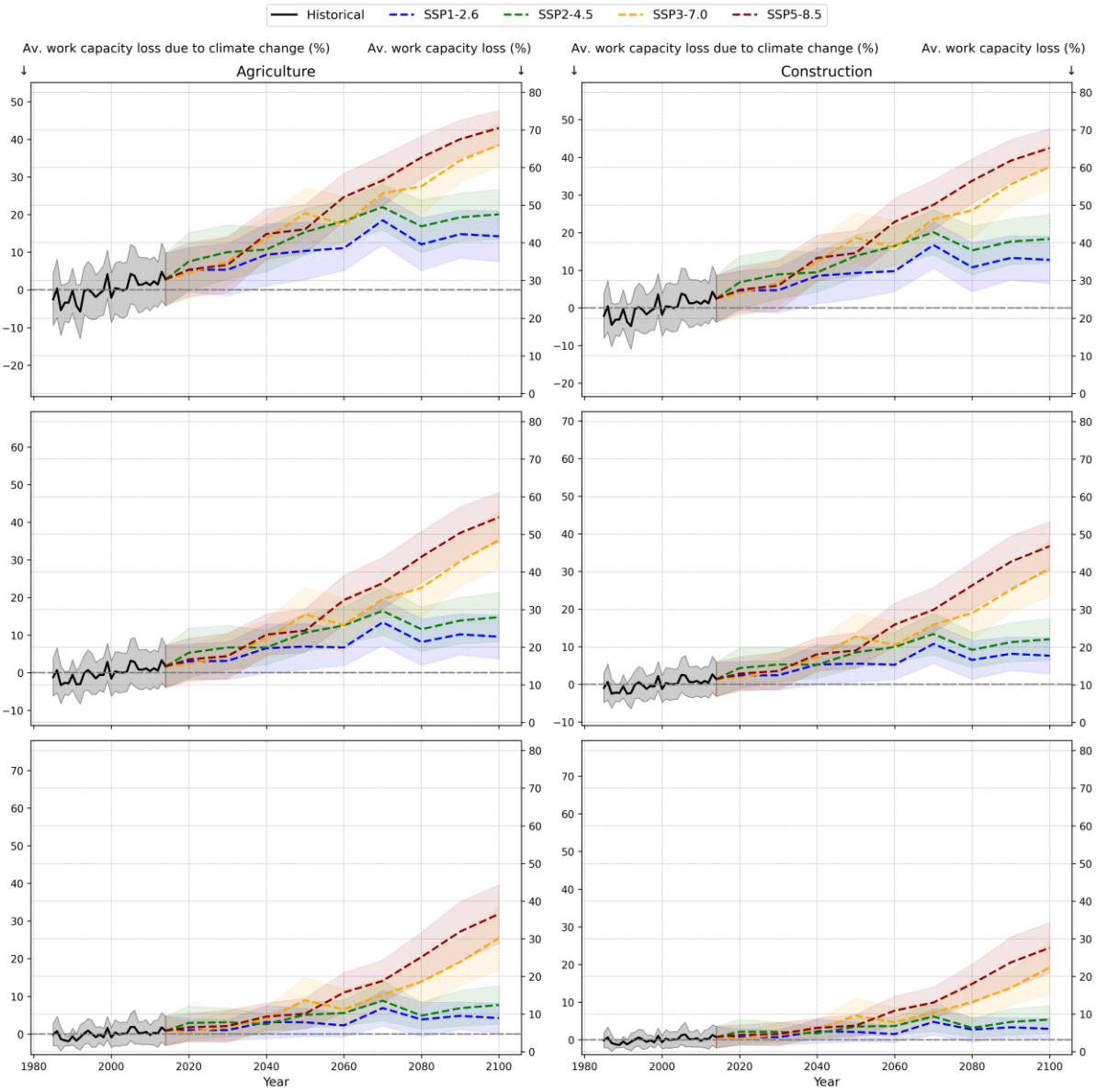


Figure 9. Average work capacity loss (%) in Sri Lanka during high- (top), moderate- (middle), and low- (bottom) intensity work in manufacturing (left graphs) as well as mining and quarrying (right graphs) during the reference historical period (1985-2014) and until 2100 across the different SSPs. Vertical axes in each graph show work capacity loss during a given year (right hand side axis) and work capacity loss due to climate change, calculated as a change from the baseline historical period 1985-2014 (left hand side axis). Shaded areas represent 95% confidence intervals.

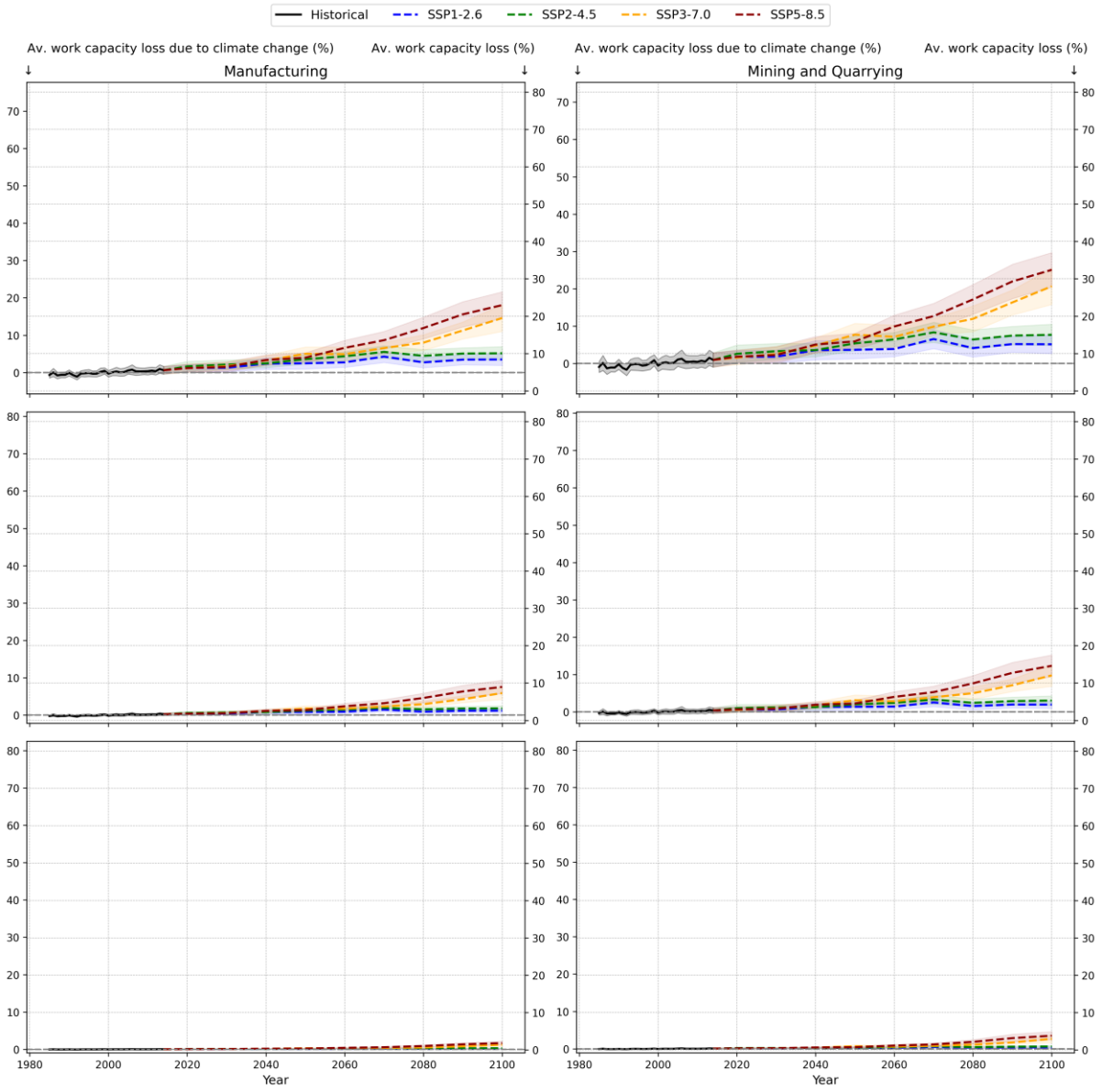
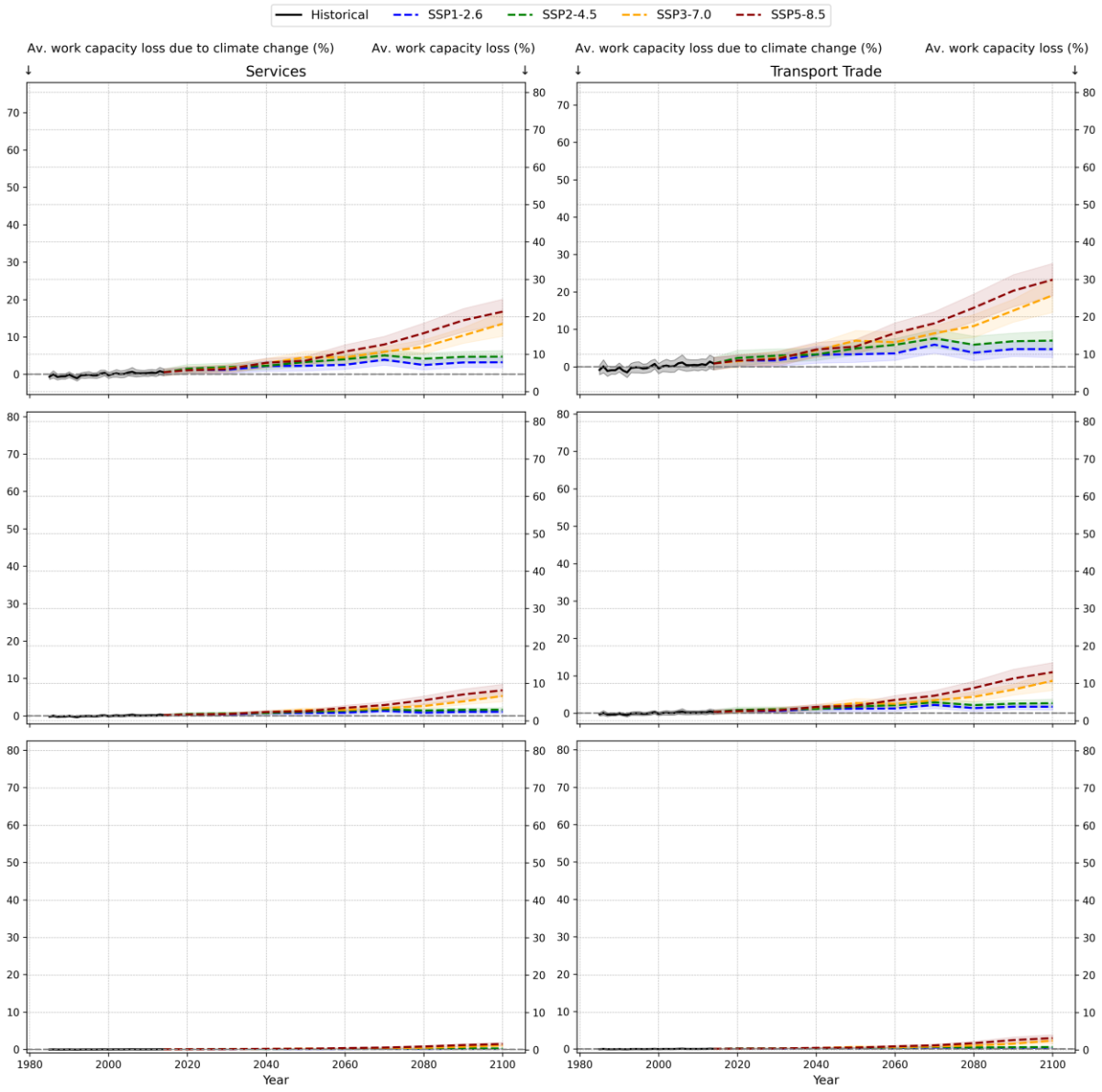


Figure 10. Average work capacity loss (%) in Sri Lanka during high- (top), moderate- (middle), and low- (bottom) intensity work in services (left graphs) as well as transportation and trade (right graphs) during the reference historical period (1985-2014) and until 2100 across the different SSPs. Vertical axes in each graph show work capacity loss during a given year (right hand side axis) and work capacity loss due to climate change, calculated as a change from the baseline historical period 1985-2014 (left hand side axis). Shaded areas represent 95% confidence intervals.



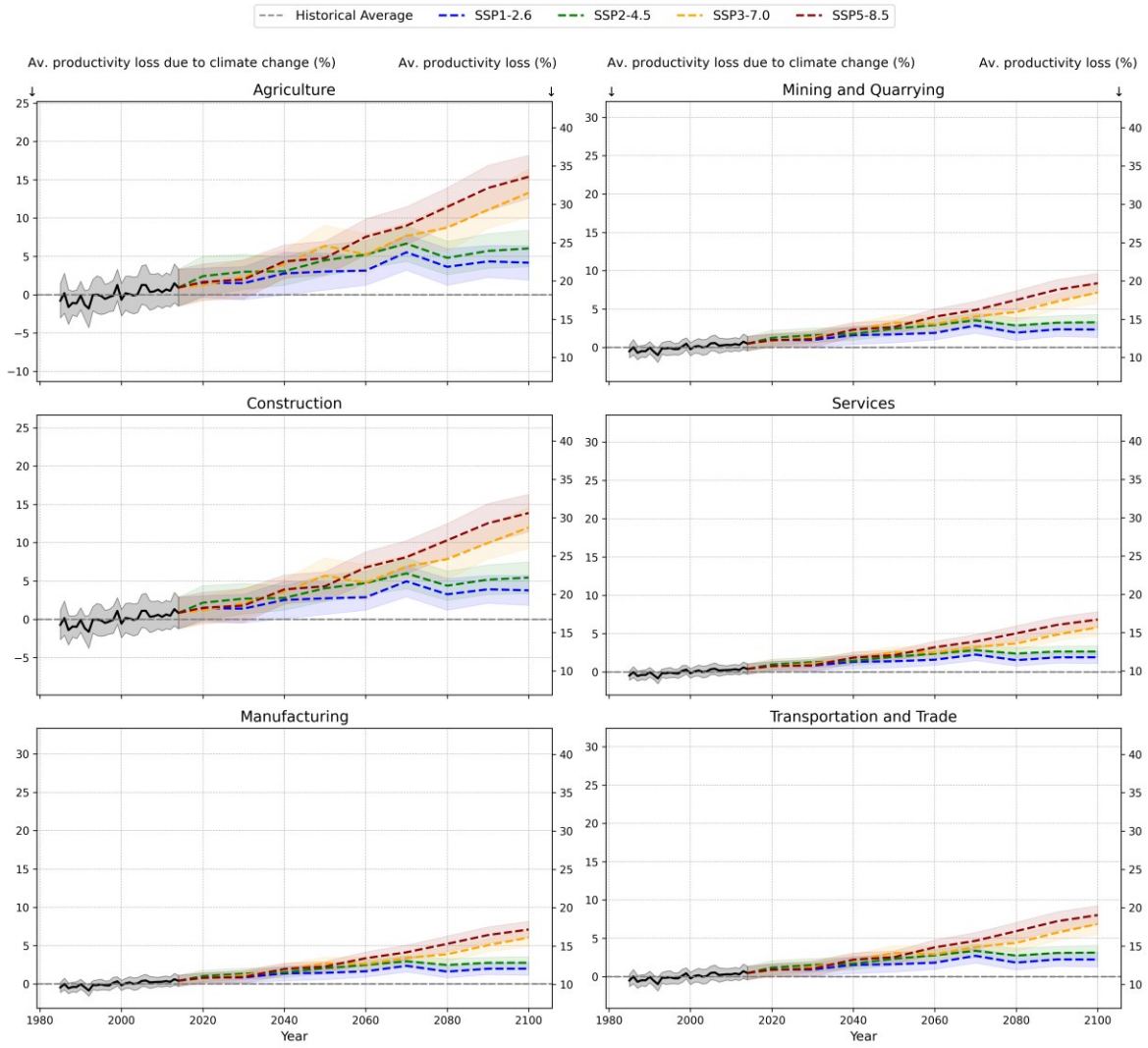
4. Loss of productivity by sector of activity

Productivity loss was estimated using a recently introduced response function linking WBGT and the time that workers allocate to work- and non-work-related activities during a typical work shift. The response function has been developed based on field studies (including studies from the ILO) that performed detailed monitoring of >600 of work shifts from different industries across multiple countries in Central America, Central and South Europe, as well as the Middle East.[16,43,44,45] This methodology provides robust estimates of productivity loss due to heat stress for the average, experienced, and acclimatized worker who performs their typical daily shift.

The estimated productivity loss by sector due to climate change and heat stress under current and projected conditions is illustrated in Figure 11. In **agriculture** and **construction**, productivity loss due to heat stress fluctuated between 15% and 18%, during the historical period. By 2100, under SSP1-2.6 and SSP2-4.5, productivity loss is expected to further increase by 4-6% due to climate change, reflecting relatively mild impacts due to climate change mitigation. Under SSP3-7.0 and SSP5-8.5, climate change will lead to increases in productivity loss compared to the average year of the reference historical period, reaching as high as 15% toward the end of the century. Agriculture and construction are thereby particularly vulnerable sectors to productivity loss due to climate change.

In **manufacturing**, **mining and quarrying**, **services**, as well as **transportation** and **trade**, productivity loss due to heat stress remained stable at about 10% to 12% during the historical period. Under SSP1-2.6 and SSP2-4.5, climate change is anticipated to further increase productivity loss by 3-4% by the end of the century. This will be higher under SSP3-7.0 and SSP5-8.5, resulting in additional productivity loss of up to 8% in these scenarios by 2100, compared to the average year within the reference period.

Figure 11. Average productivity loss in Sri Lanka in agriculture (top left), construction (middle left), manufacturing (bottom left), mining and quarrying (top right), services (middle right), as well as transportation and trade (bottom right) during the reference historical period (1985-2014) and until 2100 across the different SSPs. Vertical axes in each graph show productivity loss during a given year (right hand side axis) and productivity loss due to climate change, calculated as a change from the baseline historical period 1985-2014 (left hand side axis). Shaded areas represent 95% confidence intervals.



5. Economic and labour market impacts

5.1. Current economic impacts

Heat stress affects not only individual workers but also has far-reaching implications for national economies. When workers are exposed to high levels of heat, they tend to slow down, take more frequent breaks, or may even be unable to work at all – all of which reduce the effective work time. This reduction in labour input at the worker level (which includes all types of labour including managerial jobs) accumulates into the loss of productivity in specific sectors of the economy (agriculture, construction etc.) and, in aggregate, directly translates into lower economic output, which is reflected in a decrease in GDP. Essentially, economic production relies on the total available work hours, and when those hours diminish due to heat stress, the overall contribution of the workforce to production is reduced.

The analysis presented in Section 4 estimates the number of work hours lost due to heat stress caused by climate change across key economic sectors. These lost work hours indicate a lower effective labour input compared to the baseline historical period 1985-2014. By applying industry- and location-specific multipliers that account for each sector's share of the economy, the corresponding loss in GDP can be estimated. These estimates unravel the GDP lost due to climate change for the present (i.e., 2023), calculated as the change in heat stress levels from the reference historical period (1985-2014), while considering the associated fluctuations in GDP and industry-specific contribution to GDP. The analysis can be then expanded to provide estimates for 2040 and 2060 according to the population, socioeconomic, and governance contexts of each SSP. The methodology used for these analyses is described in Annex 1.

Table 2. Change in the contribution of each sector to GDP due to rising workplace heat stress caused by climate change, between 2023 and the reference historical period 1985-2014.

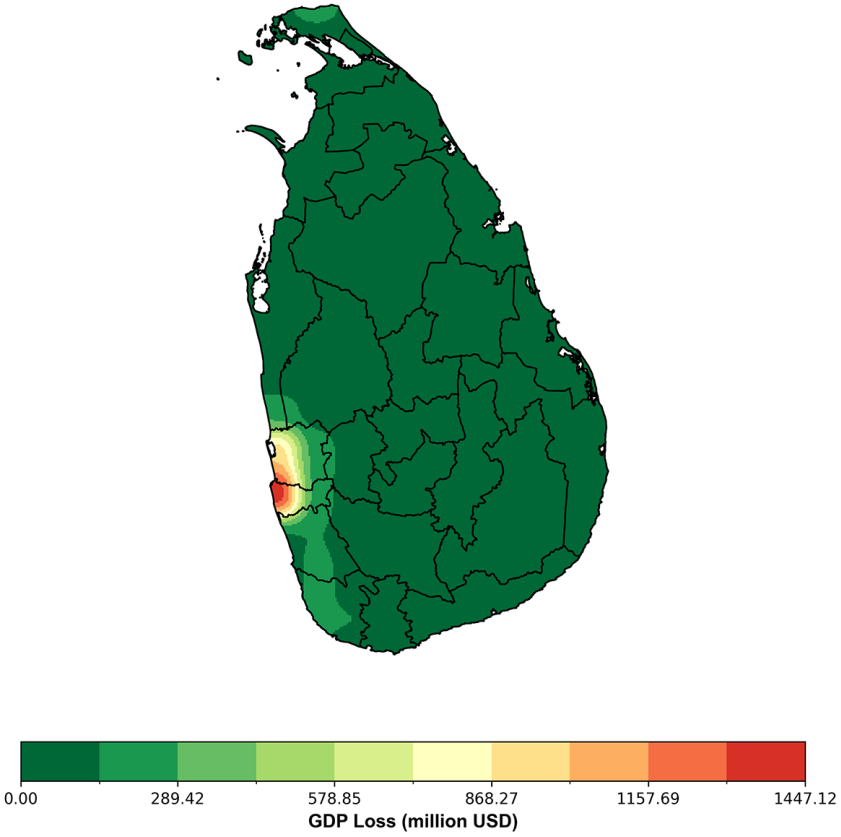
Sector	**Change in GDP**	
	*(M USD)**	*(distribution; %)*
Agriculture	-749.6	11.5
Construction	-654.5	10.0
Manufacturing	-920.2	14.1
Mining and Quarrying	-211.4	3.2
Services	-2,729.2	41.9
Transport and Trade	-1,254.9	19.3
Total GDP change	-6,519.7	

* million USD (fixed 2015 prices), with negative values indicating a GDP reduction compared to the baseline historical period 1985-2014.

The findings from the analysis on the economic impacts of rising heat stress due to climate change demonstrate that Sri Lanka lost 6.5 billion USD more in 2023 compared to the average year during the reference historical period (1985-2014) (Table 2). The distribution of the GDP loss (in million USD) due to climate change across the country is illustrated in Figure 12.

The map shows that climate change has already reduced output in 2023 compared with the 1985-2014 baseline. Losses are not even across the country. They are concentrated in the Western Province around Colombo and its suburbs. This corridor records the highest loss values and stands out clearly against the rest of Sri Lanka. This pattern follows where most value added and formal jobs are located. Services, manufacturing, trade, and logistics cluster around Colombo and the port. When heat cuts work time and slows activity, the largest absolute losses occur where output and employment are densest. Urban heat island effects and coastal humidity likely add to exposure during peak hours, which amplifies the loss in this zone.

Figure 12. GDP loss across Sri Lanka due to rising workplace heat stress caused by climate change, between 2023 and the baseline historical period 1985-2014.



Losses fade in areas away from the western metro area. Central, northern, and eastern districts show much lower absolute values. That does not mean low risk for workers. It reflects a smaller economic base. In rural areas a small absolute loss can still be significant for households and local firms, especially in agriculture and construction where most work is outdoors.

Two policy messages emerge. First, protect the Colombo metropolitan economy. Focus on services, manufacturing, the port, and major transport hubs. Use WBGT-based work rules, flexible hours, shaded/ventilated rest areas, and access to hydration and cooling. Support small enterprises so that measures are affordable and reliable during heat alerts. Second, do not overlook other regions. Promote seasonal scheduling, early warning, and basic protections for outdoor and informal work so that livelihoods are not eroded even where absolute GDP is smaller.

In short, the country is already paying an economic cost from workplace heat. The burden is highest where economic activity is most concentrated, yet the need for protection is nationwide. Targeted heat risk management can limit further losses while safeguarding worker health and productivity.

5.1.1. Sectoral contribution to current GDP loss

The analysis presented in Section 5.1 was also used to estimate the impact of climate change on each sector of economic activity. Specifically, the analysis estimated the change in the contribution of each sector to overall GDP due to rising workplace heat stress caused by climate change, between 2023 and the reference historical period (1985-2014). The methodology used for this analysis is described in Annex 1.

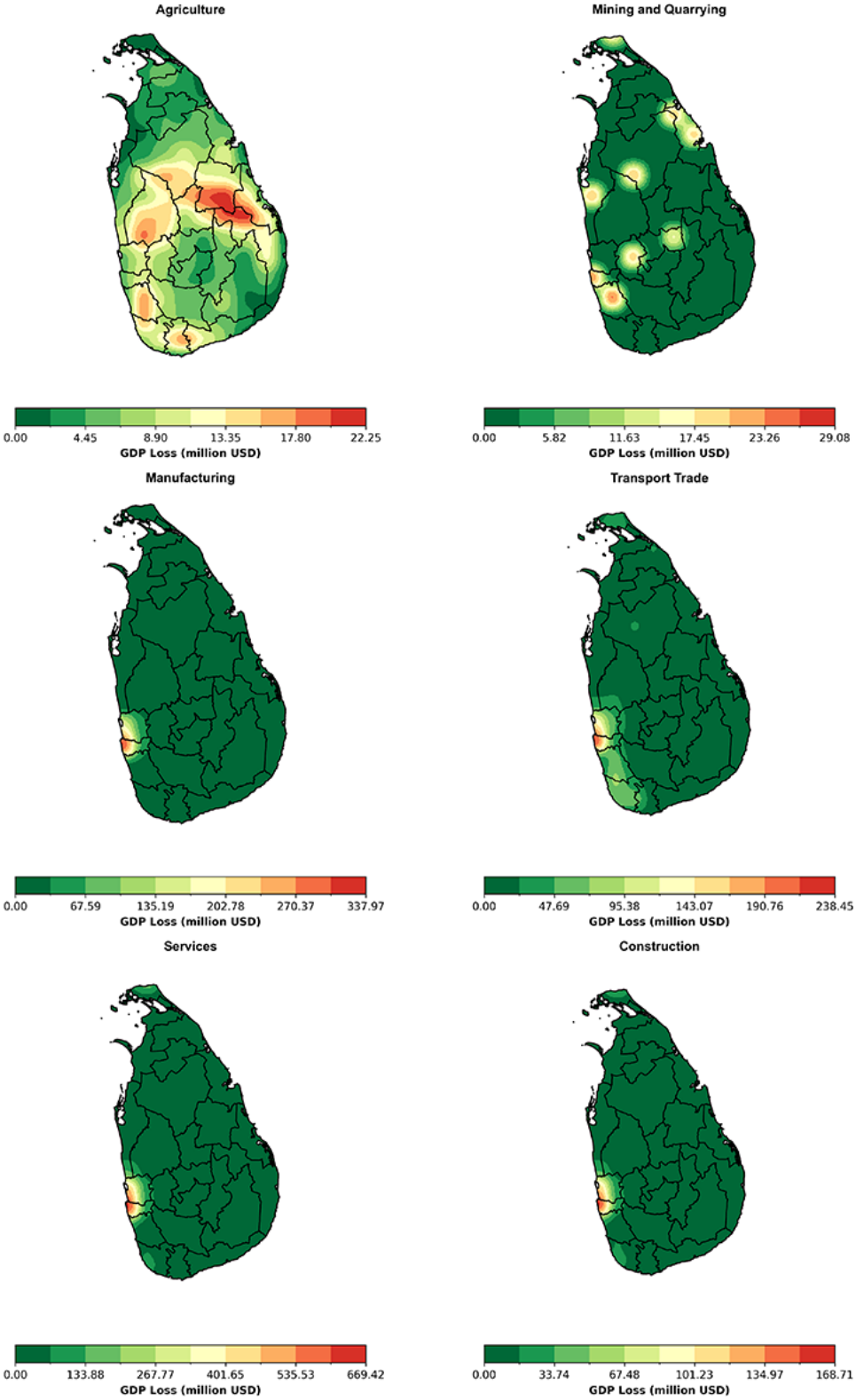
The impact of rising workplace heat stress due to climate change on each sector of economic activity is shown in Table 2. The GDP losses in the service sector far outweigh those from all other sectors, representing 41.9% of

the additional GDP losses compared to an average year during the historical period. Transport and trade are also heavily impacted, with nearly 1.25 billion more USD lost due to heat stress during 2023 in relation to an average year during the historical period (Table 2). Manufacturing and agriculture are also heavily impacted, representing 14.1% and 11.5% of the additional GDP losses compared to an average year during the historical period (Table 2).

The regional distribution of the impact of rising workplace heat stress due to climate change on each sector of economic activity is illustrated geographically in Figure 13. The map shows that services carry the biggest loss. The hotspot in the Colombo metropolitan area reaches about 670 million USD. This reflects the weight of retail, hospitality, public administration and other urban services, many of which operate in warm indoor or semi-outdoor spaces with limited cooling. Manufacturing also shows a strong cluster around Colombo and the coastal industrial belt. Losses in the core hotspot approach 340 million USD. Warm factories and workshops, together with mid-day heat peaks, reduce effective hours and output. Transport and trade follow the same pattern. The main losses sit along the port, logistics hubs and arterial roads of the Western Province, with a hotspot near 240 million USD. These activities are time-sensitive and often exposed to sun and radiant heat in loading areas and yards.

Construction mirrors the urban pattern. Losses peak at 170 million USD in the Colombo area where building activity and outdoor work are concentrated. Heat slows physically demanding tasks and forces longer breaks. Mining and quarrying show smaller national totals but clear site-specific pockets in the interior and south. Losses reach up to about 29 million USD where operations are clustered. Local economic effects can be large given the narrow employment base around each site. Finally, agriculture displays a different map. Losses are spread across the dry-zone lowlands and interior rather than the Colombo hub. Hotspots of roughly 22 million USD appear across the north-central, east-central and south-eastern districts. The absolute values are lower than in services or manufacturing, but the impact on rural incomes is significant because work is outdoors and physically demanding.

Figure 13. GDP loss across Sri Lanka due to rising workplace heat stress caused by climate change, between 2023 and the baseline period 1985-2014, in each sector of economic activity. Note: due to the dominance of the service sector in Sri Lanka's economy, it was not possible to maintain a constant range of GDP loss across all maps as the smaller size of the other sectors would prohibit an efficient illustration of the data.



Two messages emerge from this analysis. First, absolute GDP losses are greatest where economic activity is dense, especially in and around Colombo. Protecting workers and firms there will deliver the largest macro-economic gains. Second, the rural burden is real even when the map colours are lighter. Agricultural areas face persistent heat during key work hours and have fewer options for cooling or schedule flexibility.

Policy priorities follow from this geography. In the Western Province, there should be strong focus on efficient cooling, shaded and ventilated rest areas, flexible hours aligned with WBGT thresholds, and heat-safe procedures at ports, factories and construction sites. In rural areas, there should be support in the form of shade, water and rest on farms, adjusting work calendars, and investing in climate-smart practices and basic cooling for rural services. Across all sectors, early warning, worker training, and strong occupational safety rules tied to WBGT will help contain further losses.

5.2. Future economic impacts

The projected impact of rising workplace heat stress due to climate change on total and sectoral GDP during 2040 and 2060 across the different SSPs is presented in Table 3. Sri Lanka's macro-economic exposure to rising workplace heat stress is set to intensify between 2040 and 2060, with outcomes highly sensitive to global emissions scenarios. Even on a Paris-aligned trajectory (SSP1-2.6), heat-related productivity losses will reduce GDP by about 11.8% and 13.0% more in 2040 and 2060, respectively, relative to the losses during the average year within the 1985-2014 baseline. This is equal to an annual loss of 26 billion USD in 2040 and 65.6 billion USD in 2060. Under a "middle-of-the-road" scenario (SSP2-4.5), the contraction deepens from 11.5% (21.1 billion USD) in 2040 to 13.7% (51.7 billion USD) in 2060, while a regional-rivalry world (SSP3-7.0) will drastically increase the burden to 13.5% by 2060. Given the slow economic growth foreseen in SSP3 (see Section 2.4.2), this high relative loss is equal to 37.3 billion USD. Should fossil-fuel development continue unabated (SSP5-8.5), rising workplace heat stress could cut 15.2% (87.1 billion USD) off annual national output by 2060, eliminating the cumulative GDP value of several medium-sized manufacturing subsectors.

The sectoral pattern is uneven but consistent across pathways. Services, the backbone of the Sri Lankan economy, bears most of the losses: 5.1% (11.4 billion USD) more losses in 2040 under SSP1-2.6 compared to the historical period, rising to 6.5% (37.4 billion USD) in 2060 under SSP5-8.5. Manufacturing as well as transport and trade absorb steady declines deepening from 1.8% (SSP1-2.6, 2040) to 3.1% (SSP5-8.5, 2060), reflecting high indoor heat loads and partial air-conditioning coverage. Agriculture as well as mining and quarrying will record higher losses in 2040 compared to the average year within the historical period, with aggravated impacts depending on the SSP. Construction is expected to experience smaller, yet significant, climate change impacts ranging from 1.3% of GDP (2.8 billion USD) additional losses in 2040 (compared to the baseline period), to 1.7% of GDP (9.5 billion USD) in 2060.

Table 3. Annual impact of rising workplace heat stress caused by climate change on GDP in Sri Lanka during 2040 and 2060 across different SSPs, compared to the baseline historical period 1985-2014.

		Change in GDP			
		2040		**2060**	
		(M USD)[1]	*(%)*	*(M USD)*[1]	*(%)*
Agriculture	SSP1-2.6	-2,042.9	-0.92	-5,338.6	-1.06
	SSP2-4.5	-1,617.5	-0.88	-4,264.3	-1.13
	SSP3-7.0	-1,436.0	-0.87	-2,700.3	-0.98
	SSP5-8.5	-2,539.3	-1.06	-7,735.0	-1.35
Construction	SSP1-2.6	-2,788.6	-1.26	-6,925.5	-1.37
	SSP2-4.5	-2,249.7	-1.22	-5,538.3	-1.46
	SSP3-7.0	-2,121.5	-1.29	-4,045.9	-1.47
	SSP5-8.5	-3,269.1	-1.36	-9,516.9	-1.66
Manufacturing	SSP1-2.6	-5,482.8	-2.48	-13,726.9	-2.71
	SSP2-4.5	-4,421.8	-2.40	-10,741.4	-2.84
	SSP3-7.0	-4,085.2	-2.48	-7,882.3	-2.86
	SSP5-8.5	-6,241.1	-2.61	-17,839.6	-3.11
Mining and Quarrying	SSP1-2.6	-503.6	-0.23	-1,322.3	-0.26
	SSP2-4.5	-401.0	-0.22	-1,042.4	-0.28
	SSP3-7.0	-365.9	-0.22	-723.5	-0.26
	SSP5-8.5	-600.5	-0.25	-1,821.9	-0.32
Services	SSP1-2.6	-11,353.1	-5.13	-28,642.7	-5.66
	SSP2-4.5	-9,217.5	-5.01	-22,536.5	-5.96
	SSP3-7.0	-8,470.7	-5.14	-16,379.7	-5.95
	SSP5-8.5	-13,012.8	-5.43	-37,392.3	-6.52
Transport and Trade	SSP1-2.6	-3,897.0	-1.76	-9,600.4	-1.90
	SSP2-4.5	-3,189.3	-1.73	-7,608.4	-2.01
	SSP3-7.0	-2,945.9	-1.79	-5,517.0	-2.00
	SSP5-8.5	-4,501.8	-1.88	-12,771.0	-2.23
TOTAL	SSP1-2.6	-26,068.0	-11.78	-65,556.4	-12.96
	SSP2-4.5	-21,096.8	-11.47	-51,731.2	-13.67
	SSP3-7.0	-19,425.2	-11.79	-37,248.8	-13.53
	SSP5-8.5	-30,164.6	-12.59	-87,076.6	-15.19

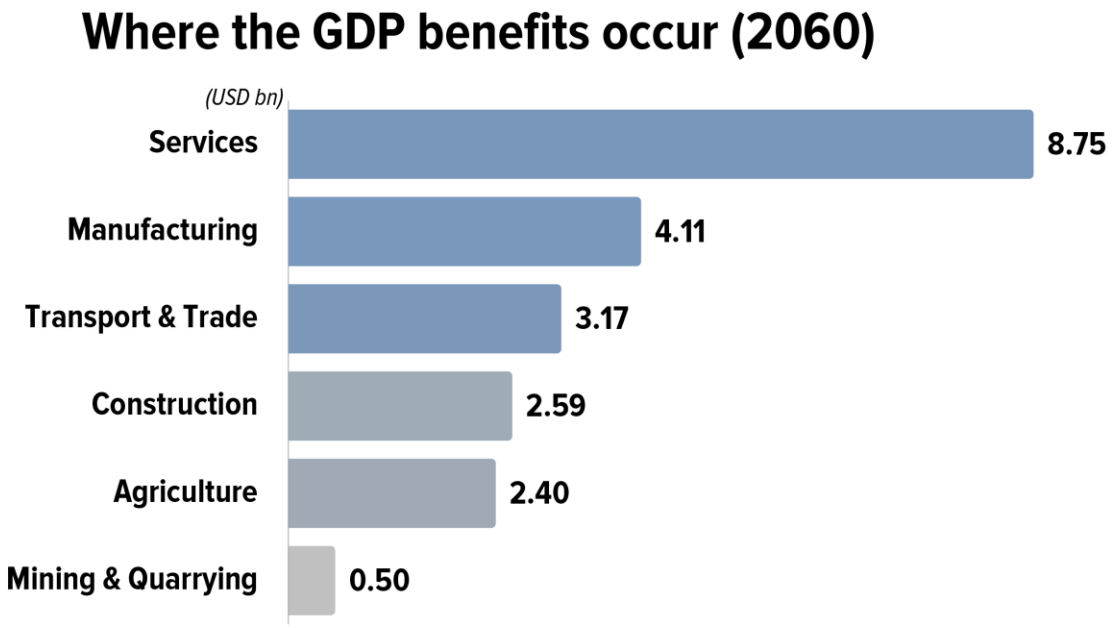
[1] million USD, fixed 2015 prices.

SSP: shared socioeconomic pathway; negative values indicate a GDP reduction compared to the baseline historical period 1985-2014.

Three policy conclusions follow. First, the steep scenario gradient confirms that ambitious global mitigation (SSP1-2.6) could avert 2.2 percentage points of GDP loss by 2060 (about 21.5 billion USD in 2060), relative to SSP5-8.5. Second, domestic adaptation should prioritise heat-proofing the services economy, particularly retail, hospitality, and public administration, where the absolute loss is greatest (Infographic 1). This implies accelerated investment in efficient cooling, urban heat-island management and flexible work scheduling. Third, sector-specific labour regulations should anticipate that expansion in transport and trade as well as

manufacturing and construction will intensify exposure to workplace heat stress. Therefore, integrating heat stress thresholds into building codes, transport and agricultural extension services, as well as social-protection schemes will be critical. Anchoring these measures in Sri Lanka's forthcoming National Adaptation Plan and Decent Work Country Programme will help safeguard both competitiveness and worker welfare as temperatures rise.

Infographic 1. Sectoral GDP benefits of implementing in Sri Lanka the decent work and sustainable development goals as described in SSP1-2.6, particularly in relation to workplace heat stress (calculated as differences between SSP5-8.5 and SSP1-2.6).



5.3. Current labour market impacts

When workers experience heat stress, they are forced to reduce their output either by working at a slower pace or by taking more frequent breaks. Over time, this reduction in effective work time accumulates and it is essential to translate the reductions in working hours into a metric that can be readily understood. The most appropriate metric is full-time equivalent (FTE) job losses, a standard indicator of economic and labour market impact. In the case of heat stress, FTE job losses describe the reduction in the number of full-time jobs that could have been sustained under optimal working conditions. This methodology allows quantifying the impact of workplace heat stress on labour markets in a standardized and comprehensible manner, facilitating comparisons across industries and informing policy decisions aimed at mitigating these adverse effects.

The conversion of lost working hours into FTE job losses is based on a standard calculation of annual working hours per worker. It is assumed that a worker takes a minimum of 14 days of leave per year. Considering a typical work schedule of 5 days per week and 8 hours per day, the total potential working hours per year are calculated as:

$$\text{Annual Working Hours} = (365\text{-}14) \times \frac{5}{7} \times 8 \approx 2006 \text{ hours}$$

The FTE job losses per industry are calculated by comparing the available work hours against the reduced work hours resulting from workplace heat stress (provided in Section 4). The difference between the total potential working hours (2006 hours per year) and the actual hours worked (after accounting for the hours lost due to workplace heat stress) represents the deficit in labour input. This deficit is then divided by the standard annual working hours (2006 hours) to obtain the number of FTE jobs lost.

The analysis used data for 2023 to describe the current impact of rising heat stress due to climate change on Sri Lanka's labour market. Thus, estimates were expressed as the change between 2023 and the reference historical period 1985-2014, while considering the associated fluctuations in GDP.

The findings in Table 4 show that the impact of climate change on Sri Lanka's labour market is significant, with over 120 thousand more jobs lost due to workplace heat stress during 2023 compared to the average year during the historical period. The analysis reflects a seasonal pattern where 35% of the impacts occur in Q2, mirroring the period of most intense heat. Nearly half (47.6%) of job losses are concentrated in agriculture, 22% occur in services, as well as about 13%, 11%, and 6% in manufacturing, construction, as well as transport and trade, respectively (Table 4 and Infographic 2).

Infographic 2. Annual impact of rising heat stress due to climate change on full-time equivalent jobs lost (proxied from work hours lost) in each sector of economic activity and across the entire economy in Sri Lanka, calculated as the change between 2023 and the reference historical period 1985-2014.

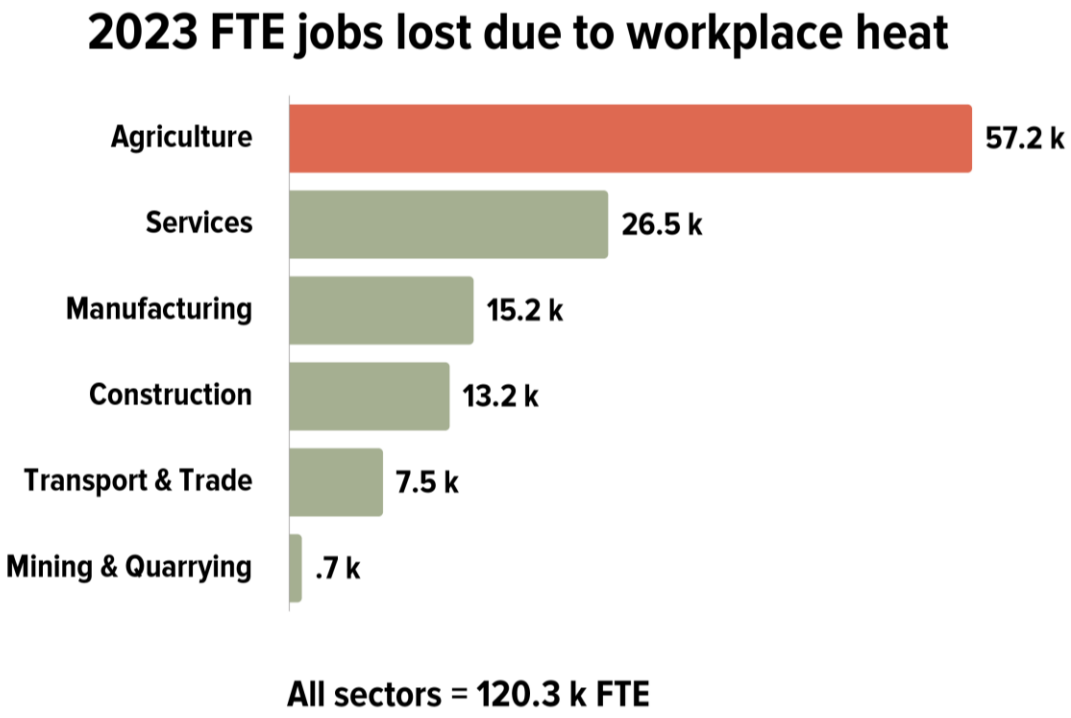


Table 4. Quarterly and annual impact of rising heat stress due to climate change on full-time equivalent jobs lost (proxied from work hours lost) in each sector of economic activity and across the entire economy in Sri Lanka, calculated as the change between 2023 and the reference historical period 1985-2014 (negative values indicate losses vs reference).

Sector	Period	Available Work Hours (n)	Change in Work Hours		Change in Jobs (FTE)
			(n)	(% FTE)	
Agriculture	Q1	1,053,620,417	-14,879,416	-1.41	-7,417
	Q2	1,065,801,000	-42,553,130	-3.99	-21,213
	Q3	1,077,981,583	-20,726,560	-1.92	-10,332
	Q4	1,077,981,583	-36,644,855	-3.40	-18,268
	Year	4,275,384,583	-114,803,962	-2.69	-57,230
Construction	Q1	280,825,463	-3,555,237	-1.27	-1,772
	Q2	284,072,000	-9,737,799	-3.43	-4,854
	Q3	287,318,537	-5,020,709	-1.75	-2,503
	Q4	287,318,537	-8,073,751	-2.81	-4,025
	Year	1,139,534,537	-26,387,496	-2.32	-13,154
Manufacturing	Q1	666,828,500	-6,580,550	-0.99	-3,280
	Q2	674,537,500	-9,679,950	-1.44	-4,825
	Q3	682,246,500	-6,465,099	-0.95	-3,223
	Q4	682,246,500	-7,716,977	-1.13	-3,847
	Year	2,705,859,000	-30,442,576	-1.13	-15,176
Mining and Quarrying	Q1	26,580,709	-261,266	-0.98	-130
	Q2	26,888,000	-474,214	-1.76	-236
	Q3	27,195,291	-265,268	-0.98	-132
	Q4	27,195,291	-366,357	-1.35	-183
	Year	107,859,291	-1,367,105	-1.27	-682
Services	Q1	1,353,251,969	-11,725,727	-0.87	-5,845
	Q2	1,368,896,500	-16,775,806	-1.23	-8,363
	Q3	1,384,541,031	-10,955,528	-0.79	-5,461
	Q4	1,384,541,031	-13,759,649	-0.99	-6,859
	Year	5,491,230,531	-53,216,709	-0.97	-26,529
Transport and Trade	Q1	286,141,506	-2,840,719	-0.99	-1,416
	Q2	289,449,500	-5,122,408	-1.77	-2,554
	Q3	292,757,494	-2,943,673	-1.01	-1,467
	Q4	292,757,494	-4,197,269	-1.43	-2,092
	Year	1,161,105,994	-15,104,068	-1.30	-7,529
TOTAL	Q1	3,667,248,563	-39,842,915	-1.09	-19,862
	Q2	3,709,644,500	-84,343,307	-2.27	-42,046
	Q3	3,752,040,437	-46,376,837	-1.24	-23,119
	Q4	3,752,040,437	-70,758,858	-1.89	-35,274
	Year	14,880,973,937	-241,321,916	-1.62	-120,300

n: number; FTE: full-time equivalent.

5.4. Future labour market impacts

Table 5 shows the annual projected labour market impacts of rising heat stress due to climate change during 2040 in each sector of economic activity and across the different SSPs, in relation to the reference historical period 1985-2014. The projected labour-time losses attributable to climate-induced heat stress grow markedly with the global emissions trajectory and are already substantial for Sri Lanka by 2040. Model results indicate that, relative to the 1985-2014 baseline, the economy will lose the equivalent of 145 thousand full-time jobs under a low-emissions pathway (SSP1-2.6). The losses rise to 161 thousand full-time jobs under SSP2-4.5 and reach 210-220 thousand under the high-emissions scenarios (SSP3-7.0 and SSP5-8.5). In proportional terms this represents a 1.9% contraction in total available labour time under the most optimistic scenario and 2.8% under unabated fossil-fuel development.

The burden is highly concentrated in the agriculture sector, which accounts for 58,639 FTE annual job losses in SSP1-2.6, rising to 99,136 in SSP3-7.0, roughly 6% of the sector's total labour force. Agriculture is particularly exposed given the sector's outdoor work intensity and the physiological limits of heavy manual labour in high humid-heat conditions. Services rank second, with annual job losses of 39-53 thousand FTEs across the scenario range, given that much of Sri Lanka's retail, hospitality, and informal urban commerce occurs in environments with limited climate control. Manufacturing follows with 21-29 thousand annual FTE job losses, indicating that existing ventilation and cooling measures in workshops and small factories remain insufficient to offset rising WBGT. Annual losses in construction (15,744 to 23,865 FTEs; 2.5% to 3.7% of total) as well as transport and trade (10,611 to 13,494 FTEs; 1.8% to 2.5% of total) are smaller in absolute terms but remain proportionately significant given those sectors' smaller employment base. Mining and quarrying show minimal impacts, underscoring the advantage of mechanisation and limited workforce size.

Table 6 shows the annual projected labour market impacts of rising heat stress due to climate change during 2060 in each sector of economic activity and across the different SSPs, in relation to the reference historical period 1985-2014. The analysis shows that, by 2060, climate-driven heat stress will remove the equivalent of 158-349 thousand FTE jobs from Sri Lanka's economy each year, depending on the global emissions pathway. Model results show that under the Paris-consistent trajectory (SSP1-2.6) Sri Lanka will lose 158 thousand FTEs, or about 2.1% of total labour force. The toll rises sharply to over 272 thousand FTEs under SSP2-4.5, 314 thousand under SSP3-7.0, and peaks at nearly 349 thousand under SSP5-8.5, where heat cuts 4.6% more aggregate work hours compared to the average year within the historical period.

Losses are highly concentrated in the agriculture sector, reflecting the impacts of heat on outdoor work and heavy manual labour in high humid-heat conditions. In 2060, agriculture will lose nearly 59,000 FTEs in the low-emissions scenario, climbing to nearly 134,000 FTEs in the high-emissions scenario, about 8.1% of the sector's labour force.

Services, often characterised by environments with limited climate control, ranks second, with losses escalating from 47 to nearly 98 thousand FTEs across the scenario range. Manufacturing, where small workshops often lack adequate cooling, will lose 25-51 thousand FTEs, while construction is expected to record 17-42 thousand FTE losses, indicating rising physiological impacts on outdoor field work. Transport and trade show comparable patterns (10,765-22,889 FTEs), whereas FTE losses in mining and quarrying remain marginal owing to mechanisation and limited labour market size. Therefore, implementation of climate mitigation and adaptation policies will save more than 77,000 FTE jobs per year in agriculture, 48,500 FTE jobs in services, as well as about 65,000 FTE jobs in the other industrial sectors (Infographic 3).

Table 5. Projected annual impact of rising heat stress due to climate change during 2040 on full-time equivalent jobs lost (proxied from work hours lost) in each sector of economic activity and across the different SSPs, calculated as the change between 2040 and the reference historical period 1985-2014.

Sector	2040	Available Work Hours (n)	Change in Work Hours		Change in Jobs (FTE)
			(n)	(% FTE)	
Agriculture	SSP1-2.6	3,308,273,280	-117,630,488	-3.56	-58,639
	SSP2-4.5		-141,045,879	-4.26	-70,312
	SSP3-7.0		-198,867,548	-6.01	-99,136
	SSP5-8.5		-177,333,684	-5.36	-88,402
Construction	SSP1-2.6	1,285,590,651	-31,582,293	-2.46	-15,744
	SSP2-4.5		-32,705,765	-2.54	-16,304
	SSP3-7.0		-46,895,749	-3.65	-23,378
	SSP5-8.5		-47,872,372	-3.72	-23,865
Manufacturing	SSP1-2.6	3,125,687,091	-42,356,857	-1.36	-21,115
	SSP2-4.5		-44,943,808	-1.44	-22,405
	SSP3-7.0		-59,510,583	-1.90	-29,666
	SSP5-8.5		-57,967,904	-1.85	-28,897
Mining and Quarrying	SSP1-2.6	89,274,343	-1,705,078	-1.91	-850
	SSP2-4.5		-1,980,775	-2.22	-987
	SSP3-7.0		-2,738,611	-3.07	-1,365
	SSP5-8.5		-2,416,399	-2.71	-1,205
Services	SSP1-2.6	6,195,025,646	-77,533,153	-1.25	-38,651
	SSP2-4.5		-81,087,722	-1.31	-40,423
	SSP3-7.0		-106,563,792	-1.72	-53,123
	SSP5-8.5		-106,459,122	-1.72	-53,070
Transport and Trade	SSP1-2.6	1,156,059,617	-19,262,392	-1.67	-9,602
	SSP2-4.5		-21,284,782	-1.84	-10,611
	SSP3-7.0		-28,888,741	-2.50	-14,401
	SSP5-8.5		-27,068,548	-2.34	-13,494
TOTAL	SSP1-2.6	15,159,910,629	-290,070,261	-1.91	-144,601
	SSP2-4.5		-323,048,733	-2.13	-161,041
	SSP3-7.0		-443,465,024	-2.93	-221,069
	SSP5-8.5		-419,118,029	-2.76	-208,932

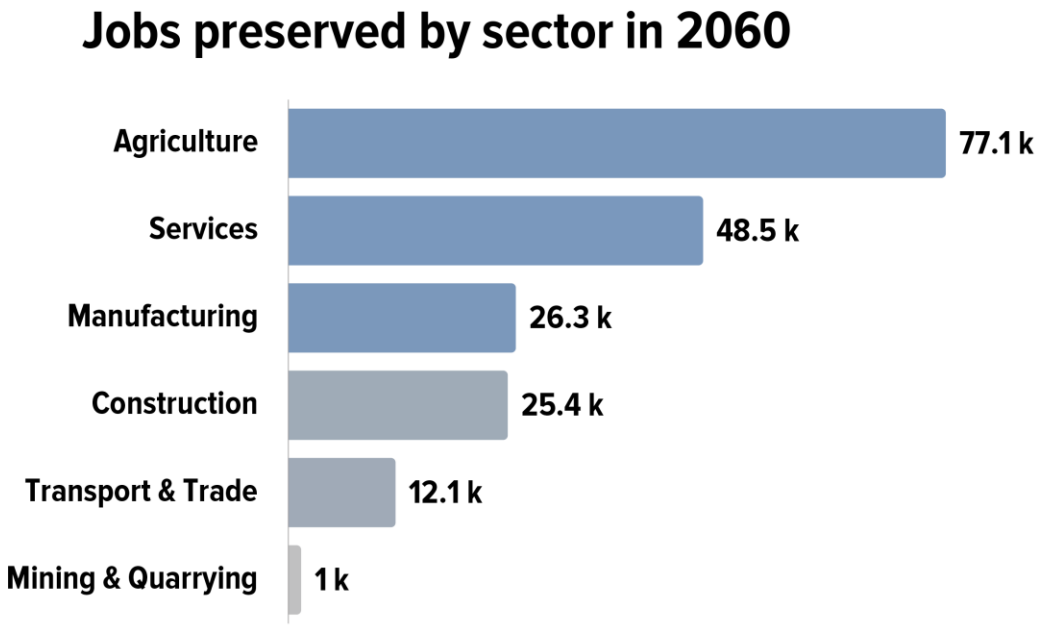
SSP: shared socioeconomic pathway; n: number; FTE: full-time equivalent.

Table 6. Projected annual impact of rising heat stress due to climate change during 2060 on full-time equivalent jobs lost (proxied from work hours lost) in each sector of economic activity and across the different SSPs, calculated as the change between 2060 and the reference historical period 1985-2014.

Sector	2060	Available Work Hours (n)	Change in Work Hours		Change in Jobs (FTE)
			(n)	(% FTE)	
Agriculture	SSP1-2.6	3,308,273,280	-114,134,779	-3.45	-56,897
	SSP2-4.5		-235,854,542	-7.13	-117,575
	SSP3-7.0		-283,279,496	-8.56	-141,216
	SSP5-8.5		-268,846,467	-8.13	-134,021
Construction	SSP1-2.6	1,285,590,651	-34,735,387	-2.70	-17,316
	SSP2-4.5		-56,405,823	-4.39	-28,119
	SSP3-7.0		-61,713,446	-4.80	-30,764
	SSP5-8.5		-85,640,805	-6.66	-42,692
Manufacturing	SSP1-2.6	3,125,687,091	-50,340,172	-1.61	-25,095
	SSP2-4.5		-75,690,164	-2.42	-37,732
	SSP3-7.0		-84,059,404	-2.69	-41,904
	SSP5-8.5		-103,163,740	-3.30	-51,428
Mining and Quarrying	SSP1-2.6	89,274,343	-1,874,643	-2.10	-935
	SSP2-4.5		-3,214,577	-3.60	-1,602
	SSP3-7.0		-3,987,575	-4.47	-1,988
	SSP5-8.5		-3,824,107	-4.28	-1,906
Services	SSP1-2.6	6,195,025,646	-94,866,881	-1.53	-47,292
	SSP2-4.5		-140,691,177	-2.27	-70,135
	SSP3-7.0		-154,890,038	-2.50	-77,213
	SSP5-8.5		-192,066,270	-3.10	-95,746
Transport and Trade	SSP1-2.6	1,156,059,617	-21,595,414	-1.87	-10,765
	SSP2-4.5		-34,591,466	-2.99	-17,244
	SSP3-7.0		-41,328,246	-3.57	-20,602
	SSP5-8.5		-45,914,548	-3.97	-22,889
TOTAL	SSP1-2.6	15,159,910,629	-317,547,276	-2.09	-158,299
	SSP2-4.5		-546,447,749	-3.60	-272,407
	SSP3-7.0		-629,258,204	-4.15	-313,688
	SSP5-8.5		-699,455,936	-4.61	-348,682

SSP: shared socioeconomic pathway; n: number; FTE: full-time equivalent.

Infographic 3. Sectoral labour market benefits of implementing in Sri Lanka the decent work and sustainable development goals as described in SSP1-2.6, particularly in relation to workplace heat stress (calculated as differences between SSP5-8.5 and SSP1-2.6).



Policy messages emerging from the macro-economic analysis

- **Global mitigation matters**. The gap between SSP1-2.6 and SSP5-8.5 amounts to more than 190 thousand saved jobs annually by 2060, underscoring the macro-labour dividend of achieving a 2 °C climate goal.

- **Agriculture and services drive vulnerability**. Targeted adaptation, such as compulsory rest-break schedules and flexible hours as well as high-efficiency cooling retrofits and heat-resilient urban design will deliver the greatest employment protection. Fiscal incentives through energy-efficiency grants or concessional credit can accelerate uptake by small enterprises.

- **Recovery could amplify exposure**. As construction and tourism rebound, additional workers will move into heat-prone roles. Embedding thermal-stress thresholds in labour codes, linking them to social-protection floors and strengthening labour-inspection capacity will be vital to safeguard productivity gains.

Integrating the above measures into Sri Lanka's National Adaptation Plan and Decent Work Country Programme will help protect the labour market from escalating climate-driven workplace heat stress while sustaining inclusive economic growth.

6. Recommendations

6.1. Relevant international labour conventions ratified by Sri Lanka

Sri Lanka would be encouraged to intensify its efforts toward adapting to climate risks, particularly in safeguarding workers from extreme heat and other climate-related hazards. This vulnerability underscores the importance of adopting ILO Conventions that enhance workplace safety in evolving environmental conditions. Aligning with ILO's Occupational Safety and Health (OSH) Conventions will enable Sri Lanka to better integrate climate-resilient practices in the workplace, helping to reduce productivity losses and health risks, particularly in heat-sensitive sectors such as agriculture and construction where workers are most exposed to heat stress.

To date, Sri Lanka has ratified 43 ILO conventions and 1 Protocol, including 8 of the 10 fundamental ones.[47] However, key OSH conventions relevant to managing heat stress have not been ratified by Sri Lanka. These include:

- **Convention No. 155** (Occupational Safety and Health [OSH]), which mandates the establishment of policies to prevent occupational accidents and illnesses. This Convention establishes guidelines for comprehensive OSH policies, which could include adaptive measures such as risk assessments, worker training on heat-related illnesses, and safety protocols specifically designed for extreme weather events.

- **Convention No. 161** (Occupational Health Services), emphasizing the provision of occupational health services. This Convention ensures access to occupational health services capable of monitoring and managing health impacts from environmental factors, and would reinforce Sri Lanka's public health adaptation strategies.

- **Convention No. 187** (Promotional Framework for OSH), which encourages the continuous improvement of national OSH systems. This Convention enables continuous improvement of national OSH systems, supporting the ongoing integration of climate adaptation into health and safety standards.

The absence of ratification and alignment with the above ILO OSH Conventions limits Sri Lanka's capacity for comprehensive OSH improvements, particularly in relation to heat-related policies. This gap highlights the need to integrate climate adaptation measures within existing OSH frameworks to protect workers from increasing heat stress. Given Sri Lanka's susceptibility to climate change and the projected rise in heat stress, as demonstrated in the present study, ratifying the above and other ILO Conventions would play a crucial role in managing heat-related risks.

Incorporating the above Conventions into Sri Lanka's OSH policies would also strengthen national resilience by promoting regular workplace risk assessments and updating safety protocols to address rising heat levels. Such measures would help Sri Lanka prepare for projected increases in heat stress and other climate-related risks, contributing to a safer and more resilient working environment.

Furthermore, ratifying and implementing these OSH Conventions aligns with Sri Lanka's broader climate and development objectives. Integrating OSH standards into climate adaptation efforts supports Sri Lanka's commitment to the Paris Agreement by fostering a just transition for workers, enhancing the country's resilience to climate impacts, and reinforcing both worker protections and economic stability.

[47] https://normlex.ilo.org/dyn/nrmlx_en/f?p=1000:11200:0::NO:11200:P11200_COUNTRY_ID:103172

6.2. Policy recommendations for climate adaptation

Rising workplace heat stress is a major driver of reduced labour productivity and loss of working hours in Sri Lanka, particularly in physically demanding sectors such as construction, agriculture, and manufacturing. In a Consultation Meeting carried out as part of the development of this study, local stakeholders also noted that workplace heat stress is associated with increased absenteeism, health outcomes, and discomfort, leading to reduced enterprise efficiency. They also highlighted additional economic pressures including increased insurance premiums and social protection expenditures related to healthcare and compensation. Overall, local stakeholders identified workplace heat stress as a threat to livelihoods, particularly in the informal economy, where reduced productivity and health risks translate directly into income loss and job insecurity. Environmental degradation and deteriorating working conditions were also linked to increased rural-urban and cross-border migration pressures.

To enhance Sri Lanka's climate resilience and protect worker health, the country could consider further aligning its climate adaptation policies with ILO OSH standards. Adopting these standards would establish a comprehensive framework for addressing heat stress and other climate-related occupational hazards, particularly in sectors most vulnerable to heat, such as agriculture, construction, and services. This alignment with ILO OSH standards includes:

1. **Development of National Heat-Stress Guidelines:** Sri Lanka is encouraged to work towards establishing national heat stress guidelines that align with recent ILO recommendations[1] on the prevention and mitigation of heat stress in the workplace, as well as those in Convention No. 155 (Occupational Safety and Health), which mandates workplace policies to prevent accidents and illnesses, and Convention No. 161 (Occupational Health Services), emphasizing the provision of adequate health services for workers. These guidelines should adopt the general OSH protection framework for heat stress recommended by the ILO[1] that includes, as a minimum standard, the following 10 basic protection requirements (grouped based on ILO's hierarchy of controls; also illustrated in Infographic 4):

- **Risk Assessment:**

1. Participatory risk assessment in the working environment integrating excessive heat.
2. Use of the WBGT as a potential heat stress indicator to assess the level of heat exposure, with varying safety thresholds based on work intensity.

- **Engineering Controls:**

3. Provision of cool, shaded, and ventilated rest areas.

- **Administrative Controls:**

4. Identification of and targeted strategies for worker groups at high risk.
5. Hydration strategies, including adequate sanitation facilities, especially for female workers.
6. Rest, breaks or modified work schedules to limit or avoid exposure to excessive heat, including the ability to self-pace.
7. Heat acclimatization measures for workers without recent heat exposure.
8. Education and awareness on heat stress and heat-related illnesses.
9. Regular medical check-ups and health monitoring.

- **Personal Protective Equipment:**

10. Personal protective equipment designed to protect workers from heat stress.

2. **Implementation of Regular Monitoring and Risk Assessments:** Sri Lanka is encouraged to implement systematic mechanisms for collecting, analysing, and reporting data on workplace heat stress impacts on health and productivity and should aim to increase awareness and communication among employers and workers regarding climate-related occupational hazards, together with consistent enforcement of existing legislation. Moreover, continuous monitoring and risk assessment protocols should be incorporated in workplaces, guided by Convention No. 187 (Promotional Framework for OSH). This would involve employers conducting regular assessments of workplace conditions using, preferably, the WBGT index, to evaluate heat stress levels and assess the effectiveness of heat mitigation measures. Additionally, employers should be encouraged to provide regular updates on worker exposure, health risks, and preventive measures, ensuring transparency and accountability in managing workplace heat hazards.[1]

3. **Role of Employers in Minimizing Heat-Related Hazards:** In a Consultation Meeting carried out as part of the development of this study, local stakeholders noted that many workplaces lack basic infrastructure, such as cooling facilities, shaded areas, access to potable water and appropriate sanitation. In this light, employers should be encouraged to implement preventive measures for minimizing heat exposure risks. This should include, at a minimum, the development of a nation-wide early warning system, modified work hours during extreme heat, access to cooling solutions, and training for both employers and workers on identifying and responding to heat-related illnesses. Aligning with ILO's Decent Work Agenda, these measures would enhance working conditions and uphold workers' rights to a safe and healthy workplace, particularly critical in Sri Lanka's agriculture and construction sectors, where exposure to high heat exposure is frequent. Particular attention should be given to ensure that the developed frameworks and procedures cover informal workers and micro, small, and medium-sized enterprises, building on existing good practices such as those in fisheries. Investments in public infrastructure (e.g., shaded rest areas, potable water points, and adequate sanitation near worksites) should be prioritised, as well as the design and use of differentiated personal protective equipment suited to varying heat and humidity conditions.

4. **Integration of Heat Stress into National OSH Policies:** In a Consultation Meeting carried out as part of the development of this study, local stakeholders noted a limited integration of workplace heat stress considerations into labour relations, collective bargaining, and social dialogue processes, as well as insufficient updating of OSH frameworks to address climate-related risks and re-skilling needs. Also, fragmented policy responses were noted across ministries responsible for labour, health, environment, and related areas, with limited coordination mechanisms in place. Stakeholder participation was described as uneven, with inconsistent engagement of the private sector, employers' organizations, trade unions, academia, and civil society. Finally, the limited localisation and application of international good practices and codes of conduct was also identified as a constraint. To reverse this situation, Sri Lanka is encouraged to explicitly incorporate heat stress as a key occupational hazard in its OSH policies, following ILO guidance on climate-responsive OSH frameworks. Policies should include minimum heat safety standards, mandatory reporting of heat-related incidents, and guidelines for high-risk sectors. Additionally, adopting national standards on emergency preparedness for extreme weather events would support worker protection in times of intense heat, aligning with ILO recommendations on OSH practices in a changing climate.[1]

   There is also a need for inclusive and structured coordination involving a broad range of actors. The National Labour Advisory Council could be used as a central platform to map stakeholders, consolidate ongoing initiatives, and promote coherent national action on workplace heat stress and OSH. Key ministries to be engaged in this process could include Finance, Health, Agriculture, Environment, Industry, Trade, Fisheries, Power and Energy, Foreign Affairs, Transport, as well as the Ministry of Digital Economy. Research and academic institutions could also contribute to evidence-based policymaking, alongside national agencies such as the Department of Labour, the Department of Census and Statistics, the Board of Investment, and the Department of Meteorology. International partners,

including the ILO, UN system agencies, development partners, climate organisations, international experts in workplace heat stress, as well as labour and human rights organisations, represent important sources of technical support, normative guidance, and good-practice exchange. Knowledge sharing through South-South and triangular cooperation represents another means of adapting successful models from countries with similar climatic and economic conditions.

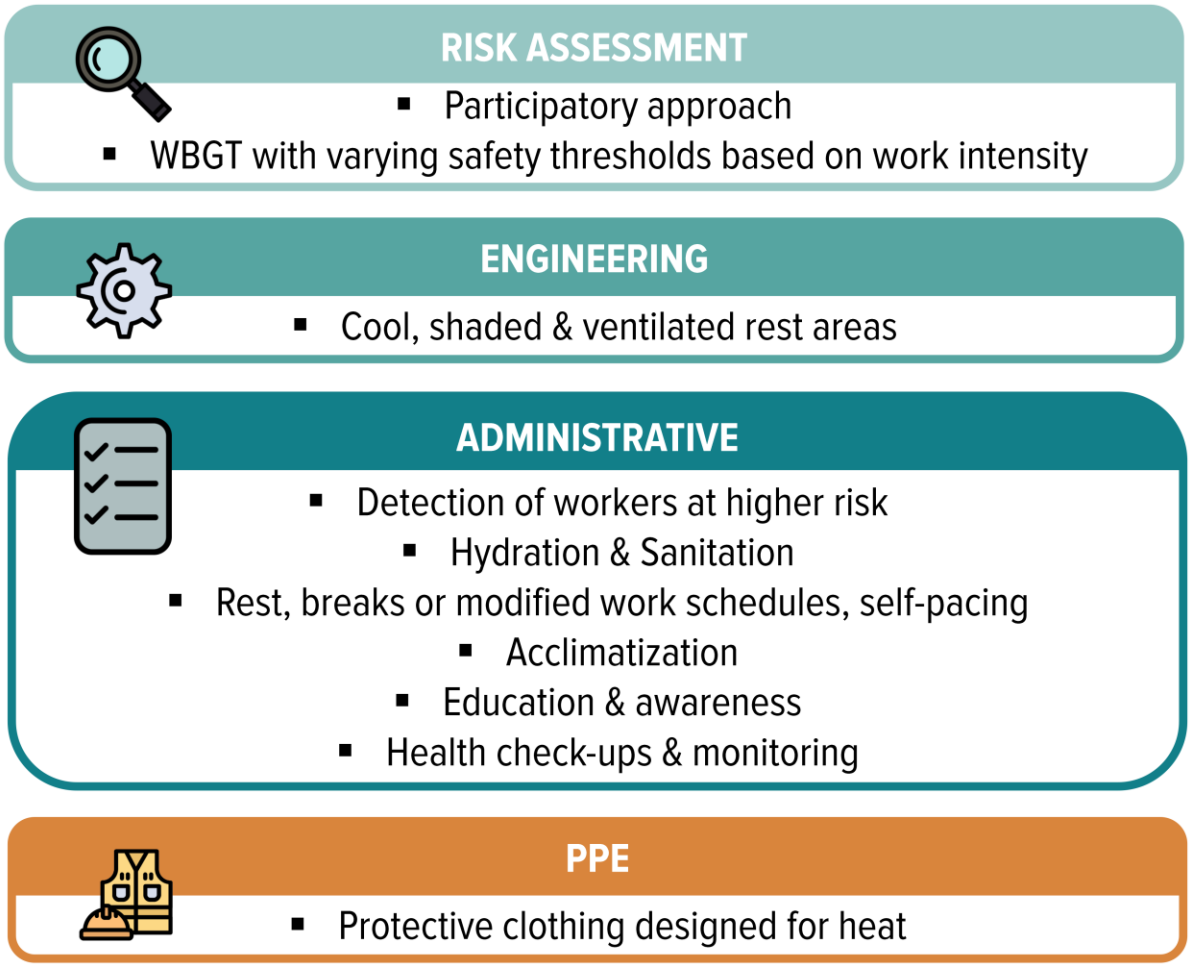
The President's Office or a dedicated inter-ministerial committee may strengthen leadership and coordination, overseeing cross-sectoral action on workplace heat stress. Actions under the Ministry of Health's Heat Health Action Plan and Sri Lanka's Third Nationally Determined Contribution should be aligned with labour, OSH, and productivity objectives. Legislative enforcement could be strengthened by updating OSH regulations to explicitly cover climate-related risks and sector-specific exposure thresholds. Greater transparency could be encouraged through enterprise-level reporting on workplace heat conditions and mitigation measures.

5. **Promotion of Workplace Health Services and Support Systems:** In a Consultation Meeting carried out as part of the development of this study, local stakeholders noted a lack of sex-disaggregated data which may mask gender-differentiated vulnerabilities, particularly affecting women in informal employment and care-related activities. Ensuring that all workplaces provide occupational health services that can monitor, advise, and treat workers affected by heat exposure is essential for worker safety. As per ILO Convention No. 161, access to these services should be mandatory, particularly in sectors most vulnerable to heat stress. It is important that Sri Lanka's health services include regular check-ups for workers, first aid for heat-related incidents, and preventive health programs focused on adapting to high-temperature work environments.[1] Re-skilling and lifelong learning programmes, including recognition of prior learning, would greatly benefit workers whose jobs are at risk due to workplace heat stress or climate-related economic shifts. Expanding social protection measures for heat-affected workers, particularly those in informal and seasonal employment, could be further emphasised, together with gender-responsive interventions, supported by targeted research, to better understand and address differentiated impacts. National awareness campaigns could improve understanding of workplace heat stress risks and adaptation measures. Strengthening social dialogue through active involvement of employers' and workers' organisations in the design, implementation, and monitoring of heat adaptation policies is also important.

6. **Utilization of social security funds to incentivise OSH and workplace heat stress adaptation:** Social security funds can be leveraged as an active policy instrument to incentivise OSH compliance and workplace heat stress adaptation. One potential approach is to introduce temporary reductions or suspensions of employer contribution rates, conditional on the verified implementation of workplace adaptation measures, such as cooling infrastructure, modified working hours, improved ventilation, or the provision of appropriate protective equipment. Foregone contributions could be recovered gradually over time, once adaptations are in place and operational. Such mechanisms can support employer cash flow in the short term, enabling necessary investments in workplace heat stress prevention and broader OSH improvements, while contributing to a reduction in work-related injuries and heat-related illnesses over time. In the medium to long term, this can generate savings for social security systems through lower benefit claims, reduced absenteeism, and improved labour productivity. By acting as preventative investors, social security funds can help shift OSH policy from a reactive to a preventive model. Temporarily lowering employer contributions in exchange for demonstrable risk-reducing measures creates financial incentives for enterprises to invest in safer and more resilient workplaces. These early-on incentives can significantly reduce future liabilities for social security administrations by lowering the incidence of occupational injuries, diseases, and disability claims. Overall, this approach aligns employer incentives with long-term system sustainability. Employers benefit from improved liquidity to upgrade workplaces, workers benefit from safer and healthier working conditions with reduced workplace heat stress risk, and social security systems benefit from improved financial sustainability through a healthier and more productive workforce.

By adopting the above ILO-aligned policy recommendations, Sri Lanka can strengthen its climate adaptation efforts, create safer working conditions, and foster resilience among its workforce against climate change and rising heat stress. Moreover, implementing these recommendations will contribute to a sustainable, just transition in Sri Lanka's labour market, in alignment with global labour and climate goals.

Infographic 4. Decent work protection package for workplace heat stress, based on ILO's 10 basic protection requirements (grouped based on the hierarchy of controls).



6.3. Key recommendations for climate adaptation per sector

Rising heat stress is already undermining worker health, productivity, and overall economic resilience in Sri Lanka. In light of the evidence presented in this study, Sri Lanka is encouraged to adopt sector-specific adaptation strategies that not only protect workers but also support continued economic activity. The following recommendations outline targeted measures for each key economic sector, integrating the sector-specific vulnerabilities highlighted in earlier parts of the present study with practical, evidence-based adaptation strategies, ensuring that policy-makers and stakeholders have clear guidance on protecting workers and supporting economic stability in the face of rising workplace heat stress due to climate change. Importantly, these recommendations should be applied in addition to – not in place of – the general OSH protection framework for heat stress recommended by the ILO[1] which is described in Section 6.2. Collectively, the

recommendations included in the present study provide a framework for tailoring climate adaptation measures to the unique challenges and opportunities within each economic sector. By implementing these strategies, Sri Lanka can protect its workforce, sustain productivity, and enhance the resilience of its economy in the face of a warming climate.

Agriculture: In recent years, agricultural output has faced stagnation and periodic declines. Policy disruptions and adverse weather led to contraction in 2021–2022. Notably, input shortages (including a temporary ban on chemical fertilizers and fuel scarcities during the 2022 economic crisis) caused significant drops in crop yields.[48] For example, the agriculture sector saw an annual decline of around 8% during parts of 2022 amid these challenges. However, there have been signs of recovery more recently. With the restoration of conventional farming inputs and favourable weather in some regions, 2023 saw agriculture return to modest growth, driven especially by improved rice and fruit harvests.[49] Still, the sector's growth remains below potential, and productivity is relatively low, as many farmers are smallholders relying on rain-fed cultivation.[50]

A major concern is climate variability and change. The country's Department of Meteorology notes that Sri Lanka frequently faces droughts and floods that cause crop failures and damage rural livelihoods.[51] Climate models project that rising temperatures will depress yields of key staples like rice, and unpredictable rainfall patterns (due to disrupted monsoons) are already impacting farm output.[21,52] These climate impacts, combined with land degradation and limited water storage, threaten the consistency of agricultural production. Another challenge is low productivity and modernization, as many farming communities lack access to advanced technologies, irrigation, and credit, leading to lower yields and incomes[50] as well as to increased labour productivity as manual labour is most vulnerable to heat-induced impacts.

As the majority of work in agriculture is performed outdoors and workers are directly exposed to the natural elements, adaptation strategies should focus on minimizing heat exposure. These include adjusting work schedules to avoid the hottest parts of the day alongside implementing on-site measures such as the installation of shade structures, provision of adequate hydration, and cooling stations. Additionally, adapting crop management practices by shifting planting cycles and choosing heat-tolerant crop varieties can reduce the vulnerability of agricultural production to extreme heat. Worker training on recognizing the signs of heat stress and on implementing first-aid measures further enhances resilience in this critical sector.

In addition to the above adaptation strategies, there is significant scope for productivity improvements through better irrigation, mechanization, and training for farmers in climate-smart techniques. Currently, the Department of Meteorology's agro-meteorology advisory services help by providing farmers with timely climate information to plan daily work as well as planting and harvesting, an approach that could be further expanded.[53] By exploring these opportunities, the agriculture sector can improve its contribution to GDP and continue to support a large segment of the population, while strengthening national food security.

Construction: Construction work is characterized by intense physical labour and significant exposure to outdoor heat. These characteristics are important to understand because the construction sector in Sri Lanka struggles

[48] Strategic Research Limited (2023). Gross Domestic Production - Sri Lanka 2022. Department of Census and Statistics, BRS Equity Research. https://cdn.cse.lk/cms-internal/news/ozmQpOwArTMPyA3R_21Sep2022041341GMT_1663733621713.pdf. Accessed: 3/12/2024.
[49] Central Bank of Sri Lanka (2023). National Accounts Estimates - 2023. Department of Census and Statistics. Colombo, Sri Lanka. https://www.cbsl.gov.lk/sites/default/files/cbslweb_documents/national_account_estimates_2023_annual_e.pdf. Accessed: 3/1/2025.
[50] Food and Agriculture Organization of the United Nations. Rehabilitation of agriculture and the rural sector in the North East. https://www.fao.org/4/ag114e/AG114E08.htm. Accessed: 3/12/2024.
[51] Manesha S., Vimukthini S., Premalal K.H.M.S. (2015). Develop drought monitoring in Sri Lanka using Standard Precipitation Index. Sri Lanka Journal of Meteorology; 1: 64-71.
[52] Ministry of Environment (2021). Updated nationally determined contributions under the Paris agreement on climate change - Sri Lanka (Cabinet Paper No. 21/1259/321/012). Climate Change Secretariat, Ministry of Environment.
[53] Sri Lanka Department of Meteorology. https://meteo.gov.lk/index.php?option=com_content&view=article&id=19:learn-about-meteorology&catid=8&lang=en&Itemid=317. Accessed: 3/12/2024.

with a lack of advanced construction technology adoption.[54] To protect construction workers, employers should consider rescheduling work to cooler periods, such as early mornings or late afternoons, and enforcing regular, scheduled breaks during the day. The deployment of portable shading, misting systems, and on-site hydration stations is critical to reducing workplace heat stress. Engineering controls, such as using reflective materials or temporary shade/insulation, can further mitigate the thermal load on construction sites. In addition, worker acclimatization programs and ongoing risk assessments are vital to ensure that adaptation measures remain effective as environmental conditions evolve.

Manufacturing: A challenge within the manufacturing sector in Sri Lanka is its limited diversification. Apparel dominates, while higher-value or tech-intensive industries are relatively under-developed.[54] Global market conditions (such as economic slowdowns in key export markets or changes in trade policies) can, therefore, significantly impact Sri Lanka's manufacturing output. For example, demand fluctuations in the US and EU directly affect garment orders and factory workloads in Sri Lanka.

Despite challenges, there are notable opportunities to expand and upgrade the manufacturing sector.[54] Sri Lanka's strategic location along major Indian Ocean shipping routes presents an opportunity to develop as a regional manufacturing hub. This will be significantly benefited by increasing labour productivity. Manufacturing facilities, whether operating indoors or in partially exposed environments, should address both process-generated and environmental heat. Enhancing indoor climate control through improved ventilation and energy-efficient air conditioning systems is a key priority. Implementing structured work-rest cycles and staggered shifts can help manage cumulative heat exposure. In addition, installing real-time monitoring systems to track WBGT levels enables a proactive response to emerging heat stress risks. Employee education and training on the importance of hydration and heat stress symptom recognition can further support a healthier and more productive workforce.

Mining and Quarrying: For mining and quarrying operations, which often occur in environments with high ambient temperatures or in confined underground spaces, robust environmental controls are crucial. Recommended actions include upgrading ventilation and cooling systems to maintain safer working conditions, as well as scheduling operations to reduce exposure during peak heat periods. Establishing mandatory rest breaks with access to cooled rest areas can help mitigate the physiological strain experienced by workers. Regular monitoring of WBGT, paired with comprehensive risk assessments, will ensure that protective measures are effectively tailored to fluctuating conditions. Where feasible, increased mechanization may reduce the need for direct human exposure to hazardous thermal conditions.

Services: The services sector is the largest segment of Sri Lanka's economy, reflecting the country's evolution toward a service-oriented market. In 2023, services accounted for 66% of GDP,[31] making it the dominant contributor to economic output. Services also provide 57% of all jobs, covering a range of activities from trade and transport to education and finance.[37] Major service industries include wholesale and retail trade, transportation, banking and finance, telecommunications, public administration, and importantly tourism. Tourism is often highlighted as a critical sub-sector given its foreign exchange earnings and community-level economic impact.

Although the services sector is predominantly indoor, many subsectors (including retail, hospitality, and tourism) are vulnerable to heat stress, especially in facilities with inadequate climate control or in areas where outdoor work is required. Ensuring that workplaces are fitted with efficient cooling and ventilation systems, and that indoor temperatures remain within safe limits during heatwaves will safeguard workers' health and their productivity levels. Flexible scheduling and remote work options can also help mitigate risks for workers, particularly those performing heat-vulnerable jobs/tasks. In addition, service providers are encouraged to develop contingency plans and to conduct regular training and awareness campaigns about the risks of workplace heat stress. Such measures not only protect worker health but also support uninterrupted service delivery during periods of extreme heat.

[54] World Bank (2024). Sri Lanka Development Update. Opening up to the Future. Washington DC, USA.

Transportation and Trade: The transportation and trade sector, which encompasses both outdoor activities and logistics operations, faces unique challenges from heat stress. It is recommended that work schedules be modified to avoid extreme heat, with the establishment of climate-controlled rest areas and loading docks. Equipping drivers and logistics personnel with cooling equipment and appropriate personal protective gear will protect their health, reduce absenteeism, and safeguard uninterrupted service delivery. Moreover, infrastructural improvements, such as installing shading and misting systems at key transport hubs, can reduce heat exposure and maintain the efficiency of supply chains. These measures are critical to ensuring that the sector's operational continuity is not compromised by rising heat levels.

6.4. Role of the ILO's decent work agenda

Implementing the above-mentioned ILO-aligned policy recommendations and advancing the broader goals of the ILO Decent Work Agenda will generate important benefits for Sri Lanka, as demonstrated in this study. This agenda aims to provide safe, productive, and fair working conditions, which are increasingly critical as Sri Lanka faces heightened climate impacts, particularly rising heat stress levels. By adopting these measures, Sri Lanka will bolster its climate adaptation efforts, enhance workplace safety, and build resilience among its workforce against climate change and increasing heat stress. Furthermore, as shown below, adopting these measures will support a sustainable and just transition within Sri Lanka's labour market, aligning with both global labour standards and climate objectives.

- **Promoting Safe and Healthy Workplaces in Sri Lanka Amidst Rising Heat:** The Decent Work Agenda[55] prioritizes safe and healthy workplaces as essential for sustainable and equitable employment. For Sri Lanka, adopting OSH Conventions such as Convention No. 155 (Occupational Safety and Health) and Convention No. 161 (Occupational Health Services) establishes a solid framework for safeguarding workers in sectors particularly susceptible to extreme heat, including agriculture and construction. As highlighted in the present study, these sectors are crucial to Sri Lanka's economy but are highly vulnerable to climate impacts, making the implementation of heat stress protections a pressing need. Establishing national heat stress guidelines and mandatory mitigation strategies aligns closely with the Decent Work Agenda's commitment to securing safe conditions across industries.[55]

- **Enhancing Productivity through Climate-Responsive OSH Measures:** Safe working conditions are essential to sustaining worker productivity, a core priority of the Decent Work Agenda.[55] Implementing heat adaptation strategies, such as structured work-rest cycles and hydration protocols, allows Sri Lanka to minimize productivity losses due to heat stress.[1] These measures help maintain productivity levels during periods of intense heat, reducing economic disruptions and supporting a resilient labour market.[1] The Agenda's focus on fair and productive workplaces highlights the importance of addressing environmental risks that could jeopardize economic stability and workforce productivity.[55]

- **Focusing on Vulnerable and Informal Workers:** Informal workers, particularly those in agriculture, construction, and other high-risk sectors, are especially vulnerable to climate impacts due to limited access to social protections and occupational safety measures.[1] The Decent Work Agenda promotes inclusive and fair working conditions, ensuring protections for vulnerable groups.[55] Applying OSH standards to address climate risks helps prevent these workers from being disproportionately affected by rising heat. By mandating workplace safety measures, Sri Lanka can enhance both climate resilience and social equity, fostering safer work environments across all segments of its labour market.

[55] International Labour Organization. Decent work and the 2030 Agenda for sustainable development. Geneva, Switzerland (https://www.ilo.org/topics-and-sectors/decent-work-and-2030-agenda-sustainable-development).

- **Advancing Social Protection and Fair Conditions:** The Decent Work Agenda emphasizes social protection as a cornerstone of fair and sustainable employment.[55] By adopting ILO OSH Conventions, Sri Lanka can establish climate-responsive social protections, including health monitoring, emergency response services, and compensation for heat-related illnesses. This approach promotes equitable conditions amid climate challenges, aligning with the Agenda's commitment to secure and just employment for workers facing environmental stressors.[55]

- **Contributing to Sri Lanka's Just Transition to a Climate-Resilient Economy:** Incorporating the Decent Work Agenda into climate adaptation initiatives also aligns with Convention No. 187 (Promotional Framework for OSH), which encourages continuous improvement in national OSH policies. This framework is key to Sri Lanka's just transition, supporting the development of a climate-resilient economy by fostering equitable and sustainable working conditions across all sectors. By embedding OSH standards within climate policies, Sri Lanka can protect its workforce, ensuring that workers—especially those in high-risk sectors—are supported against the impacts of climate change and increasing heat stress.

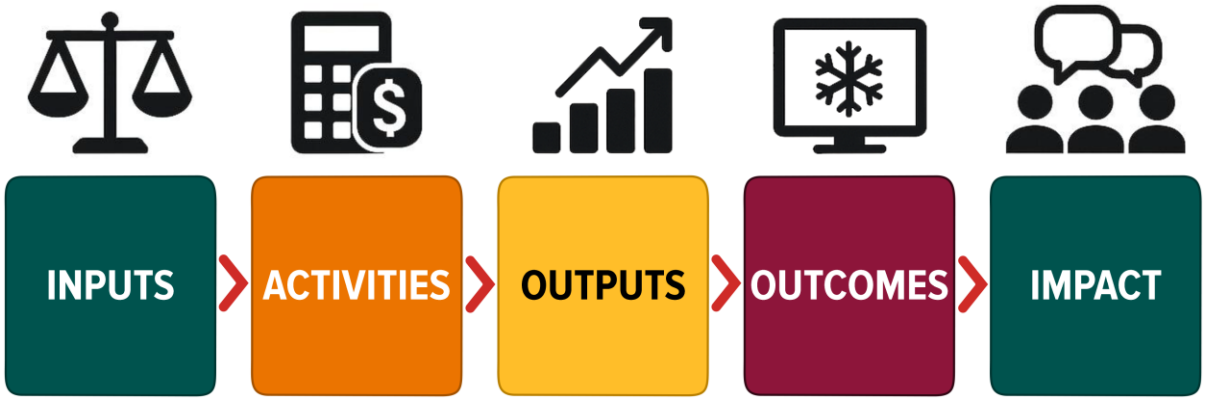
In summary, designing future climate and environment policies in line with the ILO Guidelines for a just transition towards environmentally sustainable economies and societies for all will generate important public health, societal, and labour market benefits for Sri Lanka. This will ensure that these policies will maximize the opportunities and minimize any challenges from the transition to a climate-resilient economy, including for workers in heat sensitive sectors. Coordinated efforts between the Government of Sri Lanka, international organizations, and civil society are essential to ensuring that climate actions promote economic recovery and safeguard employment. Aligning climate adaptation strategies with the ILO Decent Work Agenda provides Sri Lanka with a comprehensive approach to addressing climate impacts on labour, helping ensure that its workforce remains safe, productive, and resilient in the face of rising heat.

7. Scenario analysis to decent work and SDG implementation

Building on the findings described in Sections 2-5, scenario analyses were used to examine what changes if Sri Lanka fully implements the ILO Decent Work Agenda and advances the 2030 Agenda. The analysis follows the ILO results logic used in Decent Work Country Programmes, moving from inputs to activities, to outputs, to outcomes, and to impact (Infographic 5). It also uses the GDP and employment projections reported in Section 5 for 2040 and 2060 under SSP1-2.6 (low emissions) and SSP5-8.5 (high emissions), contrasting the two policy futures (SSP1-2.6 vs. SSP5-8.5) and highlighting the "policy dividend" of decisive action. The approach is grounded in the four pillars of decent work: employment, rights at work, social protection, and social dialogue. These pillars are the core of the ILO mandate and guide national action and international support.

Inputs include strong political commitment to the four Decent Work pillars, ratification and enforcement of key ILO Conventions, budgetary allocations for heat-risk management, as well as access to climate and social finance. They also include reliable data on workplace heat exposure and labour conditions, as well as tripartite dialogue that brings government, employers, and workers to the same table. Finally, they include ILO's technical support under the Global Flagship Programme on Building Social Protection Floors and the Guidelines for a just transition towards environmentally sustainable economies and societies for all.

Infographic 5. Decent Work theory of change for heat-safe work in Sri Lanka: from inputs to impact.



Activities translate the inputs into practice. They comprise: (1) ratification and enforcement of ILO Conventions 155, 161 and 187; (2) adoption of a national heat-stress legislation anchored in the 10 ILO protection requirements and the recommendations of Section 6; (3) extending social-protection floors to cover heat-related sickness, income protection and injury benefits for formal and informal workers; (4) shift of public- and private-sector investment equal to 0.3-0.5% of GDP per year toward heat-safe, energy-efficient workplaces and public spaces (efficient cooling, urban heat-island mitigation, shaded transport hubs), and skills for green and heat-safe jobs; and (5) strengthening labour inspection and tripartite social dialogue to co-design sector-specific protocols; and (6) establishing monitoring systems to track WBGT, lost work time, and heat-related illness.

Outputs follow quickly. More worksites apply heat-safe procedures. More workers have access to shade, water, rest, as well as first aid and health checkups. A larger share of workers is covered by health services and income support when heat disrupts work. Labour inspection has practical tools for oversight. Local governments and firms use heat alert systems. Trade unions and employer groups have agreed playbooks for peak-heat days. These outputs align with the ILO Just Transition Guidelines, which call for policy coherence, social dialogue, rights, and decent work in climate action.

Outcomes include fewer hours lost to heat and absenteeism, lower injury and illness rates, higher retention, and steadier productivity. Women, youth, and informal workers gain from safer jobs and better income protection. Firms report fewer heat-related disruptions and smoother logistics. Municipal services and public works run more reliably during hot months.

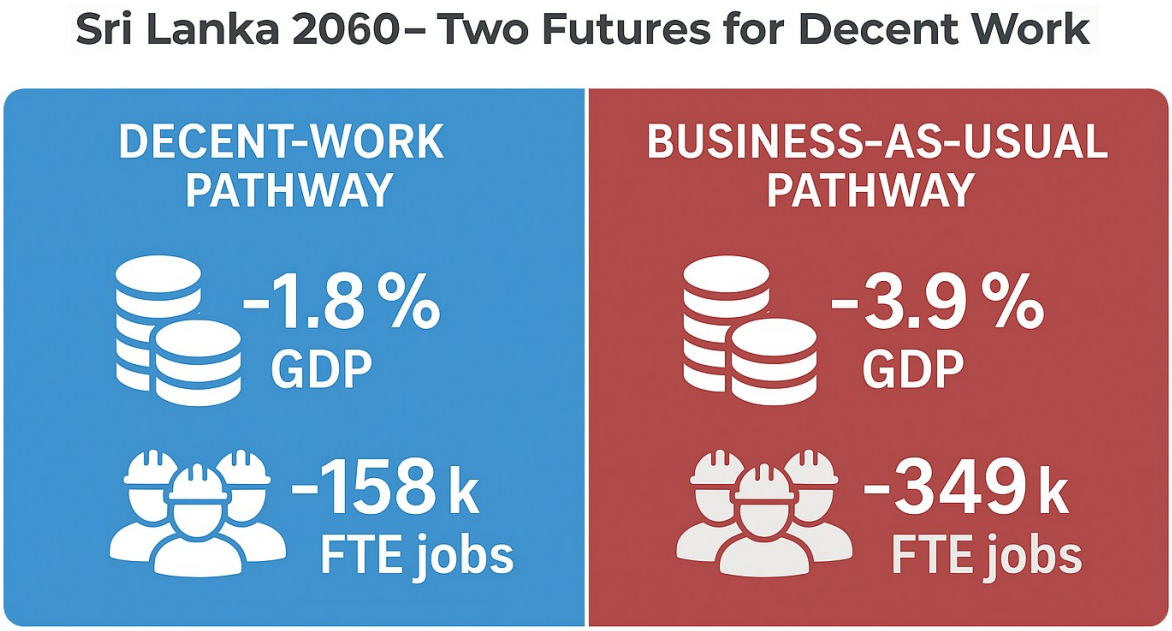
The long-term ***impact*** is a larger effective labour supply, safeguarded GDP, fewer jobs lost to heat, and higher output. Progress is visible on SDG 8 on decent work and economic growth, SDG 3 on health and well-being, and SDG 13 on climate action. This path also supports SDG 1 on poverty reduction through income security when work should pause.

Scenario design

The scenarios examined use the projections in Section 5 of this study for 2040 and 2060, coupling global climate pathways with domestic policy efforts. The numbers below are those in Section 5, representing the heat penalty against the 1985 to 2014 baseline (key results summarized in Infographics 6-9).

- **Scenario 1: "Sustainable Decent Work Future"** – *High ambition for climate and decent work.* In this scenario, Sri Lanka aligns national policy with the ILO Decent Work Agenda (employment creation, rights at work, social protection and social dialogue) and the Sustainable Development Goals, while pursuing a low-emission development trajectory consistent with SSP1-2.6. This means aggressive climate action and adaptation measures, along with social and labour reforms. Some key reforms include:
  - **Climate Pathway:** Global and national efforts limit climate change, in line with SSP1-2.6 or Paris Agreement goals. Temperature and heat stress increases are kept moderate.
  - **Policy Actions:** The country invests in adaptation and labour protections: (1) ratification and enforcement of ILO Conventions 155, 161 and 187; (2) a national heat-stress code of practice anchored in the 10 ILO protection requirements and the recommendations of Section 6 above; (3) expansion of the Social Protection Floor to cover all formal, informal, and migrant workers affected by climate shocks; (4) shift of public- and private-sector investment equal to 0.3-0.5% of GDP per year toward green construction, renewable energy, and adaptive infrastructure; and (5) institutionalised tripartite dialogue so that workers' voices help shape adaptation strategies. These actions reflect core Decent Work pillars (employment, social protection, rights, social dialogue) directed at climate resilience.
  - **Impacts:** With lower global warming and strong domestic measures, the negative impacts on productivity and jobs are greatly mitigated. The findings presented in Section 3.2.2 show that, under a low-emissions scenario, productivity loss due to rising heat stress from climate change is relatively limited (only **2-14% loss** in low/moderate-intensity work and **10-18% loss** in high-intensity work by 2100). If Sri Lanka further improves workplace conditions by adopting effective labour policies (e.g. those outlined in Section 6), even these moderate losses can be curbed. Economically, this scenario means **far less GDP lost** to heat stress. For instance, whereas 2023 saw an estimated **USD 6.5 billion GDP loss due to climate-induced heat stress**, under a sustainable path this annual loss would grow slowly or even plateau as adaptation is initiated. Socially, the number of jobs at risk would be much lower: the estimate of **~120 thousand full-time equivalent jobs lost** in 2023 (see Section 5.3) to heat stress would remain manageable or decline with interventions. In short, this "high-action" scenario portrays a Sri Lanka that achieves **resilient growth** – protecting workers from climate hazards, creating new decent jobs in sustainable industries, and thus advancing multiple Sustainable Development Goals (decent work, poverty reduction, good health, climate action). It exemplifies how implementing the Decent Work Agenda and 2030 Agenda **reduces vulnerabilities and strengthens the economy** in the face of climate change.

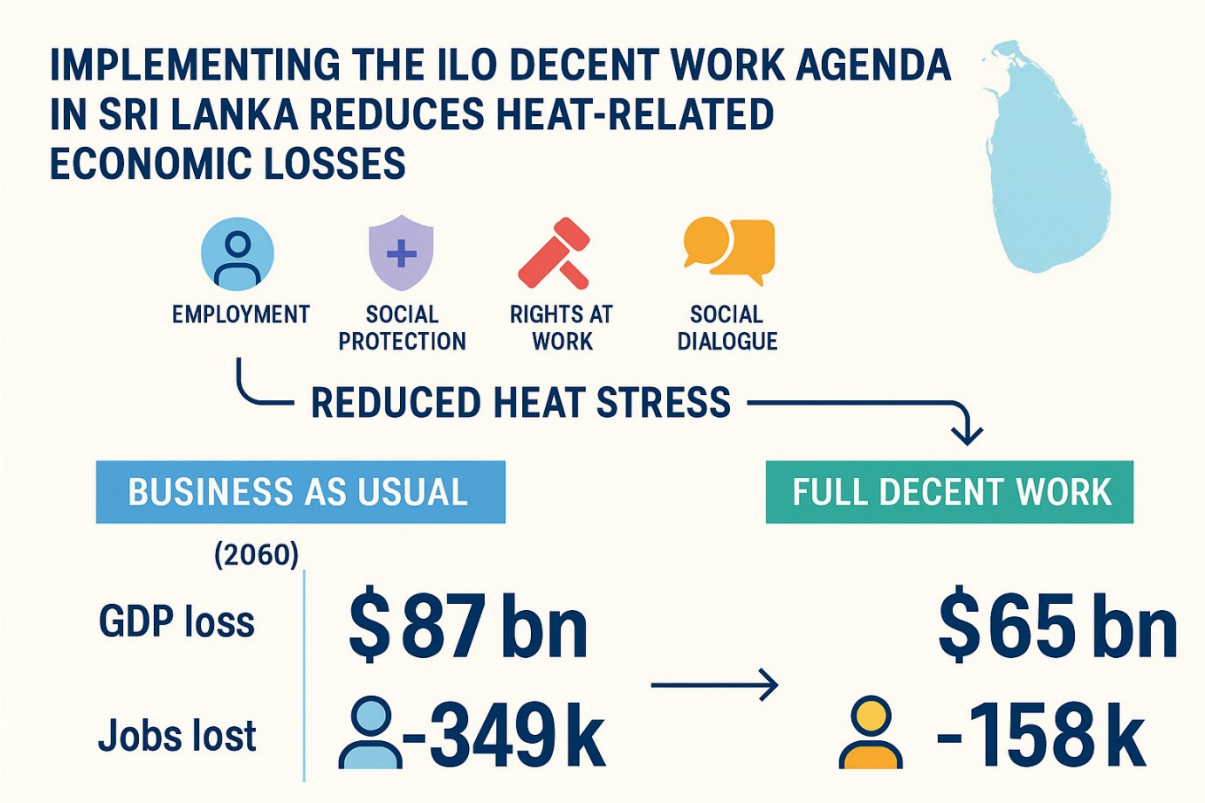
Infographic 6. Scenario analysis to decent work and sustainable development goal implementation. Figures calculated based on the results presented in Section 5.



- **Scenario 2: "Business-as-Usual and Inaction"** – *Low ambition, high climate risk.* This scenario assumes that neither strong climate action nor Decent Work Agenda reforms are pursued sufficiently:
  - **Climate Pathway:** The world follows a high-emissions trajectory (analogous to SSP5-8.5), leading to **severe warming** and intensifying heat stress in Sri Lanka. By late century, summers are significantly hotter – a drastic rise in days exceeding safe work temperatures.
  - **Policy Status:** Sri Lanka's policies remain reactive or fragmented. Workplace safety measures against heat are minimal, social protection systems do not expand to cover climate-related risks (leaving many informal and rural workers without support), and many opportunities in the green economy are missed. Economic development continues with a brown growth model (economic development that relies heavily on fossil fuels and does not consider the negative side effects that economic production and consumption have on the environment), and labour rights/enforcement improvements stall.
  - **Impacts:** Under this scenario, the **worst case** from the present analysis **comes true**. By 2100, workplace productivity in high-intensity labour could **decline by over 40%** more than the historical period due to extreme heat, and even low-intensity sectors will see 25-30% increases. The loss of workable hours would slash national output – effectively, climate change becomes a major burden on GDP. In 2023, climate-induced heat stress already cost **8% of GDP**; by mid-to-late century under unabated warming, Sri Lanka could be losing **up to 15.2% of GDP** annually from heat stress alone. The sectoral breakdown of productivity indicates that the **agriculture and services sectors** would be hardest hit, potentially facing productivity losses up to ~70% in worst conditions by 2100 (loss observed during historical period plus loss caused by climate change), which is devastating for livelihoods in rural communities and among outdoor workers. In terms of employment, the **FTE job losses would mount year by year**. Today's ~120 thousand annual jobs lost could increase nearly three-fold as temperatures rise – meaning hundreds of thousands of jobs effectively erased by climate impacts. Unchecked, this scenario undermines several Sustainable Development Goals: poverty and inequality worsen (as vulnerable workers lose income), health deteriorates (from heat-related illnesses), and economic growth stalls (missing targets of Goal 8). Moreover, without decent work reforms (Section 6), any new jobs that do appear (e.g. in adapting infrastructure) may be low-quality or

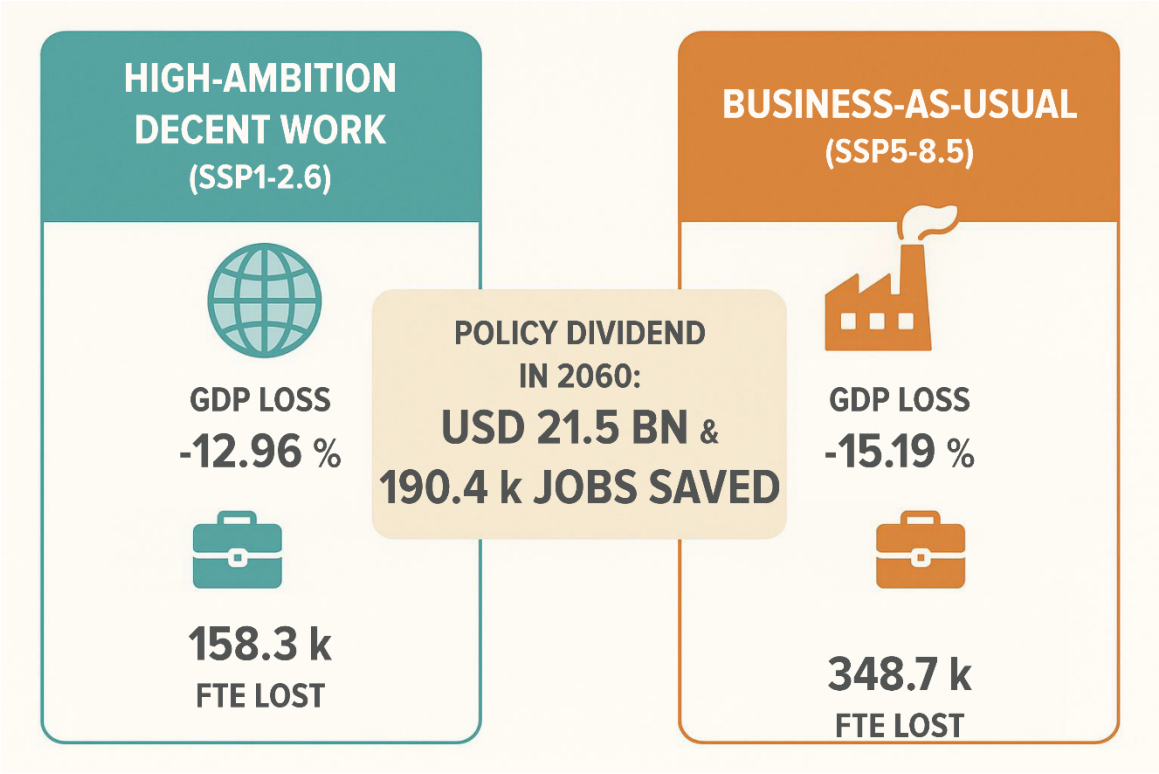
informal. This Business-as-Usual scenario paints a grim picture of **social and economic strain**, illustrating the high cost of inaction. It reinforces the rationale behind ILO's call for a just transition – without proactive policies, the **"high-emission, no-reform" pathway** leaves the workforce exposed to climate shocks and foregoes the benefits of sustainable development.

Infographic 7. Benefits of implementing the decent work and sustainable development goals in Sri Lanka. Figures calculated as differences between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5.

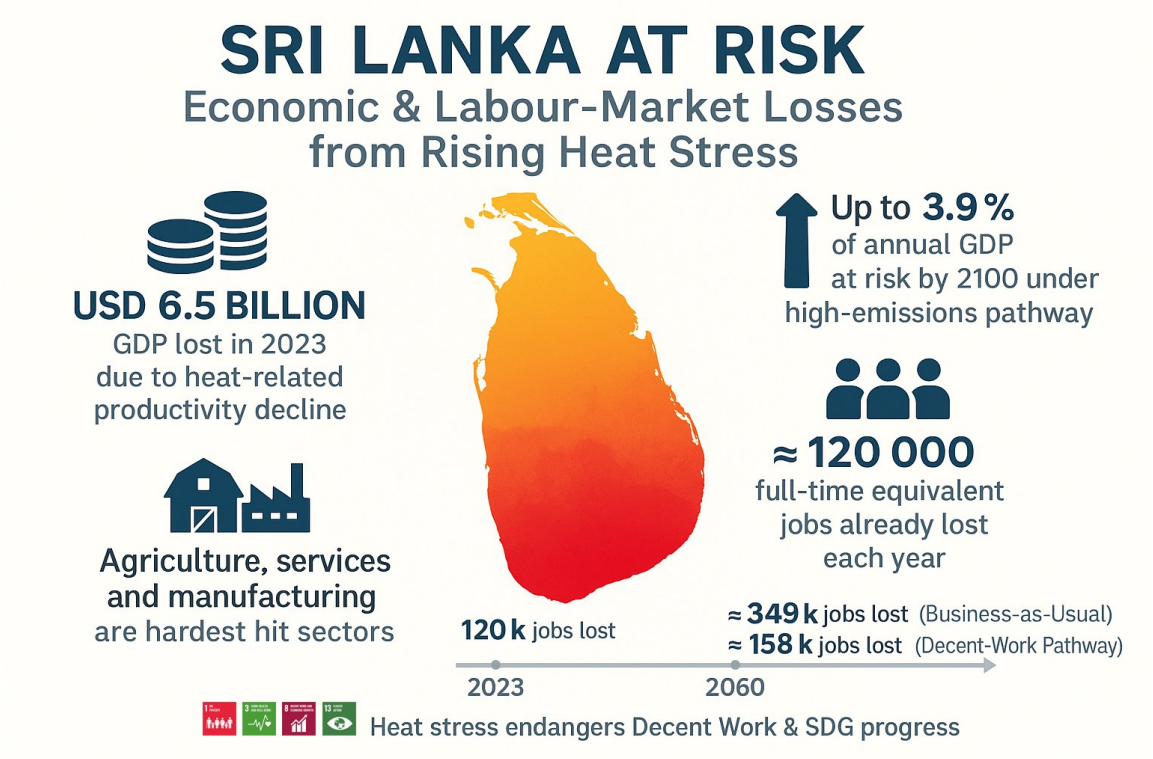


In the above scenarios the difference is stark: one future where Sri Lanka's economy is more resilient, diversified with green jobs, and workers are protected – versus another future where climate change inflicts heavy losses and development goals slip out of reach. Importantly, there is a gradient between these extremes. For instance, an intermediate scenario might have moderate climate action and partial policy uptake, yielding mixed outcomes. Another scenario of **"delayed action"** may also materialize, where warming continues unchecked until mid-century, then belated policies are implemented. Projections for such a scenario suggest that, while late mitigation/adaptation is better than none, some losses (economic damages, depleted worker capacity) become irreversible.

Infographic 8. Scenario analysis to decent work and sustainable development goal implementation in Sri Lanka in relation to workplace heat stress. Figures calculated as differences between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5.



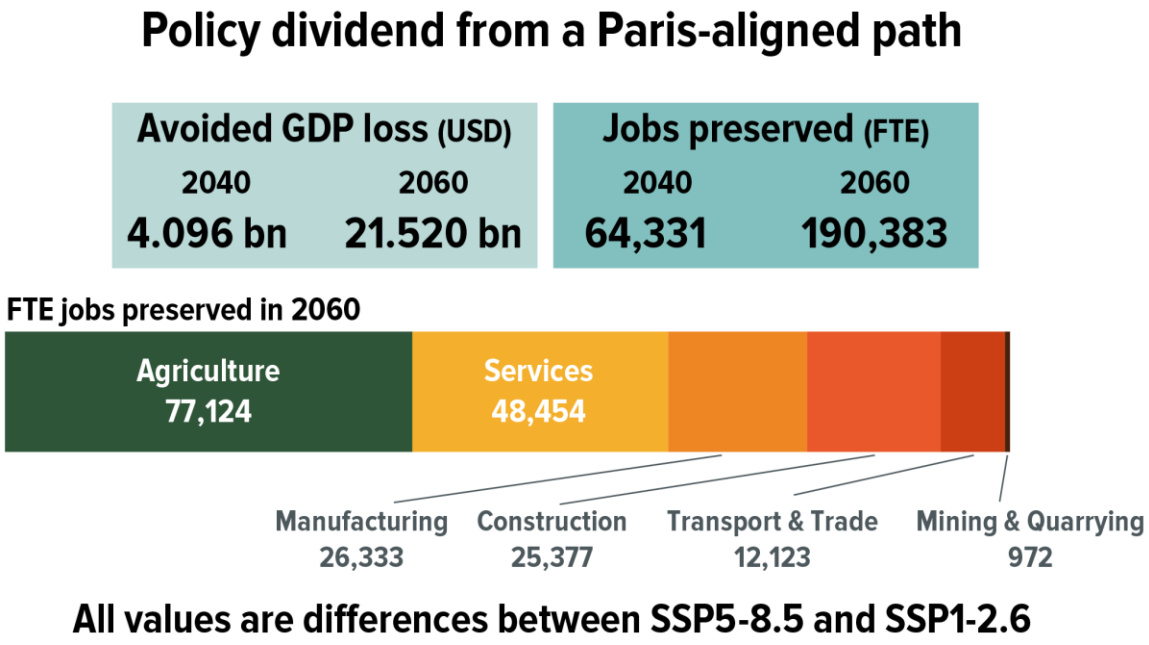
Infographic 9. Economic and labour market impacts in Sri Lanka from climate-induced rising heat stress. Figures calculated as differences between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5.



The policy dividend

The choice of path carries a large dividend. The gap between the high-ambition path SSP1-2.6 and SSP5-8.5 in 2060 is about **21.5 billion USD of annual GDP**. In job terms the gap is about **190,000 FTE jobs** saved each year (Infographic 10). Much of the avoided loss sits in agriculture and services because of their weight in output and employment. These gains accumulate over time through better worker retention, fewer stoppages, and more resilient local supply chains.

Infographic 10. GDP and labour market benefits of implementing the decent work and sustainable development goals in Sri Lanka, particularly in relation to workplace heat stress. Figures calculated as differences between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5.



Qualitative pathways and distributional results

Employment levels remain higher when heat-safe schedules and efficient cooling are in place. Earlier starts and longer midday breaks protect output in agriculture and construction. Indoor climate control and ventilation reduce errors and slowdowns in retail, hospitality, and light manufacturing. Absenteeism falls when hydration and medical monitoring are standard practice. Occupational health services linked to social protection detect early signs of illness and avoid severe cases. These changes are consistent with ILO guidance on safe and healthy work and with the aim of social protection floors to secure access to health care and basic income security.

Equity improves when the floor reaches informal workers and when minimum heat safety rules cover outdoor and street-based work. Cash support during heat alerts prevents income collapse, food insecurity, and child labour risk. Targeted measures for pregnant workers, young workers, and older workers reduce health risks. Social dialogue helps balance rest breaks and pay rules so that safety does not mean a wage penalty.

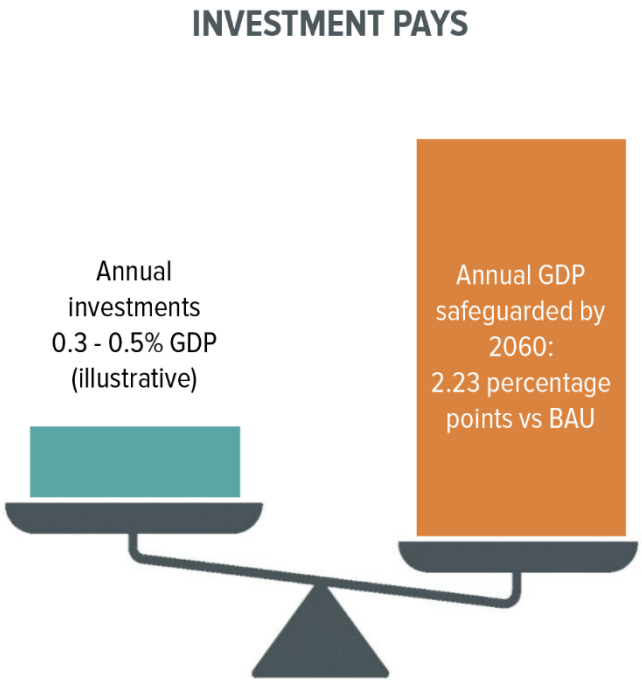
Implementation priorities

Implementing the high-ambition path requires a series of steps. First, adopt and enforce a national heat protection standard across sectors, triggered by WBGT-based thresholds. Use public procurement to require compliance on public works and service contracts. Second, extend the social protection floor so that heat-related sickness and income loss

are covered for both formal and informal workers. Third, finance efficient cooling, shade, ventilation, and water access for small companies and public facilities and invest in urban heat mitigation and climate-smart agriculture. As shown in Infographic 11, even small annual investments directed toward implementing policies consistent with a Paris-aligned pathway (SSP1-2.6) will generate significant returns by 2060. All steps should be designed and monitored through tripartite dialogue in line with the Just Transition Guidelines. They set out the need for policy coherence, rights, and dialogue so that climate action delivers decent work.

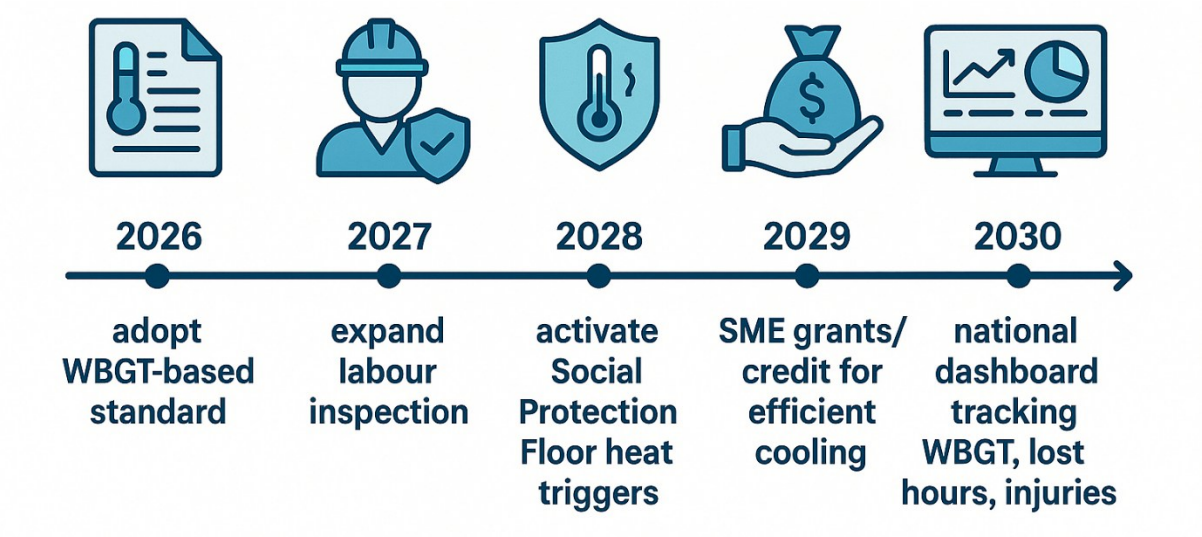
The evidence in the present study shows that Sri Lanka already faces a heavy heat penalty. The size of future losses depends on global mitigation but also on domestic execution of the Decent Work Agenda. A full package centred on safe work, social protection, green investment, and dialogue can preserve output and protect jobs as temperatures rise. This is how Sri Lanka can turn climate risk into a path for safer work and sustained growth while advancing the SDGs.

Infographic 11. Investment case: cost vs returns of heat safe workplaces (calculated as difference between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5).



Next steps: A suggested timeline to implement the recommendations stemming from this study is presented in Infographic 12. Initial proposed actions as a follow-up to this study may include the need to strengthen national capacity on the use of the WBGT index and related thresholds, in support of the adoption of WBGT-based OSH legislation. Heat-related occupational health modules could be integrated into the Heat-Health Action Plan led by the Ministry of Health, within the framework of Sri Lanka's Third Nationally Determined Contribution implementation. Moreover, a National Technical Workshop could be convened to bring together local stakeholders to translate the agreed recommendations into a concrete, time-bound action plan addressing the impacts of rising temperatures on worker health and welfare, business operations and productivity, the national economy, and community resilience. The workshop could also focus on raising awareness of workplace heat stress risks among workers, micro-, small-, and medium-enterprises, as well as communities. It could also aim to build policymaker capacity to design and implement measures addressing the impacts of rising temperatures on labour productivity and business resilience, as well as providing practical training and support for workers and employers on preventive and adaptive responses to workplace heat stress.

Infographic 12. Implementation timeline: a path to achieve heat-safe workplaces.



8. Research limitations

While providing valuable insights, the analysis described in the present study is subject to technical limitations stemming from its methodology, data sources, and assumptions, which should be acknowledged in the context of Sri Lanka's specific conditions.

One important limitation lies in the **modelling assumptions** used to estimate heat-induced work losses. The study applies a recently developed global labour loss function that links WBGT to the fraction of a work shift lost to heat exposure.[43] This function was derived from field studies across various countries and is calibrated for an "average, experienced, acclimatized worker" operating under typical conditions.[43] While this provides a robust general framework, it may not capture all nuances of Sri Lankan labour contexts. For instance, actual work-rest behaviours, acclimatization levels, and protective measures in Sri Lanka could differ from the study's general assumptions. Moreover, the historical baseline chosen for analysis (1985-2014) is already approximately 0.75 °C warmer than pre-industrial times.[35] This means the projected climate-induced impacts in workplace heat stress are **conservative**, as some climate warming that has already occurred before the baseline is essentially "included into" the reference scenario. In effect, using a late-20th-century baseline avoids biases due to outdated work patterns but **underestimates the absolute impact of climate change** on heat stress by not accounting for pre-1985 warming. Policymakers should recognize that real-world impacts could be larger if referenced to true pre-industrial conditions.

Another set of limitations arises from the **data sources and resolution** used in the analysis. Owing to sparse localized data, the study relies on global datasets and model outputs that have been downscaled or resampled for Sri Lanka. Climate variables (temperature, humidity, etc.) were taken from a single global climate model and downscaled to a grid of about 5 km, then aggregated for analysis (see Annex 1). Other key datasets (population, economic output, etc.) were available at coarser resolutions (~25 km) and likewise had to be interpolated or merged. While these steps ensure consistency across data layers, they inevitably **smooth over local variability**. Sri Lanka's complex terrain and microclimates – from cooler higher altitude areas to hotter, humid coastal cities – may not be fully captured by grid-averaged climate data. Small geographic "hot spots" (for example, inner-city districts with urban heat island effects or particular valleys with extreme conditions) could, therefore, be under-represented. Similarly, using national or gridded averages for labour and economic activity can mask differences in heat exposure within sectors or regions. The model distributes impacts based on generalized population and sector data rather than detailed local employment patterns, so the **spatial distribution of losses** should be viewed as indicative rather than exact. Furthermore, there are **coverage gaps in labour data**, especially regarding informal employment. Official statistics and economic output data likely undercount informal and unregistered workers, who represent a significant proportion of Sri Lanka's workforce. These workers are often in heat-exposed sectors such as agriculture, construction, or street trade, yet their productivity losses may not fully translate into the formal GDP metrics adopted in the present study. As a result, the projections may **underestimate total work hours lost and economic costs**, since any heat-stress impact on the sizable informal sector is not rigorously captured by formal data. In essence, data limitations mean that the findings paint a broad picture rather than a granular one, and actual on-the-ground impacts could diverge in specific locales or sub-populations.

The **climate projection scenarios** used in the present study also introduce technical caveats. The analysis focuses on four SSP scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5) to represent a range of future greenhouse-gas emission pathways. These SSPs are global storylines and serve as useful proxies for low, moderate, and high warming futures, but they are not tailor-made for Sri Lanka. In reality, Sri Lanka's future emissions and development path may not neatly correspond to any single SSP. Sri Lanka's outcomes could fall between scenarios or follow a different trajectory. Moreover, by necessity only a subset of possible scenarios was analyzed. Intermediate pathways (for example, scenarios reflecting uneven development or delayed mitigation beyond those chosen) were not explicitly modeled, meaning that the **full uncertainty range** of climate outcomes is not captured. A related limitation is that the study's climate projections are based on a **single climate model** (UKESM1-0-LL) for temperature and humidity. While this model was high-resolution and is a state-of-the-art choice, relying on one model's output means that the results do not reflect inter-model variability. Different climate models can project somewhat different patterns of warming, humidity, or extreme heat days for Sri Lanka. By using one model, the analysis assumes its simulation is representative, but if that

model underestimates (or overestimates) future heat extremes in Sri Lanka, the projected work productivity losses would be skewed accordingly. In addition, the climate data were handled at a monthly time scale. This captures long-term warming trends well, but may not fully account for **short-term heatwaves or day-to-day extremes** that can sharply impact work capacity. Any sub-monthly variability and the potential for consecutive extremely hot days (which can compound stress on workers) are largely averaged out in the scenario data. Therefore, while the SSP-based projections give a credible envelope of future conditions, one should bear in mind that **scenario and model choices** introduce uncertainty. The actual climate impact on Sri Lanka could be somewhat higher or lower than depicted, especially if unmodeled extremes or divergent regional climate changes occur.

There is also **uncertainty in the workability and productivity response functions** when applied to Sri Lankan conditions. The physiological model underpinning the work-hour loss estimates is grounded in empirical studies, but these studies have inherent variability and may not include all the circumstances present in Sri Lanka's labour force. For example, the response function assumes a given relationship between WBGT and the need for rest, based on an average worker sample. In practice, Sri Lankan workers' ability to cope with heat can vary with factors such as age, health status, type of work, and cultural practices (e.g. timing of work shifts or rest periods). The analysis does not explicitly differentiate how a young, healthy construction worker might tolerate heat versus an older agricultural worker or a street vendor with limited shade. This one-size-fits-all function means that **individual and subgroup differences** are not captured, as some workers may experience greater productivity loss than predicted, while others less. Moreover, the model presumes **current levels of acclimatization and work routines remain constant in the future**. It does not account for potential adaptation measures by workers or employers in response to rising heat (such as shifting work hours to cooler times of day, improving hydration and rest breaks, or mechanization to reduce physical strain). If such adaptations become common, they could mitigate some productivity losses, meaning the projected impacts might overstate what actually occurs. On the other hand, if extreme heat increases beyond physiological coping ranges, the simplistic linear response may understate losses for the hardest-hit days. While the present study provides uncertainty ranges (e.g. confidence intervals) around the estimated losses, these primarily reflect the statistical uncertainty in the empirical function and climate variability, rather than the full spectrum of **behavioural and physiological uncertainty**. In summary, users of the present study's results should recognize that the translation from heat levels to lost work hours is based on an idealized average response. Real-world outcomes could deviate if Sri Lankan workers' responses to heat stress differ from the model's assumptions.

Finally, the **estimation of WBGT and sectoral heat exposure** in this analysis involved necessary generalizations that limit precision. The WBGT for each location and sector was computed from meteorological data using a standard method (Liljegren's approach) with set parameter assumptions. For instance, **indoor working conditions** are modeled by assuming no direct solar radiation and a modest, fixed air movement of 1 m/s (to mimic light ventilation or fans). Indoor temperature and humidity were estimated as a function of outdoor conditions without accounting for building-specific cooling or insulation. In reality, indoor environments in Sri Lanka vary widely. Some offices or facilities are air-conditioned (keeping WBGT lower than outdoor), while in other workplaces without cooling, heat can build up more than the model's simple ratio may predict (especially during power outages or in poorly ventilated spaces). Likewise, **underground or enclosed worksites** (e.g. any mining or tunnel operations) were approximated from surface weather data, which may not fully reflect actual thermal conditions underground where geothermal heat and ventilation play a role. The exposure assumptions also treat entire sectors uniformly in terms of work setting. For example, the agriculture and construction sectors were considered mostly outdoors (hence directly exposed to ambient heat), whereas sectors such as services or manufacturing were treated as predominantly indoor. In a Sri Lankan context, this generalized approach may be an oversimplification. Within services, a tourism worker guiding tours outside faces different heat stress than a bank employee inside an air-conditioned branch, yet both are counted under "services." Even within outdoor sectors, micro-environmental differences (working in shade versus sun, use of protective clothing, etc.) are not distinguished. Consequently, the **sector-level results should be interpreted as averages**, as actual heat exposure and productivity loss can vary within a sector based on specific job roles and locales. Moreover, because the analysis aligns workers with grid-cell climate data (using population distributions and national economic data), any mismatch between where people live versus where they work could introduce minor errors. For example, if many workers commute from cooler highlands to hotter coastal workplaces, the model may underestimate their exposure by tying them to home location climate. These granular issues are inherent in a

nationwide modeling study and highlight that the findings are **indicative trends subject to these aggregation effects**.

In conclusion, while the present study's projections of climate-induced workplace heat stress impacts on jobs and productivity in Sri Lanka are grounded in the best available science and data, they remain constrained by the above technical factors. The use of global models and datasets, necessary assumptions about worker behaviour and sectoral exposure, and scenario uncertainties all mean the results are **approximate and conditional**. These limitations do not undermine the overall message that workplace heat stress poses a serious and growing challenge to Sri Lanka's labour productivity, but they do delineate the **bounds of confidence** for the numbers presented. Policymakers and stakeholders should thus view the quantitative estimates as **guidelines within an expected range** and complement them with local observations and knowledge. A transparent understanding of these technical caveats will ensure that decisions and strategies informed by the present study properly account for its scope and the uncertainties in projecting climate change impacts on Sri Lanka's workforce. This nuanced interpretation will help ground policy responses in realism, neither underestimating the threat of workplace heat stress nor overextending the precision of modelled forecasts.

Annex 1 – methodology

A1.1. Calculation of WBGT

For the calculation of the WBGT, the approach of Liljegren[56] was adopted because it is considered the most accurate method when calculating WBGT from meteorological data.[57] The environmental temperature, relative humidity, and wind speed data required for the calculation of WBGT were obtained from the relevant historical and SSP datasets provided in Section A1.2. Wind speed was corrected for height above the ground using previous methodology.[58] Solar radiation was estimated[59] for the midday of the middle day of each month using the geolocation (longitude and latitude) of each grid cell, while correcting for cloud coverage using published literature.[60] For indoor conditions, solar radiation was considered negligible, while wind speed was kept constant at 1 m/s, as this velocity is more indicative of the occupational settings where some air movement is generated by workers while they walk or move in the worksite.[57] Indoor temperature and humidity were estimated as a function of outdoor conditions.[61] Similarly, for the mining industry, underground temperature[62] and humidity[63] were estimated as a function of surface conditions.

A1.2. Datasets and Methodology

The present analysis included a collection of global datasets from recognized sources outlined in the following sub-Sections, including historical and projected data on population counts, global terrain elevation, climate, emissions, economic activity and demographics. Each dataset adopted different resolution and format, requiring resampling. Climate data were resampled to a target resolution of 3 arc minutes (0.05 degrees, 7200 longitude x 3600 latitude), while other datasets were resampled to 15 arc minutes (0.25 degrees, 1440 longitude x 720 latitude) using Python-based tools. This ensured consistent alignment across datasets for accurate merging and analysis.

A1.2.1. Population Datasets

Historical population data from the GPWv4 dataset,[64] covering the years 1990, 1995, 2000, and 2005, was obtained at a 15 arc-minute resolution. This dataset was already aligned with the target resolution and contained important information related to grid cells, including country mapping and land-water areas and it was used as the reference dataset for subsequent analysis.

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Population projections datasets, based on the SSP1, SSP2, SSP3, SSP4, and SSP5 were obtained from standard sources.[65,66] These projections were originally available at a resolution of 7.5 arc minutes (0.125 degrees 2880 longitude and 1440 latitude) and required resampling to 15 arc minutes. The process was performed using the rasterio library, applying the "Resampling.sum" method to aggregate population data across the new grid cells.[67] After resampling, datasets for rural, urban, and total populations were merged for the years 2010 to 2100, in 10-year increments.

A1.2.2. Global Terrain Dataset

The global terrain data from the GEBCO terrain model[68] was used. The data was initially provided at a resolution of 15 arc seconds (86400 longitude and 43200 latitude), and it was averaged into 15 arc-minute grid cells. During this process, negative values representing undersea topography were excluded, focusing only on land elevations for merging with climate data.

A1.2.3. Climate Datasets

The CMIP6 climate historical and projection datasets, derived from the "UKESM1-0-LL" model under the "r1i1p1f2" experiment,[69] were downloaded using the CHELSA (Climatologies at High Resolution for the Earth's Land Surface Areas) Python library. This library provides downscaled climate data estimates at a horizontal resolution of 30 arc seconds.[70,71,72] To ensure compatibility and facilitate computational efficiency, the datasets were upscaled to a target resolution of 3 arc minutes (0.05 degrees, 7200 x 3600 grid). Monthly data from the "UKESM1-0-LL" model was gathered for the following experiments: Historical, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5. The historical dataset spans 1985 to 2014, while the projection data covers 2020 to 2100. Specifically, near surface air temperature and near surface relative humidity, wind speed, maximum temperature, and total cloud cover percentage were obtained.

A1.2.4. Demographic Dataset

Hybrid gridded demographic dataset was obtained at resolution of 290 latitude by 720 longitude.[73] This demographic dataset contains fractional percentages for various age ranges, spanning from 5 to 65 years old. The data includes both historical and projected population distributions, covering the period from 1950 to 2050.

A1.2.5. Land Cover Dataset

The 2022 C3S Land Cover dataset (v2.1.1)[74] at 300-meter resolution was downloaded via the CDSAPI library, using lccs_class values to identify urban areas (class 190). A binary mask was created, assigning 1 to urban areas and 0 to others, and added to the dataset. The data was then resampled to a 15 arc-minute resolution by summing

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the urban area cells using xarray's coarsen method.[75] A final dataset was produced with country-level details via geographical mapping, calculating each country's percentage of urban area grid-by-grid.

A1.2.6. Greenhouse Gas Emissions Datasets

Greenhouse gas emissions data were downloaded from the EDGAR datasets[76] and divided across four sectors:

- Agriculture sector, which included emissions from agricultural soils and enteric fermentation.
- Mining and Quarrying sector, which included methane emissions from natural gas extraction and processing.
- Manufacturing sector, which included emissions from chemical processes, industrial combustion, iron and steel production, solvent use, oil refining, and waste incineration.
- Transport and trade sector, which included emissions from aviation (landing and takeoff), road transportation, railways, pipelines, and off-road transport.

Each sector's emissions were aligned by latitude and longitude, summed, and resampled to a 15 arc-minute resolution. The emissions were then merged into a single dataset, indexed with sectoral and country-level details via geographical mapping. Finally, a new dataset was created to quantify each country's percentage contribution to emissions within each sector, calculated grid-by-grid.

A1.2.7. GDP Dataset

Country-level economic data on the structure of value added was obtained from the United Nations Statistics Division (Latest Data Upload: January 2025) for the period 1970-2023.[77] The dataset contains the contributions of various sectors, including agriculture, hunting, forestry, fishing (ISIC A-B), mining, manufacturing, utilities (ISIC C-E), manufacturing (ISIC D), construction (ISIC F), wholesale, retail trade, restaurants and hotels (ISIC G-H), transport, storage and communication (ISIC I), other activities (ISIC J-P), as well as total value added, to each country's GDP, expressed in constant 2015 USD.

In addition, a multi-country, multi-sector, multi-scenario gridded dataset of projected gross domestic product (GDP) was developed for the years 2040 and 2060. Historical sectoral GDP for each country was sourced from UN National Accounts,[78] and these values were spatially distributed to grid cells based on the emissions dataset. Future total GDP projections for each grid cell, scenario (SSP1–SSP5), and years (2040, 2060) were obtained from the Zenodo global gridded GDP dataset v7.[79]

For each country, the proportional contribution of each sector per grid cell was computed based on the distribution for the year 2023. These sectoral shares were then applied to projected total grid cell GDPs for 2040 and 2060 to estimate sector-specific GDP at each location under each scenario.

Future grid-cell and sector-level GDP values were initially expressed in purchasing power parity (PPP) international dollars. To enable cross-country comparison and economic analysis in nominal terms, the PPP-based GDP values were converted to market exchange rate (MER) GDP using country- and year-specific Price Level Ratios (PLR). The PLR for each country and scenario was extrapolated to 2040 and 2060 using a linear fit to World Bank historical PLR values (2000-2019).[80] The conversion was performed as follows: GDP_MER=GDP_PPP*PLR

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A1.2.8. Employment Dataset

Economic activity data was obtained from ILOSTAT,[81] providing employment data across different economic sectors and genders. The 14 variables provided in the ILO dataset were divided into six sectors using the standard intermediate-level aggregation[82] as follows:

- Agriculture (ISIC rev.4: A).
- Mining and Quarrying (ISIC rev.4: B).
- Manufacturing (ISIC rev.4: C).
- Construction (ISIC rev.4: F).
- Transportation and Trade (ISIC rev.4: H, G).
- Services, which included all remaining activities: utilities (ISIC rev.4: D, E), accommodation and food service activities (ISIC rev.4: I), information and communication activities (ISIC rev.4: J), financial and insurance activities (ISIC rev.4: K), real estate; business and administrative activities (ISIC rev.4: L, M, N), public administration and defense (ISIC rev.4: O), education (ISIC rev.4: P), human health and social work activities (ISIC rev.4: Q), and other services (ISIC rev.4: R, S, T, U).

A1.2.9. Sector Distribution

Two datasets were used to calculate the distribution of each sector on each grid cell: the urban area land cover data (providing the percentage of urban area per grid cell; see A1.2.5) and the emissions data (including sectoral emission percentages; see A1.2.6). For the Agriculture, Mining-Quarrying, Manufacturing, and Transportation-Trade sectors, sectoral emission percentages were used from the above-mentioned emissions dataset as the distribution parameter within the grid cells, while urban area percentages were applied for the Construction and Services sectors.

In cases where the emissions dataset did not include information for mining in the country of interest, the Global Mines and Minerals dataset from the United States Geological Survey was utilized.[83] The original data consisted of point locations specified by latitude and longitude coordinates for various mining sites. To align with the target resolution of 15 arc minutes, the point data was transformed into grid cells. During this process, an equal distribution method was applied within each grid cell containing mining points.

Next, using the ILO employment dataset (with gender-specific employment counts), the number of male and female workers in each sector was calculated for each grid cell based on sectoral employment data and the percentage contribution from emissions or urban area. This process was repeated for all six economic activity sectors, with the final dataset containing estimated number of male and female workers per sector, indexed by latitude, longitude, sector, and country.

Similarly, for each grid cell, using the above-mentioned GDP dataset, the GDP by sector of economic activity was calculated based on the percentage contribution from emissions or urban area. This process was also repeated for all six sectors, producing a final dataset containing the estimated GDP in USD millions, indexed by latitude, longitude, sector, and country.

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