International Labour Organization

Impacts of heat stress on jobs and productivity in the Maldives

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, this study builds on the available data to provide just transition input to Climate Prosperity Plans (CPPs). It evaluates the implications of heat stress in the labour market of the Maldives 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 focus on productivity losses due to heat stress.

1.2. ILO in the Maldives

The Republic of the Maldives is an island nation in the Indian Ocean that comprises 26 atolls and 1,192 coral islands, of which 188 are inhabited (Figure 1). The country's 298 km² land surface is dispersed over roughly 90,000 km², making the Maldives one of the most geographically dispersed countries on the planet, with water covering 99% of its territory. As the planet's lowest-lying nation, the country has an average elevation of just 1.5 metres above sea level, with approximately 80% of its land area situated less than 1 metre above sea level.[2]

Despite geographical challenges, including land dispersion, a small population, and limited natural resources, the Maldives achieved their Millennium Development Goal of halving the proportion of people living under the poverty line to 1% as of 2011.[3] In addition, the country has achieved remarkable economic progress over the

[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.
[2] Dauphin L. and Voiland A. (2021). Preparing for Rising Seas in the Maldives. NASA Earth Observatory.
[3] UNDP (2011). Maldives: Poverty Reduction. United Nations Development Programme – Maldives (https://web.archive.org/web/20111203000144/http://undp.org.mv/v2/?lid=65).

past two decades. From 1997 to 2010, the economy grew at an average annual rate of 5.7%, stabilizing at around 6.1% thereafter.[4] In 2022, the nation's GDP per capita was approximately 15,730 USD.[5] In 2023, the Maldives had the highest GDP per capita in South Asia, as well as health and education indicators similar to those of high-income economies.[6]

The country's economic growth has been driven predominantly by the tourism and fisheries sectors, along with strong contributions from transportation, communication, and construction industries. Together, these sectors accounted for approximately 37% of GDP in 2017, with tourism alone supporting 34,500 jobs, or 16% of total employment, according to the World Travel and Tourism Council.[7]

In 2018, the Maldives was officially classified as an upper-middle-income country. This achievement reflects significant strides in raising incomes, reducing poverty, and advancing human and social development indicators. However, the country's heavy reliance on tourism and fisheries renders its economy highly vulnerable to external shocks, such as global economic downturns, and environmental risks linked to climate change.[6] Climate-induced hazards such as rising sea levels, coastal erosion, and extreme weather events pose ongoing threats to livelihoods, infrastructure, and economic stability, making the Maldives one of the world's most climate-vulnerable nations.[4,6,8] The World Bank estimates that the impacts of climate change on tourism would reduce the country's GDP by more than 11 percentage points by 2050, under a high-emissions scenario.[6] Fisheries will be also heavily impacted, with recent projections indicating a dramatic decrease of almost 100% in fish catch potential by the end of the 21st century under a high-emission scenario.[6] To address this, the government has partnered with international organizations to implement climate adaptation strategies, including renewable energy projects and sustainable tourism practices, but more efforts are needed to integrate climate resilience into national development plans.[4].

Urbanization has been a notable trend, with 42% of the population residing in urban areas as of 2023.[9] Between 2012 and 2023, the urban population grew by 4.7 percentage points, suggesting a steady migration towards urban centers.[9] One reason for this trend is economic growth, which has created substantial employment opportunities, particularly for expatriate workers, who now constitute nearly one-third of the total workforce.[4] The unemployment rate in 2023 was 4.1%, reaching its lowest value in recent years.[10] Yet, while unemployment is negligible among expatriates, the unemployment rate among resident Maldivians stands at approximately 6%.[4] This discrepancy is partly due to a lack of skilled workers for high-end jobs and a cultural reluctance to accept roles perceived as "low status." These challenges underscore the need for targeted workforce development initiatives and enhanced skills training programs to ensure the long-term sustainability of the nation's development trajectory.[4]

Additionally, a significant portion of the workforce is employed in informal sectors or seasonal jobs tied to tourism, leaving many workers without adequate social protections or OSH measures. The ILO has been actively involved in supporting the Maldives to address these gaps, focusing on strengthening OSH standards, improving labour market governance, and promoting decent work opportunities.[4] Investments in building a well-trained, resilient workforce are critical for reducing dependency on foreign labour and ensuring inclusive economic growth.

Addressing the skills gap and fostering a culture of lifelong learning are essential to improving labour market outcomes. The Maldives must prioritize education and vocational training programs aligned with the demands of high-value sectors, such as tourism, technology, and renewable energy. Enhancing women's participation in

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[4] International Labour Organization (2019). The ILO in Maldives - Key Facts and Figures. ILO Country Office for Sri Lanka and the Maldives.
[5] FocusEconomics (2024). Maldives Economic Data & Projections (https://www.focus-economics.com/countries/maldives/).
[6] World Bank (2024). Maldives Country Climate and Development Report. The World Bank Group, Washington, DC, USA.
[7] Travel & Tourism Economic Impact 2018 Maldives. World Travel & Tourism Council, https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2018/maldives2018.pdf.
[8] Country Operations Business Plan, Maldives 2016-2018 (August 2015), ADB, https://www.adb.org/sites/default/files/institutional-document/173147/cobpmld-2016-2018.pdf.
[9] Trading Economics (2024). Maldives - Urban Population (% Of Total). https://tradingeconomics.com/maldives/urban-population-percent-of-total-wb-data.html
[10] O'Neill A. (2024). Unemployment rate in the Maldives 2023. Statista (https://www.statista.com/statistics/808780/unemployment-rate-in-maldives/).

the labour force and ensuring social protections for informal workers are also critical to achieving inclusive growth.[4]

Looking ahead, the Maldives faces the challenge of balancing economic growth with environmental sustainability and social equity. Key policy objectives include diversifying the economy beyond tourism, enhancing public service delivery in remote atolls, and implementing robust climate adaptation measures to safeguard the nation's future. 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/fisheries and construction, where exposure to heat stress is high.

Figure 1. Maldives physical map.

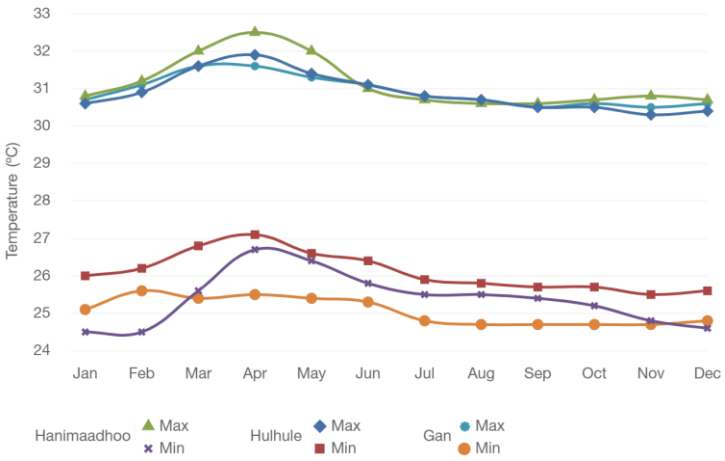


2. Current and future heat exposure and climate change

2.1. Current weather and climate overview

The Maldives experiences a tropical monsoon climate characterized by consistently warm and humid conditions throughout the year, with relatively high levels of precipitation. Historically, the mean annual temperature has been 27.6°C, with minimal inter-seasonal variability as monthly average temperatures typically fluctuate by no more than 1°C (Figure 2). The seasonal temperature cycle is most pronounced in the northern regions of the Maldives, where the average maximum temperature reaches approximately 29.3°C just before the onset of the southwest monsoon (April–May). Similarly, the average minimum temperature drops to around 27.4°C prior to the northeast monsoon (December–January). In contrast, the southern equatorial regions receive precipitation year-round and are less affected by the dry spell typically associated with the northeast monsoon.

Figure 2. Monthly environmental temperature in the Maldives across the north (Hanimaadhoo), central (Hulhule) and southern (Gan) atolls.[11]



2.2. Choice of environmental indicators

To characterize the prevailing environmental conditions for work in the Maldives, 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.[12]

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.[12,13,14,15] 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 experienced by the human body. Importantly, WBGT-based guidance takes into account work intensity and the use of personal

[11] Image provided by the Maldives Meteorological Service.
[12] 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.
[13] 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.
[14] 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.
[15] ACGIH, Heat stress, TLVs and BEIs: threshold limit values for chemical substances and physical agents & biological exposure indices, ACGIH, Editor. 2020, ACGIH: Cincinnati.

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.[12,16,17,18] 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 and international organizations for assessing heat stress including the ILO, the World Health Organization, and the World Meteorological Organization.[1,19] 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.[20]
- **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.[21]
- **Fatigue and cognitive impairment:** Higher WBGT levels are associated with quicker onset of fatigue and reduced cognitive function, impacting decision-making and coordination.[1,22,23]
- **Heat-related illnesses:** Prolonged exposure can result in dehydration, heat cramps, heat exhaustion, or even heat stroke, especially in high-intensity work environments.[1,21] Working in a hot environment for a significant part of the year can lead to acute/chronic kidney injury.[1,21]

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.

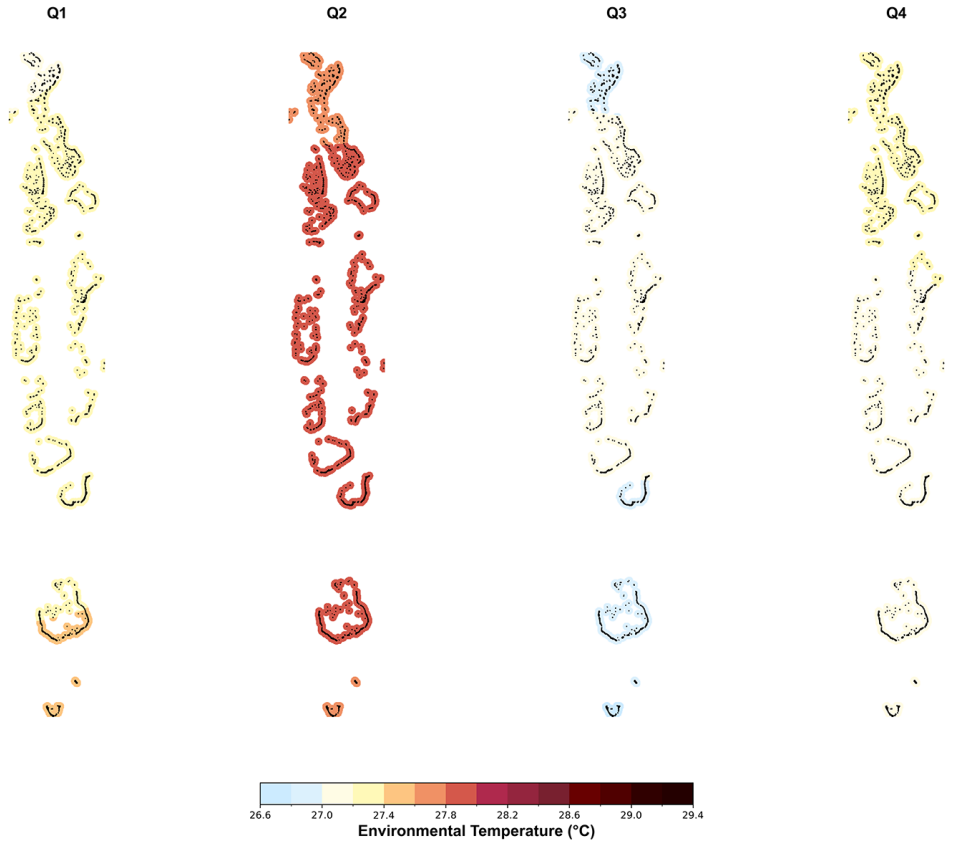
2.3. Current heat and environmental conditions

Figure 3 illustrates the quarterly average maximum environmental temperatures across the Maldives. The maps show a clear seasonal cycle with only modest spatial variation along the north-south chain of atolls, consistent with a small, ocean-dominated country. Quarterly average maximum temperatures generally sit within a narrow band (26.5-29.5 °C) across the year.

[16] 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.
[17] 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.
[18] 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.
[19] World Health Organization and World Meteorological Organization (2025). Climate change and workplace heat stress: technical report and guidance. Geneva, Switzerland.
[20] 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.
[21] 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.
[22] Flouris A.D. (2019). Human thermoregulation. in: Périard J., Racinais S., eds. Heat stress in sport and exercise: Springer.
[23] 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.

- **Q2 (Apr-Jun)** is the hottest quarter nationwide. Maxima are highest and most widespread in this period, with large areas reaching 28.5-29.5°C. This marks the main thermal peak relevant for outdoor work planning.
- **Q3 (Jul-Sep)** is the coolest quarter of the year. Widespread cloudiness and rainfall during the southwest monsoon reduce daytime heating, and quarterly maxima frequently fall to 26.5-28°C.
- **Q1 (Jan-Mar)** and **Q4 (Oct-Dec)** represent "shoulder seasons", with maxima typically 27.5-28.5°C. Spatial gradients are weak, with occasional local pockets of higher values appearing but not forming persistent hotspots.

Figure 3. Quarterly average maximum environmental temperature across the Maldives during the reference historical period (1985-2014).



From a labour and productivity perspective, these patterns imply that peak thermal exposure from air temperature occurs in Q2, with lower but still warm conditions in Q1 and Q4 and a relative respite in Q3. Because the Maldives experiences high humidity year-round, air temperature alone understates heat stress; workers' risk – especially in construction, port operations, resort and island-services, and fisheries – will depend on WBGT, which also reflects humidity, wind and solar load. Nevertheless, this temperature baseline is useful for seasonal scheduling (earlier starts, extended mid-day breaks in Q2), hydration and shade planning, and maintenance of cooling/ventilation in indoor workspaces. The limited spatial contrast suggests that national-level guidance with sector-specific protocols will be more effective than location-specific rules, while local microclimates (sun-exposed worksites, low-wind lagoons) should still be monitored.

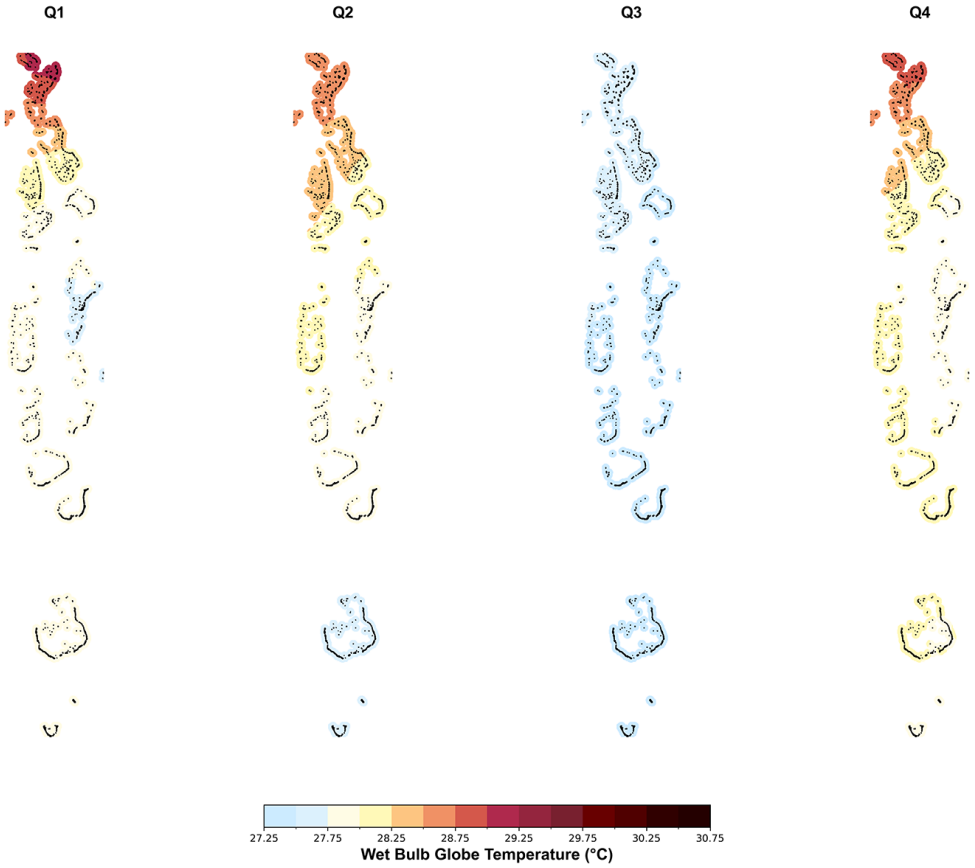
Figure 4 illustrates the quarterly average maximum WBGT across the Maldives. WBGT is an important measure of heat stress, taking into account not only temperature but also humidity, wind speed, and solar radiation, which makes it particularly useful in assessing the risk of heat stress for working people. The maps show a pronounced seasonal cycle in heat stress with only modest spatial variation along the atoll chain. Across the year, quarterly average maximum WBGT generally falls within 27-31°C.

- **Q1 (Jan-Mar)** shows the highest WBGT, particularly across the northern atolls, where values approach 30-31°C. These conditions imply that continuous moderate-to-heavy work is not advisable without controls (e.g., work-rest cycles, shade, hydration).
- **Q2 (Apr-Jun)** remains elevated but transitional, with slightly lower WBGT than Q1 in many atolls as the southwest monsoon begins to develop.
- **Q3 (Jul-Sep)** is the coolest quarter nationwide. Enhanced cloudiness, rainfall, and stronger winds reduce daytime heat load, with widespread 27-28 °C WBGT.
- **Q4 (Oct-Dec)** rises back toward the levels of Q1, with the north marginally hotter than central and southern atolls.

Spatial differences are subtle but persistent: northern atolls tend to register the highest WBGT in Q1 and Q4, whereas central and southern atolls are slightly lower in all quarters. Given the Maldives' ocean-dominated setting, local microclimates (leeward vs windward sides of islands, urbanised islands, enclosed lagoons) may create site-specific hotspots not visible at the analysed scale.

The WBGT analysis has important implications for work and productivity. The primary occupational heat-risk windows are Q1 and Q4, with Q2 requiring heightened vigilance during hot spells and Q3 offering relative relief. Sectors with extensive outdoor or semi-outdoor work (e.g., construction, port/logistics, resort and island services, fisheries, and utilities) should consider earlier work schedules, water-rest-shade interventions, and shaded/ventilated rest areas in Q1 and Q4. Given year-round humidity, relying on air temperature alone will underestimate risk. WBGT-based thresholds are the appropriate trigger for workplace protections and heat-alert monitoring across the archipelago.

Figure 4. Quarterly average maximum WBGT across the Maldives during the reference historical period (1985-2014).



2.3.1. Findings from comparing temperature against WBGT

Across quarters, WBGT values (27.3-30.8 °C) are consistently higher in risk terms than air-temperature maxima (26.6-29.4 °C) would suggest, due to the Maldives' persistently high humidity and light winds. As a result, relying on temperature alone underestimates heat risk, especially for moderate-to-heavy work outdoors or in semi-outdoor settings. When comparing the maps showing environmental temperature against those illustrating the WBGT, the following key insights emerge:

Seasonal trend

- **Q1 (Jan-Mar):** Air temperature is warm, but not extreme. The WBGT shows the highest values of the year, particularly in the northern atolls. This indicates that calm, humid conditions amplify heat stress despite only moderate air temperature peaks.
- **Q2 (Apr-Jun):** Air temperature shows the highest values of the year. The WBGT is elevated but transitional. In many atolls, the WBGT it is slightly lower than Q1, showing that humidity/wind changes around monsoon onset modulate heat stress even when air temperature peaks.
- **Q3 (Jul-Sep):** Air temperature and WBGT show the lowest values of the year. The WBGT records more widespread relief, consistent with cloudier, windier southwest monsoon conditions that reduce solar load and aid evaporative cooling.
- **Q4 (Oct-Dec):** Both indicators rebound from Q3. The WBGT climbs back toward Q1 levels, again strongest in the north, indicating a second high risk window.

Spatial contrasts and divergences

- **North–central/south gradient:** WBGT maps show a modest but persistent northward elevation in Q1 and Q4 not apparent in temperature alone. This is evidence that humidity and wind patterns also drive risk.
- **Limited cross atoll variability:** Both indicators show small spatial contrasts overall, typical of an ocean dominated archipelago. Site-specific microclimates (leeward coasts, enclosed lagoons, urbanised islands) may still create local hotspots not visible at the analysed scale.

Implications for labour risk management

- **Primary heat risk windows:** Q1 and Q4 (WBGT driven), with Q2 requiring vigilance during hot spells; Q3 shows relatively lower values.
- **Prioritised sectors:** Construction, port/logistics, transport/delivery as well as resort and island services, fisheries handling, utilities, and other outdoor/semi outdoor work.
- **Operational guidance:** Plan earlier work starts/breaks, water-rest-shade, and shaded/ventilated rest areas based on WBGT thresholds, not air temperature. Given limited spatial variation, national protocols with local WBGT triggers are appropriate.

Overall, different metrics paint different pictures. Temperature maps highlight thermal peaks in Q2, while WBGT maps identify a north-south gradient and highest occupational risk in Q1 and Q4 because of humidity and wind conditions. The policy takeaway is that WBGT is the decision metric for OSH and productivity planning in the Maldives. While air-temperature maps provide a useful context, they should not be used alone to trigger protections.

2.4. Climate projections

2.4.1. Country overview

Inter-annual temperature and precipitation patterns in the Maldives are intricately linked to global climate circulation phenomena, including the El Niño Southern Oscillation and the Indian Ocean Dipole.[24] Historical analyses from 1969 to 1999 reveal rising temperature trends in Malé, located in the central region, where the annual average maximum temperature increased by 0.17°C per decade, and the annual average minimum temperature rose by 0.07°C per decade.[25] These warming trends are more pronounced in the northern atolls, with this regions exhibiting a sharper increase.[25] In contrast, the southern atolls do not show a significant rising trend in annual average maximum temperatures.[25]

Detailed climate change trends against natural variability are illustrated in Figure 5. These trends illustrate a consistent upward trend in temperatures (Figure 5, top left graph), as well as that warming has become more pronounced in the Maldives during the recent decades (particularly in the period 2000-2020) and during Q1 (Jan-Mar) (Figure 5, top right graph). In addition, the available evidence reveals a clear shift in the distribution of average mean surface air temperatures in the Maldives from the mid-20th century until 2020 (Figure 5, bottom left graph). Finally, the evidence gathered thus far shows increasing frequency and intensity of extreme temperature events (Figure 5, bottom right graph).

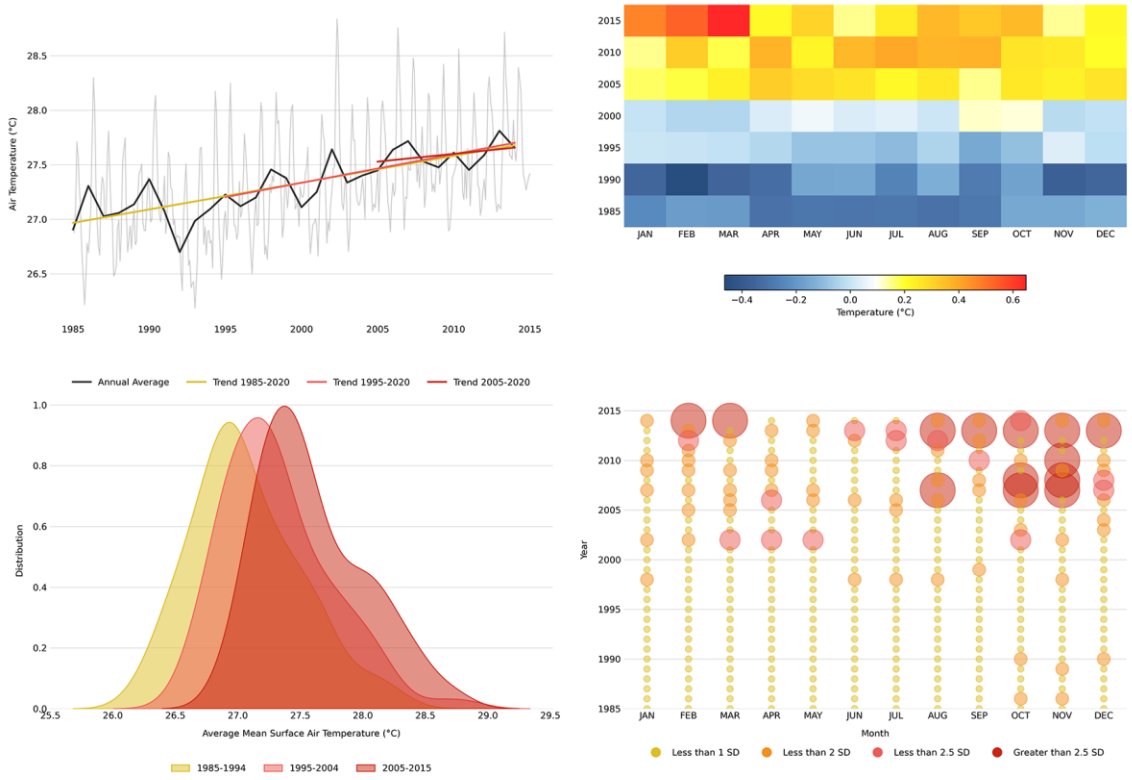
Collectively, the available evidence demonstrates a clear and accelerating warming trend in the Maldives over the past seven decades (1951–2020):

[24] Dong L., McPhaden M.J. (2018). Unusually warm Indian Ocean sea surface temperatures help to arrest development of El Niño in 2014. Scientific Reports, 8(1): 2249.
[25] Climate Risk Country Profile: Maldives (2021): The World Bank Group and the Asian Development Bank.

- Average maximum temperatures have increased significantly, as indicated by the shift in distributions and steeper annual trends over recent decades.
- The occurrence and intensity of extreme temperature events, particularly in Q1, have grown substantially since the early 2000s.
- Monthly temperature trends reveal that warming is not limited to specific seasons but is more pronounced during the pre-southwest monsoon months.
- The trends highlight the growing impact of climate change in the Maldives, 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 Maldives' vulnerability to climate change and its dependence on sectors such as tourism and fisheries, which are highly sensitive to climatic variations.

Figure 5. Climatological averages and trends of change against natural climate variability in the Maldives 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 the Maldives, the present study uses four “storylines” known as Shared Socioeconomic Pathways (SSPs). These scenarios were used by the IPCC Sixth

Assessment Report[26] 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,[26] 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.[26] 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.

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.

[26] 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.

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.

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.[26]

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 the Maldives tomorrow.

Table 1. Characteristics of the 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.

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 the Maldives

While the SSPs are developed as global scenarios, they provide critical insights for national decision-makers, including those in the Maldives. 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 the Maldives, 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, Maldivian 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 the Maldives 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 the Maldives 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 during the reference historical period (1985-2014) ranged between 27°C and 28°C, while the WBGT for the same period ranged between 27.5°C and 28.5°C (Figure 6). 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), the Maldives 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 5°C environmental temperature and WBGT. Without effective adaptation strategies, these would lead to significant health impacts and severely reduce the capacity to perform manual labour.

Figure 7 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 increase in temperature by 2040, generally around 0.5°C. By 2060 and until the end of the century, the temperature increases could stabilize at around 1.5°C across most of the Maldives.

Figure 6. 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.

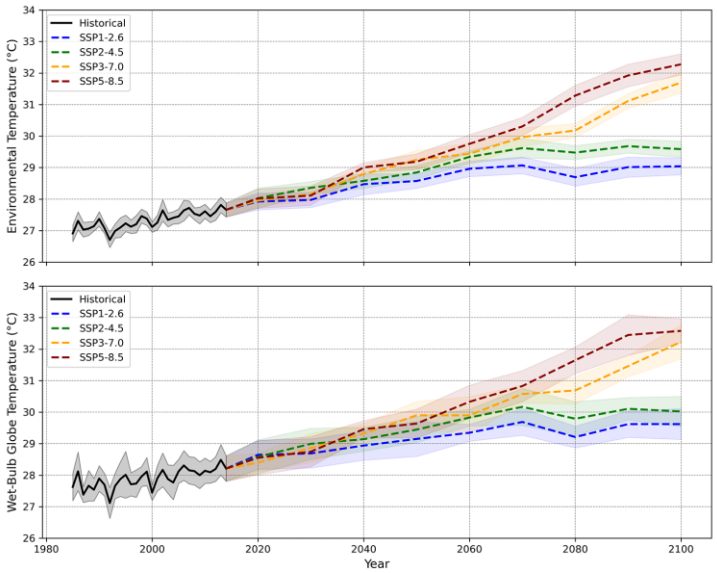
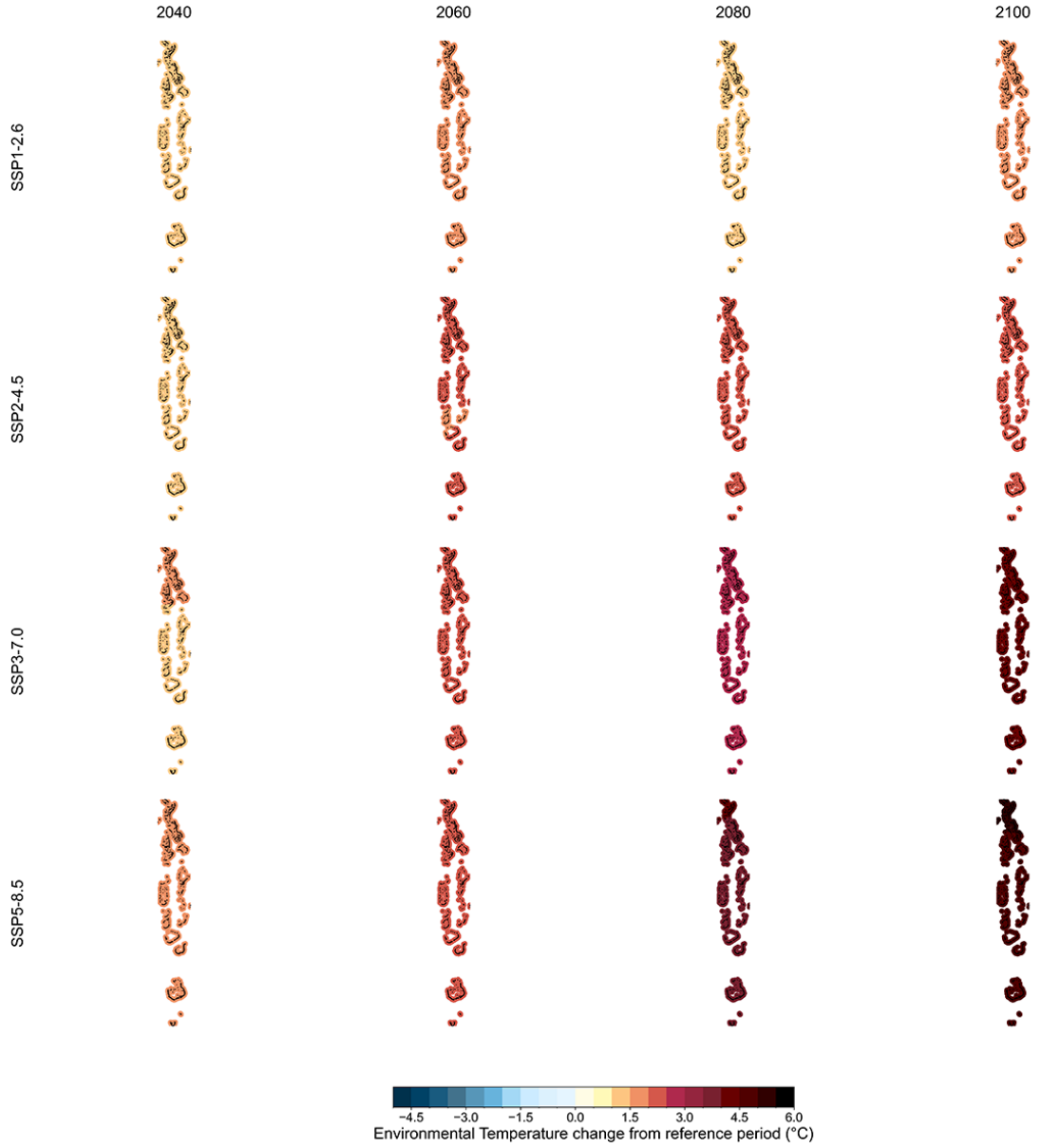


Figure 7. Change in the average maximum environmental temperature in the Maldives compared to the reference historical period (1985-2014) across the different SSPs and at different time points during this century.



Based on the SSP2-4.5, a more significant increase in temperature is expected by 2040 with temperature rises of up to 2°C in many parts 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 3°C is anticipated to emerge in many areas by 2060 and spread throughout the country by 2100. After 2080, the Maldives could face severe temperature rises, with much of the country experiencing increases of up to 6°C, which would have significant impacts on water resources, services, and heat stress. According to the SSP5-8.5, the temperature rise by 2060 will be around 3°C across the country. With continued fossil fuel use and unchecked emissions (assumed in this scenario), the Maldives will see a substantial rise in temperatures, reaching 5°C to 6°C by 2080. By the end of the century, this pathway projects the Maldives' temperatures increasing by over 6°C across all regions. This would represent severe climate impacts, including unmanageable heatwaves, water shortages, and disruptions to daily life and service 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 8. 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), the Maldives will face WBGT increases of 1 to 1.5°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, the Maldives could see WBGT rises of over 6°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 the Maldives.

3. Loss of work capacity by sector of activity

3.1. Overview of economic activity sectors

The Maldives' economy is shaped by its unique geographic and environmental context, combining traditional sectors like fisheries with a rapidly expanding tourism industry. Despite being a small island developing state with limited resources, the Maldives has achieved significant economic growth, driven by strategic investments and an emphasis on sustainable development. Key sectors of the economy include:

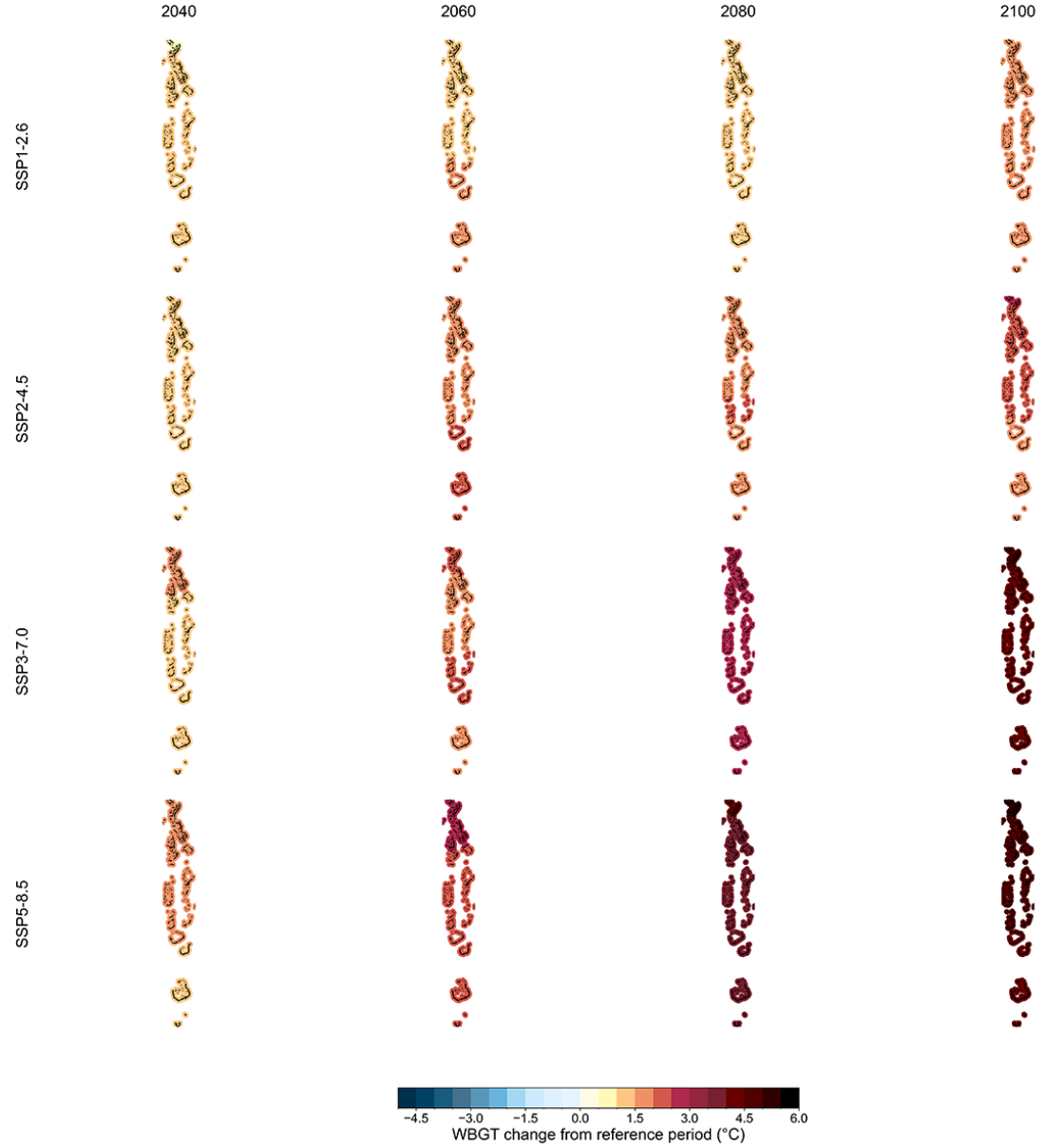
1. **Tourism:** Tourism is the backbone of the Maldivian economy, contributing approximately 30% of GDP, 60% of foreign exchange earnings, and 50% of public revenues.[27] It also has substantial indirect contributions to related sectors such as transportation and retail. The Maldives is a world-renowned destination for luxury and eco-tourism, attracting visitors to its beaches, coral reefs, and resorts. Tourism directly and indirectly employs a significant portion of the workforce, with 25% of all women and 33% of men engaged in tourism-related activities.[27] Employment in resorts is predominantly dominated by male and foreign workers; in 2019, resorts employed approximately 45,000 individuals, with foreign male and local male employees each comprising 45%, foreign females 7%, and local females only 3%.[28] Tourism has been instrumental in driving economic growth and improving infrastructure, though it also underscores the country's vulnerability to external shocks and environmental challenges.
2. **Fisheries:** Fisheries is the Maldives' second-largest economic sector, accounting for ~4.5% of GDP and contributes 50% of the country's merchandise exports.[6] The sector provides direct or indirect income to over 20% of the population and plays a crucial role in food security.[6] Sustainable fishing practices, including pole-and-line tuna fishing, have bolstered the Maldives' reputation for environmentally responsible fisheries, opening access to premium international markets. However, the sector faces challenges from overfishing, rising sea temperatures, and climate change impacts on marine ecosystems.
3. **Transportation and Communication:** The transportation and communication sectors are critical to supporting the Maldives' dispersed island geography, facilitating connectivity for both residents and tourists. Investments in inter-island transport, ports, and telecommunications infrastructure have enhanced access to services and economic opportunities. These sectors also provide employment and contribute to the development of other industries, including tourism and fisheries.[4]
4. **Construction:** The construction sector is a vital driver of economic activity, accounting for 12% of GDP growth. Investments in resort development and urban infrastructure, including climate-resilient housing and public facilities, have boosted economic activity. However, these projects rely heavily on expatriate labour, further emphasizing the importance of developing local expertise in technical fields.[4,29]
5. **Renewable Energy and Climate Resilience:** While the Maldives remains reliant on imported fossil fuels, the government has initiated renewable energy projects to reduce emissions and enhance energy security. Solar and wind energy projects are part of a broader strategy to achieve net-zero emissions by 2030. These efforts align with the Maldives' global leadership in climate advocacy, as the country is among the most vulnerable to rising sea levels and other climate change impacts.[4]

Overall, the economic structure of the Maldives reflects a blend of traditional sectors and modern industries, supporting steady growth and development. However, challenges remain, including income inequality, high unemployment rates among resident Maldivians, and the economy's heavy reliance on tourism. Climate change

[27] World Bank Group. 2023. Maldives Country Partnership Framework.
[28] National Bureau of Statistics (2019). Employment in Tourist Resorts 2019. Government of the Maldives.
[29] GDP Outlook Tables 1995 – 2017, National Bureau of Statistics, Malé (revised 28 Oct, 2018), http://statisticsmaldives.gov.mv/nbs/wp-content/uploads/2018/11/GDP-Outlook_Tables.xlsx.

presents a critical threat to the Maldives, necessitating substantial investments in climate adaptation and disaster risk management. Diversifying the economy, fostering a skilled and inclusive workforce, and enhancing infrastructure resilience will be essential for the Maldives to sustain its economic progress and address emerging challenges.

Figure 8. Change in the average maximum WBGT in the Maldives compared to the reference historical period (1985-2014) across the different SSPs and at different time points during this century.



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.[21] 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.[22] 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.[22,30]

Work intensity and metabolic heat production

The physical effort required for high-intensity work naturally produces metabolic heat.[22,31] When this internal heat generation combines with external (environmental) heat stress, the body's cooling mechanisms can be overwhelmed.[22] 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"[23] and it is a key factor in the observed loss of work time and, therefore, productivity.[32]

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[32,33] and increased error rates.[34] This occurs because workers should take more frequent breaks, reduce their pace, or even stop working to avoid heat-related health risks.[35] 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.[20,33]

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 the Maldives was estimated using a response function for workability, based on previous methods.[36] The estimated work capacity loss in the Maldives'

[30] Kenny G.P., Wilson T.E., Flouris A.D., Fujii N. (2018). Heat exhaustion. Handbook of Clinical Neurology; 157: 505-529.
[31] 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.
[32] 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.
[33] 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.
[34] 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.
[35] 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.
[36] 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.

agricultural, construction, manufacturing, mining and quarrying, services, as well as transport and trade sectors are illustrated in Figures 9-11. 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/fisheries** and **construction** (Figure 9) fluctuated between 10-12% in high-intensity work, between 3% and 5% in moderate-intensity work, and remained lower than 1% 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 10-15% in high-intensity work, 7-10% in moderate-intensity work, and 1-2% 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 14% 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 10), **services**, as well as **transportation and trade** (Figure 11), work capacity losses remained below 5% 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-intensity work under scenarios SSP1-2.6 and SSP2-4.5, which assume sustainability-focused global action. However, in high-intensity work under scenarios SSP1-2.6 and SSP2-4.5, climate change will cause additional work capacity losses of 1-4%. Moreover, in SSP3-7.0 and SSP5-8.5, climate change will lead to additional work capacity losses reaching 6% in moderate-intensity work and exceeding 15% 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/fisheries and construction show the highest work capacity losses due to increased heat stress from climate change, reaching as high as 42% 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), losses remain relatively low across all intensity levels. However, in scenarios where climate action is delayed or absent (SSP3-7.0, SSP5-8.5), 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 the Maldives.

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 9. Average work capacity loss (%) in the Maldives during high- (top), moderate- (middle), and low- (bottom) intensity work in agriculture/fisheries (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.

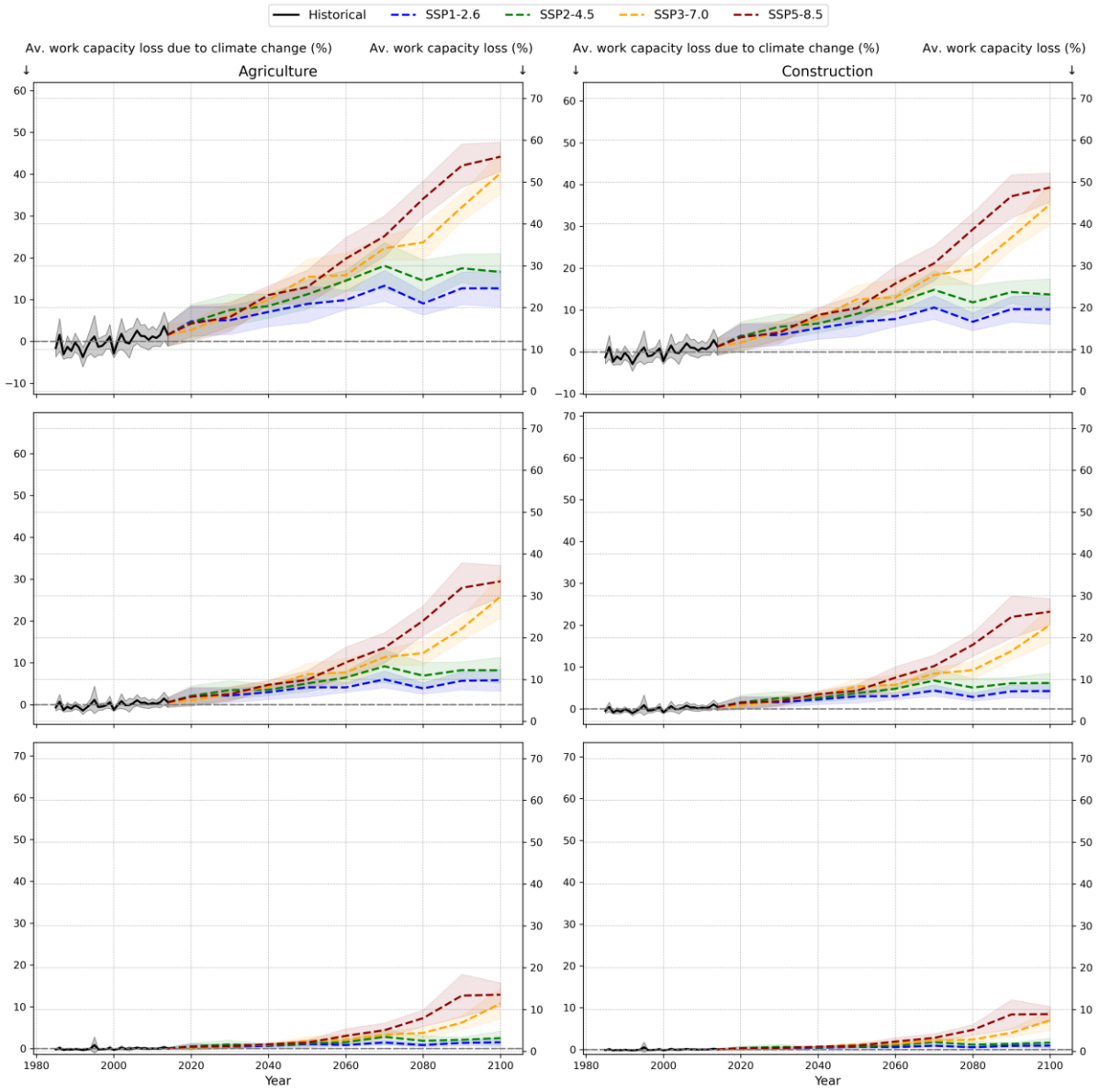


Figure 10. Average work capacity loss (%) in the Maldives during high- (top), moderate- (middle), and low- (bottom) intensity work in manufacturing (left graphs) as well as mining and quarrying (right graphs) during the reference historical period (1985-2014) and until 2100 across the different SSPs. 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.

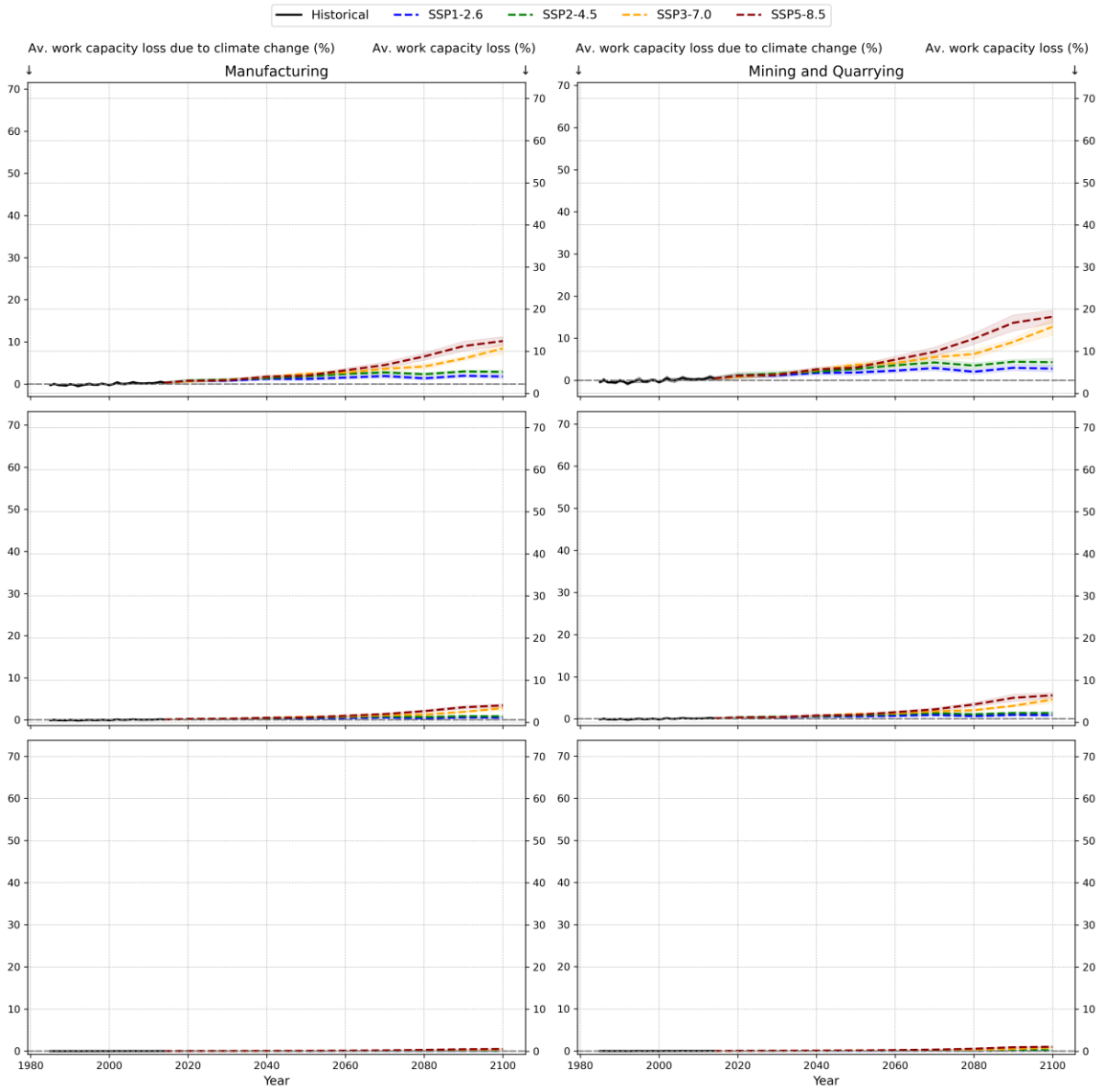
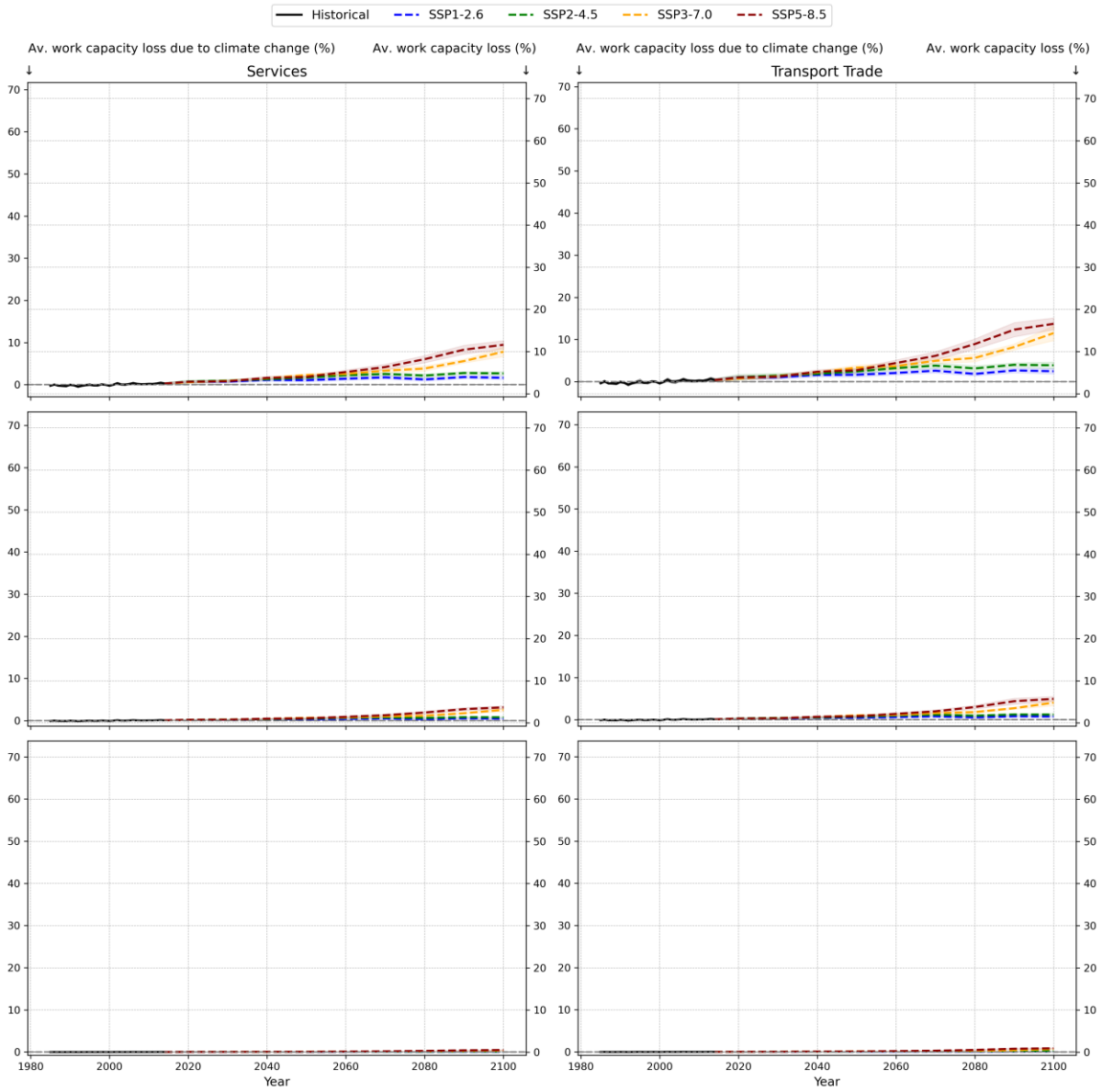


Figure 11. Average work capacity loss (%) in the Maldives during high- (top), moderate- (middle), and low- (bottom) intensity work in services (left graphs) as well as transportation and trade (right graphs) during the reference historical period (1985-2014) and until 2100 across the different SSPs. 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.



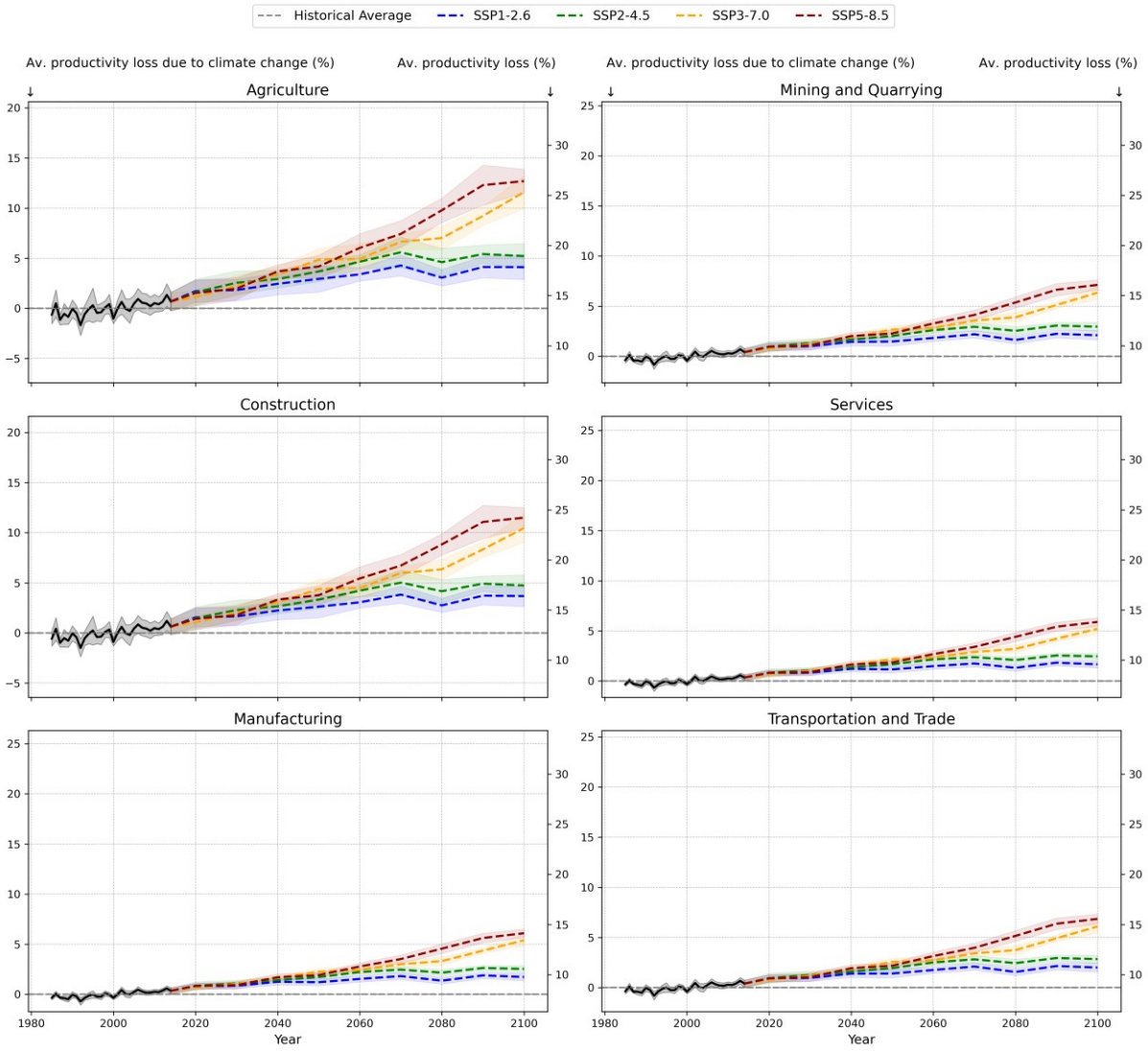
4. Loss of productivity by sector of activity

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.[20,33,34,35] 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 12. In **agriculture/fisheries** and **construction**, productivity loss due to heat stress fluctuated between 13% and 15%, during the historical period. By 2100, under SSP1-2.6 and SSP2-4.5, productivity loss is expected to further increase by 3-5% 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 13% toward the end of the century. Agriculture/Fisheries and construction are thereby particularly vulnerable sectors to loss of productivity 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 5% to 8% during the historical period. Under SSP1-2.6 and SSP2-4.5, climate change is anticipated to further increase productivity loss by 2-3% 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 7% in these scenarios by 2100, compared to the average year within the reference period.

Figure 12. Average productivity loss in the Maldives in agriculture/fisheries (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.

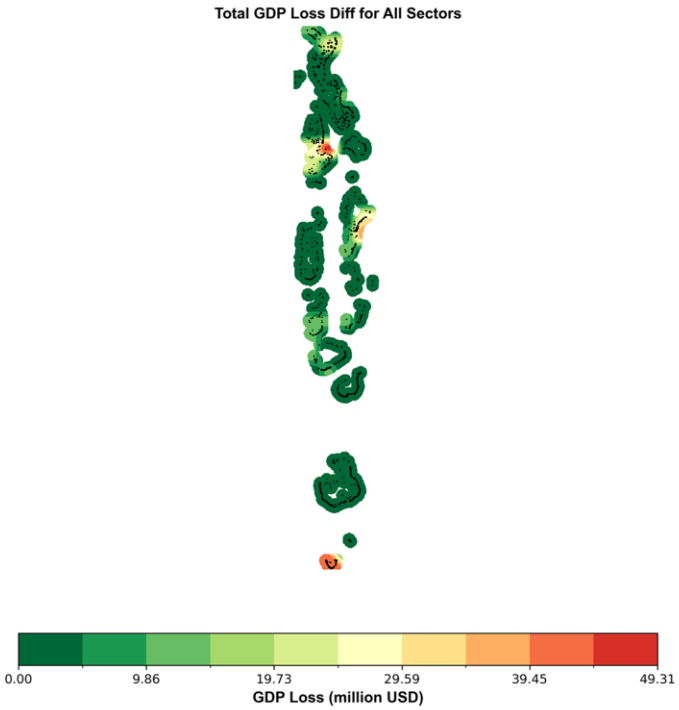
The findings from the analysis on the economic impacts of rising heat stress due to climate change demonstrate that the Maldives lost 364 million USD more in 2023 compared to the average year during the reference historical period (1985-2014) (Table 2). The distribution of the GDP loss (in million USD) due to climate change across the country is illustrated in Figure 13.

The map shows that climate change impacts on GDP cluster in a few atolls with dense activity. The largest losses appear around the Greater Malé area and the nearby resort belt. A second hotspot is visible in the far south around Addu. Many other islands show low absolute losses. Values range from near zero to roughly 50 million USD per hotspot. The pattern follows where people live and work. It aligns with tourism, ports, airports, logistics and construction. Heat during the hottest hours cuts effective work time and raises cooling needs in hotels, restaurants, transport hubs and building sites. Fish processing and dock work are also affected. Low figures on outer islands do not mean low risk. They reflect smaller local economies. Workers there still face high exposure and few protections, so the impact on household income can be large even when the national loss is small.

The main message is straightforward. Protect workers and firms in the places where losses concentrate first, then extend the same standards across the archipelago. Use WBGT thresholds to manage work and rest. Provide shade, ventilation and reliable drinking water. Move heavy tasks to cooler hours. These steps will reduce current losses and help avoid larger losses as heat stress rises.

The macro-economic implications of the present findings are important since reductions in available work time of key industries due to climate change can have significant macroeconomic effects. For example, the service sector – which plays a key role in the Maldives' national production – loses a substantial portion of its effective work hours due to climate change and the cumulative effect leads to significant declines in overall GDP. This economic result underscores the importance of addressing heat stress induced by climate change, not only to protect worker health and productivity, but also to maintain economic stability and growth. The connection between reduced work time and GDP loss highlights the broader economic risks posed by rising heat stress due to climate change, emphasizing the importance of investing in heat mitigation and adaptation strategies to protect both worker well-being and the nation's economic prosperity.

Figure 13. GDP loss across the Maldives due to rising workplace heat stress caused by climate change, between 2023 and the baseline historical period 1985-2014.



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 69.3% of the additional GDP losses compared to an average year during the historical period. Transport and trade are also heavily impacted, with 50.3 million more USD lost due to heat stress during 2023 in relation to an average year during the historical period (Table 2). Construction and agriculture/fisheries are also heavily impacted, representing 7.5% and 4.4% of the additional GDP losses compared to an average year during the historical period.

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/Fisheries	-16.0	4.4
Construction	-27.3	7.5
Manufacturing	-6.4	1.8
Mining and Quarrying	-11.7	3.2
Services	-252.6	69.3
Transport and Trade	-50.3	13.8
Total GDP change	-364.3	

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

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 14. The maps indicate that workplace heat stress caused by climate change already imposes a measurable economic burden across all sectors in the Maldives, with a strongly uneven distribution by both sector and location. Losses cluster in and around Greater Malé and in several resort-dense atolls along the central chain and in the far south. Many other islands record small absolute losses because local output is smaller, not because work is safe.

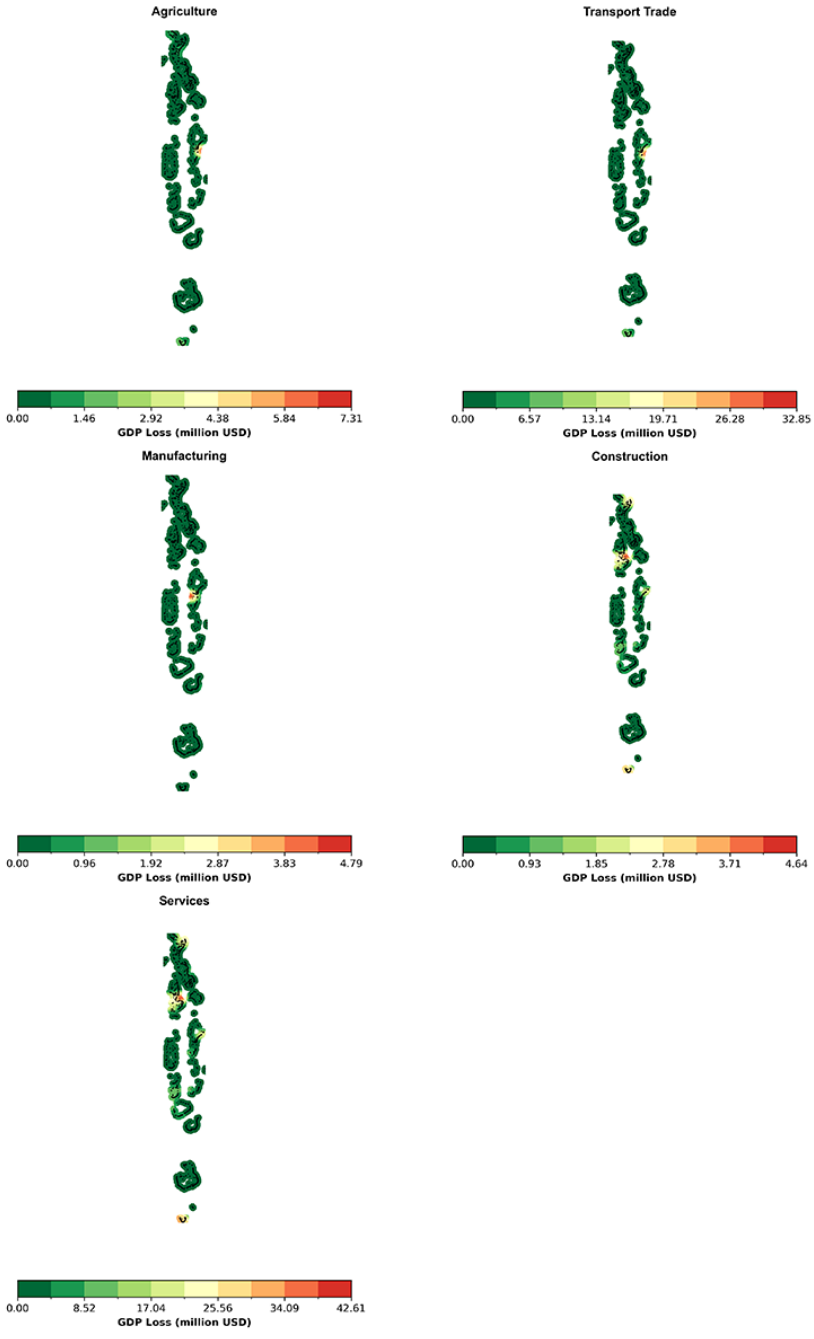
Services carry the largest losses. The strongest impacts are observed in tourism islands and in Malé. Midday heat cuts hours in hospitality, retail, administration and small urban services. “Back-of-house areas” without good ventilation add to the strain. Where guesthouses and resorts are dense, the losses are higher.

Transport and trade rank next. Hotspots align with ports, airports and busy ferry hubs. Heat slows cargo handling, ground operations and inter-island logistics. These delays spill over to supply chains and service delivery. Construction losses are smaller but visible near Malé and other islands with active projects. Heavy outdoor work is sensitive to high WBGT, which lowers on-site productivity during the hottest hours.

Manufacturing and agriculture/fisheries have a limited footprint and show localized losses, mainly around fisheries as well as fish processing and light industry near Malé and in a few southern atolls. Heat in enclosed spaces reduces throughput unless cooling and ventilation are adequate. Outdoor work in farming and fisheries as well as and post-harvest handling is exposed. Even small GDP losses can matter for household incomes on outer islands.

A technical note is warranted: because sector sizes differ markedly – particularly the dominance of services – the figure uses sector-specific GDP ranges to preserve spatial detail. Cross-map comparisons should therefore focus on patterns and locations of loss rather than colour intensity alone. Taken together, the results clearly show the need to protect workers and firms in Malé, resort hubs and key logistics nodes using WBGT thresholds. To provide shade, ventilation, and reliable hydration. Adjust schedules around the hottest hours and to extend the same basic protections to outer atolls. These steps will reduce current losses and help contain future ones as heat levels rise.

Figure 14. GDP loss across the Maldives due to rising workplace heat stress caused by climate change, between 2023 and the baseline historical period 1985-2014, in each sector of economic activity. Note: due to the dominance of the service sector in the Maldives' 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. Spatial distribution not available for mining/quarrying; national totals only (Tables 2-3).



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. The Maldives' 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 7.7 and 9.2% 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 575.5 million USD in 2040 and 1.5 billion USD in 2060. Under a "middle-of-the-road" scenario (SSP2-4.5), the contraction deepens from 7.9% (589.6 million USD) in 2040 to 9.9% (1.6 billion USD) in 2060, while a regional-rivalry world (SSP3-7.0) will drastically increase the burden to 10.1% by 2060, equal to 1.6 billion USD. Should fossil-fuel development continue unabated (SSP5-8.5), rising workplace heat stress could cut 10.5% (1.7 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 Maldivian economy, bears most of the losses: 5.4% (403 million USD) more losses in 2040 under SSP1-2.6 compared to the historical period, rising to 7.3% (1.2 billion USD) in 2060 under SSP5-8.5. Manufacturing absorbs small steady losses between 0.1% (SSP1-2.6, 2040) to 0.2% (SSP5-8.5, 2060), reflecting its small footprint in the economy. Agriculture/Fisheries will record higher losses compared to the average year within the historical period, with aggravated impacts depending on the SSP, rising from 25.6 million USD (SSP1-2.6, 2040) to 97.6 million USD (SSP5-8.5, 2060). Construction is expected to experience steady climate change impacts ranging from 0.6% of GDP (43.7 million USD) additional losses in 2040 (compared to the baseline period), to 0.8% of GDP (133.2 million USD) in 2060. Transport and trade are expected to experience moderate rising climate change impacts ranging from 1% of GDP (75 million USD) additional losses in 2040 (compared to the baseline period), to 1.3% of GDP (208 million USD) in 2060.

Table 3. Annual impact of rising workplace heat stress caused by climate change on GDP in the Maldives 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 / Fisheries	SSP1-2.6	-25.6	-0.34	-80.7	-0.51
	SSP2-4.5	-27.2	-0.37	-88.5	-0.56
	SSP3-7.0	-28.7	-0.38	-90.3	-0.57
	SSP5-8.5	-29.9	-0.40	-97.6	-0.61
Construction	SSP1-2.6	-43.7	-0.59	-113.7	-0.72
	SSP2-4.5	-45.2	-0.61	-122.9	-0.77
	SSP3-7.0	-46.8	-0.63	-125.4	-0.79
	SSP5-8.5	-47.8	-0.64	-133.2	-0.84
Manufacturing	SSP1-2.6	-10.8	-0.14	-27.2	-0.17
	SSP2-4.5	-11.0	-0.15	-29.4	-0.19
	SSP3-7.0	-11.3	-0.15	-30.1	-0.19
	SSP5-8.5	-11.6	-0.16	-31.2	-0.20
Mining and Quarrying	SSP1-2.6	-17.5	-0.23	-41.3	-0.26
	SSP2-4.5	-17.9	-0.24	-44.4	-0.28
	SSP3-7.0	-18.4	-0.25	-45.4	-0.29
	SSP5-8.5	-18.5	-0.25	-47.2	-0.30
Services	SSP1-2.6	-402.8	-5.40	-1,012.8	-6.37
	SSP2-4.5	-411.5	-5.52	-1,092.6	-6.87
	SSP3-7.0	-423.4	-5.68	-1,119.3	-7.04
	SSP5-8.5	-426.0	-5.71	-1,156.7	-7.28
Transport and Trade	SSP1-2.6	-75.2	-1.01	-181.9	-1.14
	SSP2-4.5	-76.8	-1.03	-195.8	-1.23
	SSP3-7.0	-78.9	-1.06	-199.8	-1.26
	SSP5-8.5	-80.3	-1.08	-207.5	-1.31
TOTAL	SSP1-2.6	-575.5	-7.72	-1,457.5	-9.17
	SSP2-4.5	-589.6	-7.91	-1,573.6	-9.90
	SSP3-7.0	-607.5	-8.15	-1,610.2	-10.13
	SSP5-8.5	-614.1	-8.24	-1,673.4	-10.53

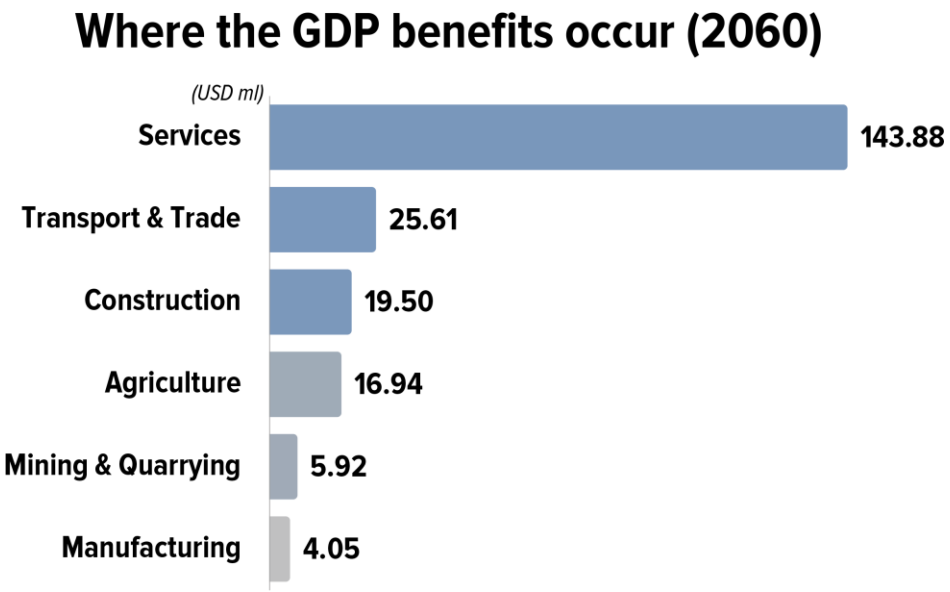
[1] million USD, fixed 2015 prices.

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 1.36 percentage points of GDP loss by 2060 (about 216 million 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 construction

and agriculture/fisheries will intensify exposure to workplace heat stress. Therefore, integrating heat stress thresholds into building codes, transport and agricultural/fisheries extension services, as well as social-protection schemes will be critical. Anchoring these measures in the Maldives' 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 the Maldives 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.

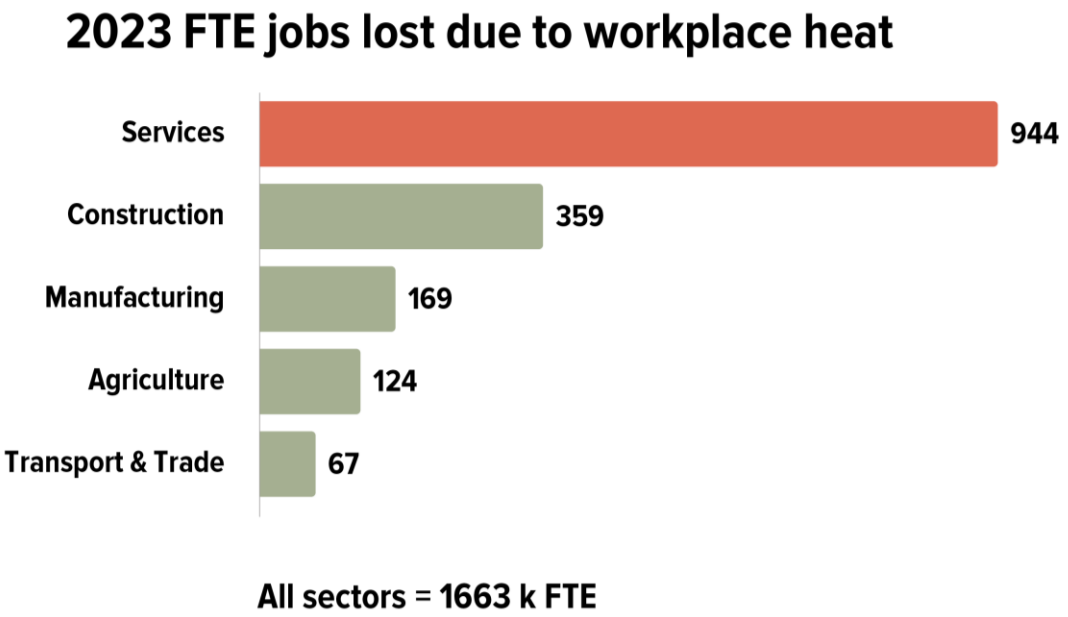
The conversion of lost working hours into FTE job losses is based on a standard calculation of annual working hours per worker. It is assumed that a worker takes a minimum of 14 days of leave per year. Considering a typical work schedule of 5 days per week and 8 hours per day, the total potential working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

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 the Maldives, calculated as the change between 2023 and the reference historical period 1985-2014. No data was available to perform analyses for mining and quarrying (see A1.2.8).



The findings in Table 4 show that the impact of climate change on the Maldives's labour market is significant, with over 1.66 thousand more jobs lost due to workplace heat stress during 2023 compared to the average year during the historical period. Nearly 57% of job losses are concentrated in services, 22% occur in construction, as well as about 10%, 7.5%, and 4% in manufacturing, agriculture/fisheries, as well as transport and trade, respectively (Table 4 and Infographic 2). The analysis also reflects a seasonal pattern where 35% of the impacts occur in Q2, with 26% and 22% during Q1 and Q3, respectively. Overall, these results highlight the urgent need for adaptive policies, such as regulated work-rest cycles, access to cooling measures, and the integration of heat mitigation into occupational safety standards, to safeguard worker productivity and health in the Maldives.

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 the Maldives, 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 / Fisheries	Q1	3,381,903	-53,425	-1.58	-27
	Q2	3,421,000	-103,727	-3.03	-52
	Q3	3,460,097	-50,843	-1.47	-25
	Q4	3,460,097	-41,154	-1.19	-21
	Year	13,723,097	-249,150	-1.82	-124
Construction	Q1	10,570,794	-153,547	-1.45	-77
	Q2	10,693,000	-294,973	-2.76	-147
	Q3	10,815,206	-151,132	-1.40	-75
	Q4	10,815,206	-120,465	-1.11	-60
	Year	42,894,206	-720,117	-1.68	-359
Manufacturing	Q1	9,061,246	-92,821	-1.02	-46
	Q2	9,166,000	-110,788	-1.21	-55
	Q3	9,270,754	-81,689	-0.88	-41
	Q4	9,270,754	-54,189	-0.58	-27
	Year	36,768,754	-339,488	-0.92	-169
Services	Q1	53,400,157	-527,276	-0.99	-263
	Q2	54,017,500	-619,739	-1.15	-309
	Q3	54,634,843	-430,065	-0.79	-214
	Q4	54,634,843	-316,409	-0.58	-158
	Year	216,687,343	-1,893,490	-0.87	-944
Transport and Trade	Q1	3,501,520	-40,641	-1.16	-20
	Q2	3,542,000	-45,049	-1.27	-22
	Q3	3,582,480	-27,451	-0.77	-14
	Q4	3,582,480	-20,279	-0.57	-10
	Year	14,208,480	-133,420	-0.94	-67
TOTAL	Q1	79,915,620	-867,710	-1.09	-433
	Q2	80,839,500	-1,174,276	-1.45	-585
	Q3	81,763,380	-741,180	-0.91	-369
	Q4	81,763,380	-552,497	-0.68	-275
	Year	324,281,880	-3,335,664	-1.03	-1,663

n: number; FTE: full-time equivalent; no data was available to perform analyses for mining and quarrying (see A1.2.8).

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 the Maldives by 2040. Model results indicate that, relative to the 1985-2014 baseline, the economy will lose the equivalent of 2.4 thousand full-time jobs under a low-emissions pathway (SSP1-2.6). The losses rise to nearly 3 thousand full-time jobs under SSP2-4.5 and reach 3.4-3.6 thousand under the high-emissions scenarios (SSP3-7.0 and SSP5-8.5). In proportional terms this represents a 1.8% contraction in total available labour time under the most optimistic scenario and 2.5% under unabated fossil-fuel development.

The burden is highly concentrated in the services sector, which accounts for 1.4 thousand FTE annual job losses in SSP1-2.6, rising to 2 thousand in SSP3-7.0, about 2.4% of the sector's total labour force. Agriculture, manufacturing, as well as transport and trade show 116-334 annual FTE job losses depending on the climate change scenario. While these job losses are smaller in absolute terms, they remain proportionately significant given those sectors' smaller employment base, reaching up to 5.5% of the sectorial total labour force. Construction is particularly exposed given the sector's outdoor work intensity and the physiological limits of heavy manual labour in high humid-heat conditions, with 500-750 FTE job losses per year, representing up to 4.7% of the sector's total labour force.

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 3.1-5.6 thousand FTE jobs from the Maldives' economy each year, depending on the global emissions pathway. Model results show that under the Paris-consistent trajectory (SSP1-2.6) the Maldives will lose 3.14 thousand FTEs, or about 2.4% of total labour force. The toll rises sharply to 5 thousand FTEs under SSP2-4.5, 6.1 thousand under SSP3-7.0, and nearly 5.6 thousand under SSP5-8.5, where heat cuts 4.2% more aggregate work hours compared to the average year within the historical period.

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 (n)	Change in Work Hours (% FTE)	Change in Jobs (FTE)
Agriculture / Fisheries	SSP1-2.6	10,578,137	-370,177	-3.50	-185
	SSP2-4.5		-473,969	-4.48	-236
	SSP3-7.0		-576,862	-5.45	-288
	SSP5-8.5		-544,500	-5.15	-271
Construction	SSP1-2.6	33,934,680	-1,003,876	-2.96	-500
	SSP2-4.5		-1,289,665	-3.80	-643
	SSP3-7.0		-1,579,388	-4.65	-787
	SSP5-8.5		-1,503,157	-4.43	-749
Manufacturing	SSP1-2.6	39,348,103	-386,341	-0.98	-193
	SSP2-4.5		-533,074	-1.35	-266
	SSP3-7.0		-670,655	-1.70	-334
	SSP5-8.5		-546,208	-1.39	-272
Services	SSP1-2.6	171,432,411	-2,823,580	-1.65	-1,408
	SSP2-4.5		-3,402,571	-1.98	-1,696
	SSP3-7.0		-4,153,339	-2.42	-2,070
	SSP5-8.5		-3,820,230	-2.23	-1,904
Transport and Trade	SSP1-2.6	9,952,354	-233,630	-2.35	-116
	SSP2-4.5		-270,930	-2.72	-135
	SSP3-7.0		-315,304	-3.17	-157
	SSP5-8.5		-320,200	-3.22	-160
TOTAL	SSP1-2.6	265,245,686	-4,817,602	-1.82	-2,402
	SSP2-4.5		-5,970,209	-2.25	-2,976
	SSP3-7.0		-7,295,548	-2.75	-3,637
	SSP5-8.5		-6,734,296	-2.54	-3,357

SSP: shared socioeconomic pathway; n: number; FTE: full-time equivalent; no data was available to perform analyses for mining and quarrying (see A1.2.8).

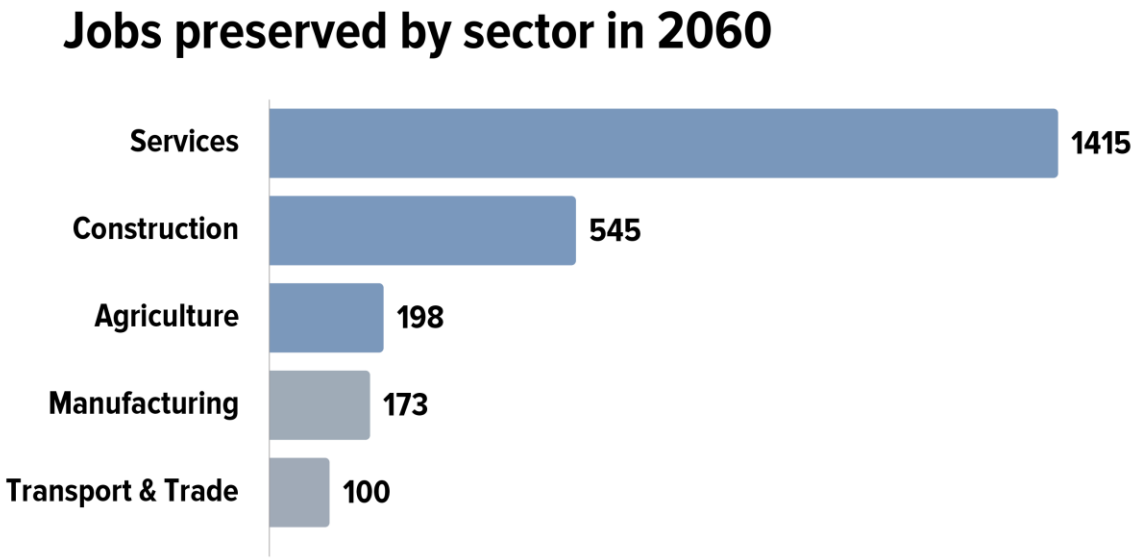
Losses are highly concentrated in the services sector, reflecting the impacts of environments with limited climate control. In 2060, services will lose nearly 1.76 thousand FTEs in the low-emissions scenario, climbing to nearly 3.2 thousand FTEs in the high-emissions scenario, nearly 4% of the total FTE loss. Construction, characterised by outdoor work and heavy manual labour, ranks second, with losses escalating from 1 to over 1.3 thousand FTEs across the scenario range. Manufacturing, where small workshops often lack adequate cooling, will lose 214-549 FTEs, while agriculture/fisheries is expected to record up to 480 FTE losses. The latter is over 9% of the sector's total labour force, underscoring the significant blow to farmers and fishers in the Maldives. Losses in transport and trade remain marginal (170-280 FTEs) owing to mechanisation and limited labour market size. Therefore, implementation of climate mitigation and adaptation policies will save more than 1400 FTE jobs per year in services, ~550 FTE jobs in construction, as well as about 500 FTE jobs in the other industrial sectors (Infographic 3).

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 / Fisheries	SSP1-2.6	10,578,137	-563,461	-5.33	-281
	SSP2-4.5		-820,612	-7.76	-409
	SSP3-7.0		-957,100	-9.05	-477
	SSP5-8.5		-960,257	-9.08	-479
Construction	SSP1-2.6	33,934,680	-1,432,101	-4.22	-714
	SSP2-4.5		-2,185,869	-6.44	-1,090
	SSP3-7.0		-2,612,601	-7.70	-1,302
	SSP5-8.5		-2,525,010	-7.44	-1,259
Manufacturing	SSP1-2.6	39,348,103	-428,762	-1.09	-214
	SSP2-4.5		-845,250	-2.15	-421
	SSP3-7.0		-1,102,166	-2.80	-549
	SSP5-8.5		-776,660	-1.97	-387
Services	SSP1-2.6	171,432,411	-3,530,565	-2.06	-1,760
	SSP2-4.5		-5,679,330	-3.31	-2,831
	SSP3-7.0		-6,990,353	-4.08	-3,485
	SSP5-8.5		-6,368,251	-3.71	-3,175
Transport and Trade	SSP1-2.6	9,952,354	-335,886	-3.37	-167
	SSP2-4.5		-485,093	-4.87	-242
	SSP3-7.0		-565,989	-5.69	-282
	SSP5-8.5		-537,179	-5.40	-268
TOTAL	SSP1-2.6	265,245,686	-6,290,775	-2.37	-3,136
	SSP2-4.5		-10,016,154	-3.78	-4,993
	SSP3-7.0		-12,228,210	-4.61	-6,096
	SSP5-8.5		-11,167,358	-4.21	-5,567

SSP: shared socioeconomic pathway; n: number; FTE: full-time equivalent; no data was available to perform analyses for mining and quarrying (see A1.2.8).

Infographic 3. Sectoral labour market benefits of implementing in the Maldives 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 nearly 2.5 thousand saved jobs annually by 2060, underscoring the macro-labour dividend of achieving a 2°C climate goal.
- **Services and construction 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 the Maldives' 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 the Maldives

The Maldives 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 OSH Conventions will enable the Maldives 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/fisheries and construction where workers are most exposed to heat stress. To date, the Maldives has ratified 10 ILO conventions, including 8 of the 10 fundamental ones.[37] However, key OSH conventions relevant to managing heat stress have not been ratified by the Maldives. 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 the Maldives' 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 lack of ratification and alignment with the above ILO OSH Conventions limits the ability of the Maldives to implement comprehensive improvements in OSH, particularly with regard to heat-related policies. This gap highlights the urgent need to embed climate adaptation measures within existing OSH frameworks to safeguard workers against escalating heat stress risks. Given the country's high vulnerability to climate change and the projected increase in heat stress, ratifying these Conventions and integrating their principles into national policies would be instrumental in managing heat-related risks.

Incorporating these OSH Conventions into the policies of the Maldives would also enhance national resilience by promoting workplace risk assessments and updating safety protocols to address rising heat levels. These measures would help the Maldives prepare for anticipated increases in heat stress and other climate-related hazards, contributing to a safer and more sustainable working environment.

Furthermore, the ratification and implementation of these OSH Conventions align with the broader climate and development goals of the Maldives. Integrating OSH standards into climate adaptation strategies reinforces the country's commitment to the Paris Agreement, supports a just transition for workers, and strengthens resilience to climate impacts while ensuring worker protections and economic stability.

37 https://normlex.ilo.org/dyn/nrmlx_en/f?p=NORMLEXPUB:11200:0::NO::P11200_COUNTRY_ID:103365

6.2. Policy recommendations for climate adaptation

To further enhance the Maldives' 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/fisheries, construction, and manufacturing. This alignment with ILO OSH standards includes:

1. **Development of National Heat-Stress Guidelines:** The Maldives 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 also indicated in 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:** The Maldives is encouraged to incorporate continuous monitoring and risk assessment protocols 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:** 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 agriculture/fisheries and construction sectors, where exposure to high heat exposure is frequent.

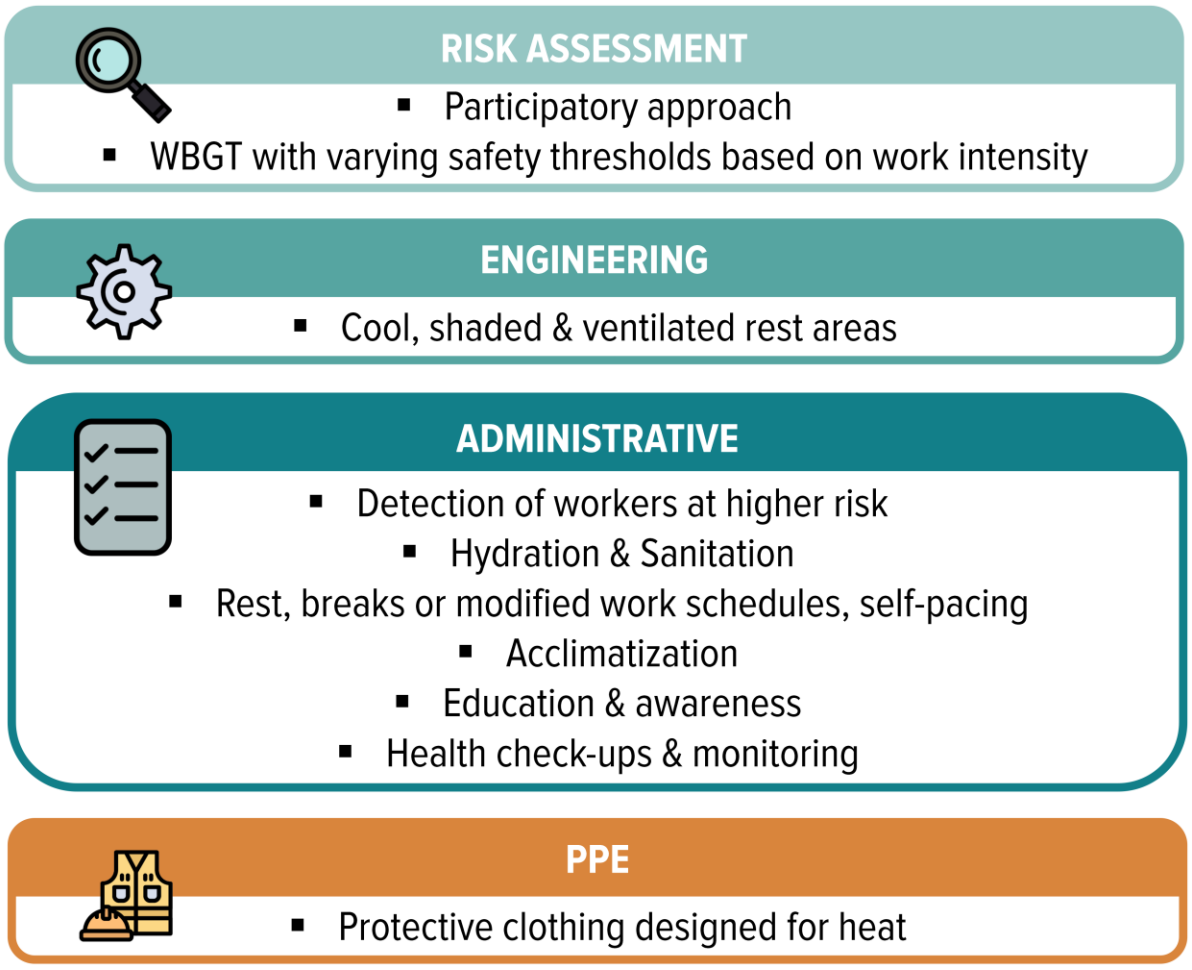
4. **Integration of Heat Stress into National OSH Policies:** The Maldives is encouraged to explicitly incorporate heat stress as a key occupational hazard in its OSH policies, following ILO guidance on climate-responsive OSH frameworks. Policies should include minimum heat safety standards, mandatory 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]

5. **Promotion of Workplace Health Services and Support Systems:** 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 in the Maldives, particularly in sectors most vulnerable to heat stress. It is important that the Maldives' 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]

6. **Utilization of social security funds to incentive 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 implementing the above ILO-aligned policy recommendations, the Maldives 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 the Maldives' 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 the Maldives, with workers, enterprises, and the labour market each experiencing distinct pressures. Outdoor sectors such as construction, fishing, tourism, and farming face the highest risks, while indoor workers also struggle with poor ventilation and rising cooling costs. Vulnerable groups including women, migrant workers, and those in the informal sector experience disproportionate impacts due to limited protection, inadequate facilities, and unsafe working or living conditions.

Enterprises face reduced productivity, higher operational costs, and climate-related disruptions, while the wider labour market sees declining participation, increased precarity, and limited readiness to adapt. Overall, heat stress affects sectors and worker groups unevenly, underscoring the need for targeted, sector-specific and group sensitive interventions to ensure safe, fair, and sustainable working conditions.

In light of the evidence presented in the present study, the Maldives 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, the Maldives can protect its workforce, sustain productivity, and enhance the resilience of its economy in the face of a warming climate.

The proposed measures emphasize the need for a comprehensive approach to managing workplace heat stress in the Maldivian workforce. Prioritizing the integration of workplace heat stress elements into the OSH framework, improving coordination among institutions, raising awareness, and building technical expertise are key steps. Short-term actions should focus on strengthening reporting and first-aid protocols, while long-term strategies call for a dedicated national OSH strategy on workplace heat stress and enhanced labour inspections. Together, these measures aim to protect workers, support enterprises, and ensure a resilient and safe labour environment.

Addressing workplace heat stress in the labour market requires effective coordination among multiple government institutions and private-sector actors. It is important to ensure that relevant authorities, including local regulatory bodies, the Health Protection Agency, the Ministry of Environment, and the Ministry of Labour, share a common understanding of workplace heat stress risks and work collaboratively to design and implement coherent responses. Establishing clear coordination mechanisms across these institutions is essential to avoid fragmented action and to ensure consistency in policy development, enforcement, and monitoring.

To support this process, a central coordinating body, for instance under the authority of the President's Office, could serve as a national focal point and repository for information on workplace heat stress. This role could be supported by a dedicated inter-ministerial task force or working group responsible for monitoring ongoing initiatives, tracking progress, and facilitating coordination across sectors and levels of governance. Such a structure would strengthen oversight, enhance accountability, and enable more strategic allocation of resources.

Implementation should proceed in parallel at both the operational level (workplaces and communities) and the policy level. This dual approach will allow for practical, ground-level interventions to inform policy development, while enabling policy frameworks to support and scale effective local solutions. Establishing platforms for structured dialogue, promoting transparent data sharing, and fostering cross-sector partnerships among government, employers, workers' organisations, and civil society will be critical to developing practical, equitable, and sustainable strategies to manage workplace heat stress in the Maldives.

Agriculture/Fisheries: In agriculture and fisheries, where the majority of work 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 is essential, 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.

Construction: Construction work is characterized by intense physical labour and significant exposure to outdoor heat. 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: Manufacturing facilities, whether operating indoors or in partially exposed environments, must 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: 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.

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 the Maldives, as demonstrated in this study. This agenda aims to provide safe, productive, and fair working conditions, which are increasingly critical as the Maldives faces heightened climate impacts, particularly rising heat stress levels. By adopting these measures, the Maldives will strengthen 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 the Maldives' labour market, aligning with both global labour standards and climate objectives.

- **Promoting Safe and Healthy Workplaces in the Maldives Amidst Rising Heat:** The Decent Work Agenda[38] prioritizes safe and healthy workplaces as essential for sustainable and equitable employment. For the Maldives, implementing OSH Conventions such as Convention No. 161 (Occupational Health Services) establishes a solid framework for safeguarding workers in sectors

[38] 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).

particularly susceptible to extreme heat, including agriculture/fisheries and construction. As highlighted in the present study, these sectors are crucial to Maldivian 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.[38]

- **Enhancing Productivity through Climate-Responsive OSH Measures:** Safe working conditions are essential to sustaining worker productivity, a core priority of the Decent Work Agenda.[38] Implementing heat adaptation strategies, such as structured work-rest cycles and hydration protocols, allows the Maldives 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.[38]

- **Focusing on Vulnerable and Informal Workers:** Informal workers, particularly those in agriculture/fisheries, 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.[38] Applying OSH standards to address climate risks helps prevent these workers from being disproportionately affected by rising heat. By mandating workplace safety measures, the Maldives can enhance both climate resilience and social equity, fostering safer work environments across all segments of its labour market.

- **Advancing Social Protection and Fair Conditions:** The Decent Work Agenda emphasizes social protection as a cornerstone of fair and sustainable employment.[38] By implementing ILO OSH Conventions, the Maldives 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.[38]

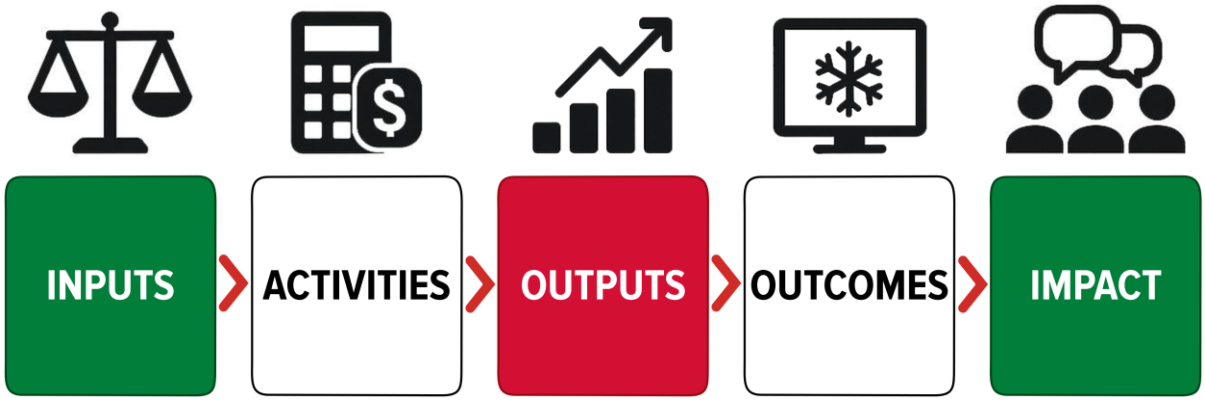
- **Contributing to the Maldives' Just Transition to a Climate-Resilient Economy:** Incorporating the Decent Work Agenda into climate adaptation initiatives also aligns with Convention No. 187 (Promotional Framework for OSH), which encourages continuous improvement in national OSH policies. This framework is key to the Maldives' 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, the Maldives 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 the Maldives. 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 the Maldives, 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 the Maldives 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 analysis was used to examine how full commitment to the ILO Decent Work Agenda and the 2030 Agenda for Sustainable Development could change the Maldives' economic and labour-market trajectory under rising workplace heat stress. It follows the ILO results logic: inputs, activities, outputs, outcomes, and impact (Infographic 5). This framing is used across ILO programmes and guidance – including the Decent Work Agenda, the Just Transition Guidelines, and the Global Flagship Programme on Building Social Protection Floors – highlighting policy coherence and tripartite action as well as defining four pillars for decent work: employment, rights at work, social protection, and social dialogue.

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



Starting point

Heat is already costly. In 2023 GDP was 364 million USD lower than the average year in 1985-2014 because of extra heat stress (Table 2). Services carried the largest absolute loss. Transport and trade followed. Construction and agriculture/fisheries also declined. The same year the economy lost the equivalent of about 1.66 thousand full-time jobs. Losses cluster in and around Greater Malé and in several resort-dense atolls along the central chain and in the far south. Many other islands record small absolute losses because local output is smaller, not because work is safe. These facts set the baseline for the scenarios in this section.

Quantified range from Section 5

By 2040 total GDP losses reach about 576 million USD in a low-emissions world and 614 million USD in a high-emissions world. By 2060 the range widens to 1.46 and 1.67 billion USD, respectively. The corresponding job-equivalent losses are about 2.4 thousand to 3.6 thousand FTEs in 2040. In 2060 the range is about 3.1 thousand to 6.1 thousand FTEs. Services and construction carry most of the toll in every case. Key results are summarized in Infographics 6-7.

Theory of change for Decent Work and SDG implementation

Inputs. Political commitment to the four pillars of decent work (employment, rights, social protection, social dialogue). A legal base that embeds the right to a safe and healthy working environment and enforces OSH standards. Budgetary allocations and climate-finance inflows (e.g., for efficient cooling and heat-safe public spaces). Social protection floors with coverage for sickness, injury and income loss. Social dialogue with strong worker and employer voice. The ILO's Social Protection Floors Flagship Programme and the Just Transition Guidelines provide a ready set of tools for this work.

Activities. (1) implementation of ILO Conventions C155, C161 and C187; (2) adoption of a national heat-stress code of practice anchored in the 10 ILO protection requirements and the recommendations of Section 6 above – the main pillar here is adopting and enforcing a national heat-stress standard based on WBGT with work-rest schedules, hydration, shade/ventilation, and acclimatisation provisions; (3) extension of social-protection floors to cover heat-related sickness, income protection and injury benefits for formal and informal workers; (4) shifting 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 (e.g., efficient cooling in schools, clinics and transport hubs; urban heat-island mitigation), and skills for green and heat-safe jobs; (5) addition of workplace heat stress to public procurement and building codes; (6) strengthening of labour inspection and tripartite social dialogue to co-design sector-specific practical protocols; and (7) establishing monitoring systems to monitor WBGT, lost work time, and heat-related illness.

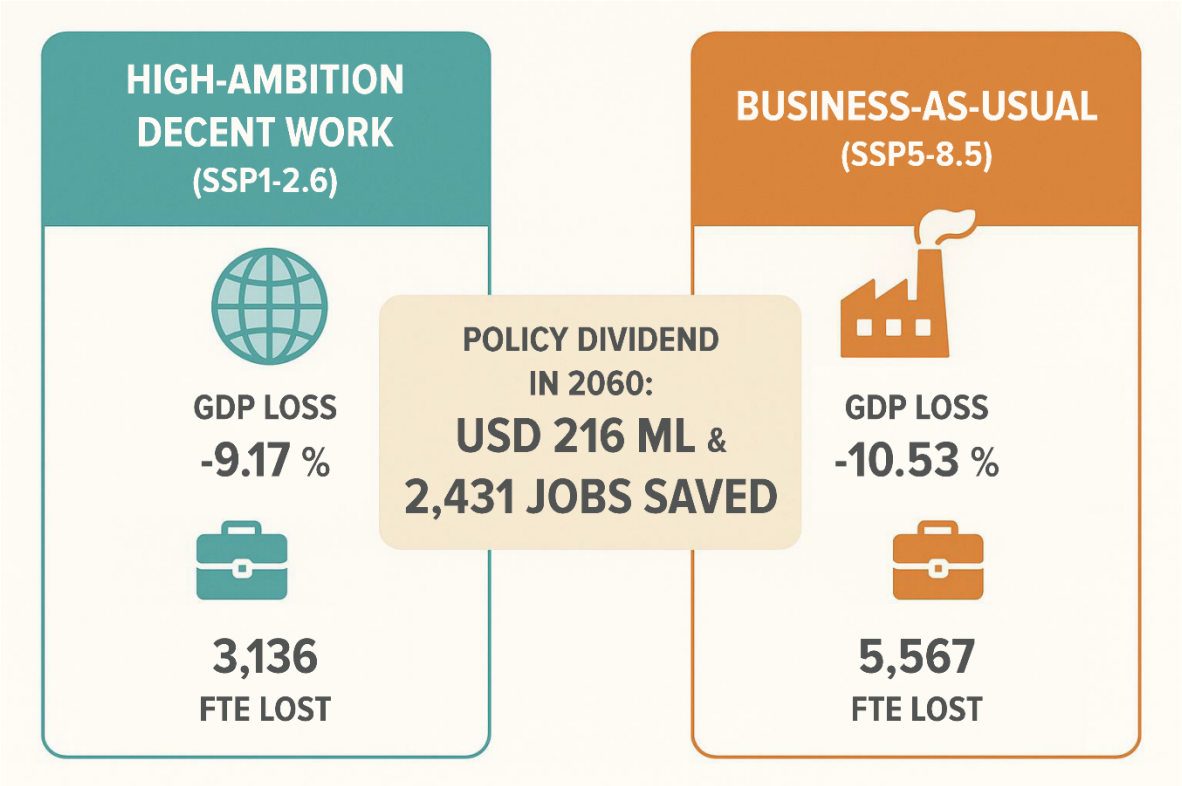
Outputs. Rapid scaling of heat-safe worksites, wider coverage of social insurance, active programmes for green and resilience-oriented employment, practical guidance for high-risk sectors, better data on WBGT, lost time, and heat illness, as well as stronger labour inspection. These outputs reflect ILO practice under results-based management.

Outcomes. Fewer hours lost to heat. Lower injury, illness, and absenteeism. Better retention and productivity in services, manufacturing and construction. Safer planting and harvesting windows. Fewer supply-chain delays at ports, markets and road hubs. Greater income security for women, migrants, and informal workers. These outcomes are consistent with the Decent Work Agenda and the SDGs (SDG8 on decent work, SDG3 on health, SDG13 on climate action).

Impact. Higher effective labour supply. More stable GDP. Stronger resilience to shocks. A fairer transition. The ILO Just Transition Guidelines and the 2030 Agenda both place equity and dialogue at the centre of this change.

- **Scenario A: High-Ambition Decent Work (Decent Work + SDGs implemented; climate consistent with SSP1-2.6).** The Maldives implements the actions above at scale by 2030 and international mitigation follows the SSP1-2.6 pathway. Section 5 projects annual heat-related GDP losses of about **576 million USD** in 2040 and **1.46 billion USD** in 2060 compared with the 1985 to 2014 baseline. The associated losses in full-time job equivalents are about **2.4 thousand jobs** in 2040 and **3.1 thousand** in 2060. The pattern of loss fits the structure of the economy. Services carry most of the burden. In 2040 services account for roughly 403 million USD of the annual loss. By 2060 the services loss reaches about 1.01 billion USD. Construction, agriculture/fisheries and transport and trade follow with smaller but material losses. Manufacturing and mining-quarrying remain small in absolute terms but still face heat-management needs in workshops, docks and processing plants. With Decent Work fully applied, these losses are managed rather than left to grow. WBGT-based scheduling and shaded rest areas reduce mid-day slowdowns in resorts, retail and public services. Efficient cooling and ventilation in hotels, guesthouses, shops and small factories cut errors and absenteeism. Early-start shifts and task rotation protect construction crews and fish-handling teams. Social protection floors cushion residual income shocks during heat alerts, which matters for informal and migrant workers. Together these steps keep firms open during hot spells and protect health, especially for women and youth in services and light manufacturing.

Infographic 6. Scenario analysis to decent work and sustainable development goal implementation in the Maldives related to workplace heat stress. Figures calculated as differences between SSP5-8.5 and SSP1-2.6 based on the results presented in Section 5.

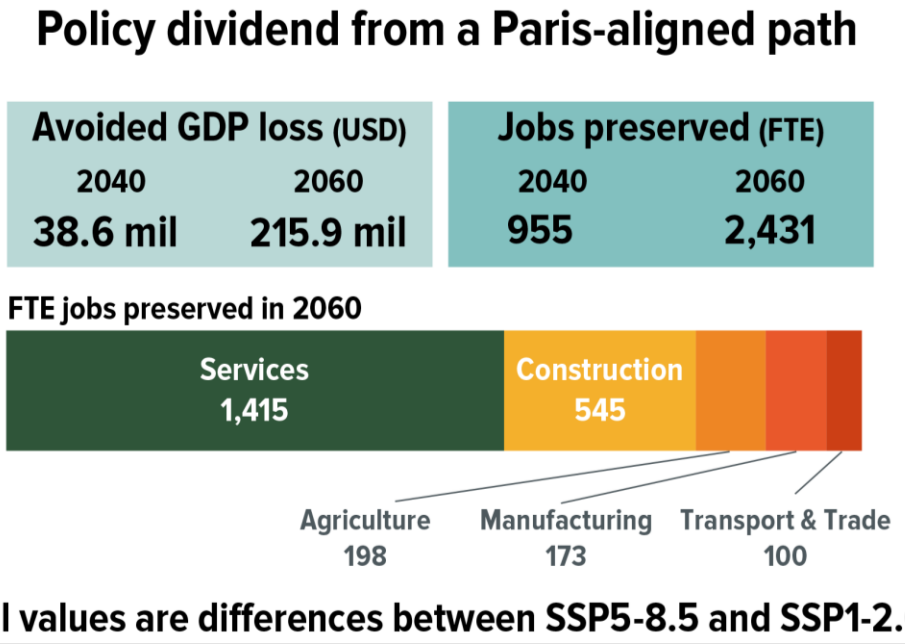


- **Scenario B: Business-as-Usual (fragmented uptake; climate consistent with SSP5-8.5).** Reforms are fragmented and enforcement is weak. Investment in cooling, urban shading and skills lags. Global emissions track SSP5-8.5. Section 5 then projects much heavier losses. Annual heat-related GDP losses rise to about **614 million USD** in 2040 and **1.67 billion USD** in 2060. Full-time job losses reach about **3.4 thousand** in 2040 and **5.6 thousand** in 2060. The same sectors are impacted, but the intensity is higher and the hot season lasts longer. Health burdens rise and work interruptions spread. Informal workers and migrants, who have less access to cooling and paid leave, carry a disproportionate share of the impact.

The policy dividend

The difference between the two futures is clear even by 2040. Moving from a high-emissions and low-action path to a low-emissions and high-ambition path avoids about **39 million USD** in annual GDP losses and preserves roughly **950 full-time job equivalents**. By 2060 the annual dividend grows to about **216 million USD** in GDP and **2.4 thousand jobs** (Infographic 7). Most of this benefit falls in services and construction because these sectors lose the most hours today and stand to gain the most from practical heat protections. The dividend is larger still when the health gains are counted. Fewer cases of dehydration, heat exhaustion and cardiovascular stress mean lower absenteeism and better long-run participation in the labour force.

Infographic 7. GDP and labour market benefits of implementing the decent work and sustainable development goals in the Maldives, 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 effects

Beyond economic and employment aggregates, Decent Work implementation changes the *quality* and *distribution* of outcomes:

- **Productivity and business continuity improve:** With water-rest-shade and efficient cooling, companies report steadier output during hot hours and fewer errors. Ports, airports and ferry hubs sustain throughput with shaded staging, cooled break rooms and rescheduled handling.

- **Occupational health improves:** Site-level WBGT monitoring with clear triggers reduces heat illness and near misses. Workers returning after illness use graded acclimatisation, supported by occupational health services.

- **Equity improves:** Social protection floors that include heat contingencies protect low-income workers, women and migrants who are concentrated in outdoor services, construction and fisheries. Rapid cash support during heat alerts prevents income shocks that can push families into debt.

- **Skills and jobs change:** Training in heat-safe methods, maintenance of efficient cooling and climate-smart fisheries logistics creates new tasks while upgrading existing ones. This supports a just transition that keeps people in work as the climate warms.

- **Governance strengthens:** Tripartite dialogue helps tailor sector rules, align incentives and prevent wage penalties when breaks are extended. Public procurement requires compliance with the national heat standard and pulls small firms into safer practice.

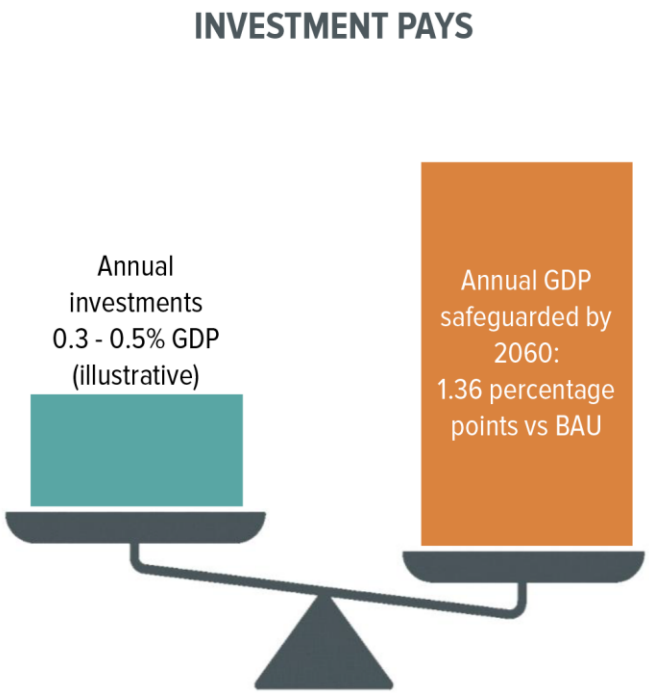
Implementation priorities

To realise Scenario A, three enablers are pivotal. First, embed **WBGT-based heat standards** in OSH regulation and public procurement and support them with labour inspection and worker participation. Second, extend **social protection floors** to cover heat-related sickness and income loss with simple triggers and rapid payment. Third, direct **0.3-0.5% of GDP per year in public and concessional finance to efficient cooling** in SMEs and public facilities, urban heat mitigation, shaded transport hubs and climate-smart agriculture/fisheries. As shown in Infographic 8, even small annual investments directed toward implementing policies consistent with a Paris-aligned pathway (SSP1-2.6) will generate significant returns by 2060. **Progress should be tracked** against the Section 5 baselines using three simple metrics: GDP safeguarded each year, FTE jobs preserved each year, and days above critical WBGT thresholds avoided. Additional activities are provided in Infographic 9.

The contrast between the two futures is stark. A high-ambition Decent Work and SDG pathway preserves output, protects workers and sustains inclusion. A business-as-usual path erodes labour capacity and compresses growth. The Maldives can reduce the macro-economic burden of heat by combining international mitigation with a domestic Decent Work package centred on OSH, social protection, green investment and social dialogue.

Based on the results of the present study, it is important to rapidly strengthen national readiness in the Maldives to address workplace heat stress as a critical occupational, public health, and socio-economic challenge in the context of climate change and the national Just Transition agenda. To achieve this, several interrelated priorities should be set from a policy and institutional development perspective. A suggested timeline to implement the recommendations stemming from this study is presented in Infographic 9. First, immediate strengthening of the OSH framework in the Maldives is required through the explicit integration of workplace heat stress definitions, thresholds, monitoring, and reporting requirements within existing laws, regulations, and technical standards. This integration is essential to ensure regulatory clarity, enforceability, and consistency across sectors.

Infographic 8. 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).



Infographic 9. Implementation timeline: a path to achieve heat-safe workplaces.



Second, there is a need for a significant institutional upgrade through the establishment of a formal, inter-institutional coordination mechanism to align actions across labour, health, environmental, and municipal authorities. This mechanism should be supported by the development of a dedicated National Strategy on OSH and workplace heat stress, to be embedded within the country's long-term development planning framework, including the 20-year National Development Plan (NDP). Third, effective governance and evidence-based decision-making require the development of a comprehensive ecosystem of information. This should involve establishing an integrated data platform linking climate and meteorological data with OSH inspection findings, workplace heat stress indicators, and relevant health records, while also strengthening transparency and data use within Environmental Impact Assessments.

A fourth priority should involve proactive and future-oriented policy design. This includes integrating climate adaptability considerations into infrastructure development and urban planning, such as heat-resilient design and greening measures, as well as developing social protection and economic policy instruments that incorporate anticipatory action and forecast-based budgeting to support workers and sectors affected by rising workplace heat stress.

The above four priorities could be synthesized to develop a comprehensive National Workplan / Action Plan to address workplace heat stress through a phased, multi-sectoral approach, translating the present findings and recommendations into concrete, time-bound, and implementable actions, supported by clear roles, responsibilities, and monitoring arrangements. The framework could comprise the following interlinked priority areas and actions:

1. **Strengthening the National OSH Framework:** The first priority is to strengthen the national OSH framework through the explicit integration of workplace heat stress into regulations, standards, and enforcement mechanisms. All heat-related risks should be clearly reflected in OSH legislation, policies, inspection protocols, and reporting systems, supported by clear definitions, thresholds, and procedures for reporting heat-related OSH incidents. In parallel, a formal inter-institutional coordination mechanism should be established to link the Ministry of Labour, the Health Protection Authority, environmental agencies, local councils, and other relevant ministries. This mechanism should support data sharing, enforcement coordination, early-warning systems, and emergency preparedness. Raising awareness of existing institutional frameworks is key, by improving understanding of institutional roles, responsibilities, and available OSH instruments among workers, employers, and communities. Moreover, it is essential to improve data availability and information flows, particularly to address gaps in the collection, consolidation, and sharing of data on heat-related injuries, sector-specific

vulnerabilities, and geographic hotspots. Finally, good practices from the Maldives Police Service and other frontline agencies should be documented and systematically integrated into OSH guidance, training programmes, and operational protocols.

2. **Capacity Building and Technical Expertise:** Building technical capacity is critical for effective implementation. Capacity-building initiatives in the Maldives should strengthen expertise on workplace heat stress prevention, OSH compliance, climate-related risks, and Just Transition principles across government institutions, workers' organisations, and employers' organisations. Close collaboration with medical professionals is needed to improve the accuracy of reporting heat-related OSH injuries and illnesses, including linking health datasets (such as Aasandha) with OSH surveillance systems. First-aid preparedness and training are key to ensure timely and effective responses to heat-related health events in workplaces.
3. **National Strategies and Regulatory Improvements:** There is a need to develop a "National Strategy on OSH and Workplace Heat Stress", integrated into the Maldives' 20-year National Development Plan (NDP). This strategy should be supported by strengthened labour inspection capacity, enabling inspectors to assess workplace heat stress risks, enforce standards, and assist employers in mitigation planning. A comprehensive mapping of institutions and actors involved in workplace heat stress, OSH, environmental health, and social protection should be undertaken to clarify mandates and reduce fragmentation. OSH regulations should include specific provisions on workplace heat stress, clarifying sector-specific requirements, employer obligations, and worker rights. Policies should treat workplace heat stress as a cross-cutting issue, involving health authorities, urban planners, education institutions, and environmental agencies. New initiatives should build on existing policy frameworks to ensure coherence, avoid duplication, and promote broad stakeholder participation through whole-of-society approaches.
4. **Community-Level Measures and Social Inclusion:** Community-level measures are essential to complement workplace interventions. Outreach programmes should raise awareness among households, local businesses, and community leaders. Workplace heat stress awareness and adaptation practices should be integrated into school curricula and youth programmes. Active engagement of women, persons with disabilities, children, migrant workers, and other vulnerable groups is essential in both policy design and implementation. Preventive and response capacities within the health sector should be strengthened, including diagnosis, treatment, and public communication on heat-related illnesses. Workers' and employers' organisations should be actively involved in co-designing workplace policies, training materials, and sector-specific mitigation measures.
5. **Infrastructure, Urban Planning, and the Built Environment:** Climate-adaptive infrastructure and urban design can play important roles in addressing workplace heat stress in the Maldives. This includes promoting climate-resilient construction materials, shading structures, improved ventilation, and island-specific adaptive designs. Urban greening policies should be strengthened, with clear requirements for shade, trees, landscaping, and green corridors, particularly in Malé and other densely populated areas.
6. **Special Considerations for Malé and Densely Populated Areas:** Dedicated urban heat strategies should be developed for Malé and surrounding islands, where heat exposure is intensified by high population density and limited green space. Research and promotion of clothing suitable for high-heat environments, particularly for outdoor and construction workers, should also be encouraged.
7. **Social Protection and Economic Measures:** Social protection mechanisms should be designed to support workers in sectors where productivity and working hours are reduced due to workplace heat stress. In this respect, it is important to consider anticipatory actions and forecast-based budgeting, linking climate forecasts with budget allocations, early warnings, and preventive measures. Workplace heat stress, labour-market impacts, OSH measures, and the protection of vulnerable workers should be explicitly integrated into the Maldives' Third Nationally Determined Contribution implementation plans. Minimum living standards, particularly for migrant workers who are disproportionately exposed to heat risks, should be clearly defined and enforced. Research and analytical reports on climate change, heat impacts, and economic implications should be made publicly available to support evidence-based policymaking.

8. **Social Protection and Economic Mental Health, Participation, and Policy Coherence:** The mental health impacts of workplace heat stress should be explicitly addressed within OSH and public-health frameworks. Health personnel should be adequately trained and equipped to manage increasing heat-related health burdens in the workplace. Environmental and climate awareness among local councils should be strengthened as part of decentralisation efforts. Workplace heat stress and OSH interventions should be aligned with the Sustainable Development Goals on health, decent work, climate action, and sustainable cities, as described in previous sections. Greening and shading initiatives should be prioritised equitably across all islands, regardless of size.
9. **Governance, Transparency, and Early-Warning Systems:** Improving governance is essential for effective implementation. Environmental Impact Assessments should be strengthened to ensure that infrastructure and development projects are climate-resilient. Transparency and oversight mechanisms should be reinforced to support fair implementation of regulations and allocation of resources. An integrated ecosystem of information should be established, linking climate data, OSH incidents, health records, and labour statistics to support evidence-based decision-making. This should be complemented by SMS-based systems for heat alerts, early warnings, and public health advisories coordinated across ministries and local councils. Fair taxation systems and sustained political commitment should be considered to finance adaptation measures.

Next Step: Workplan Development and Tripartite Just Transition Strategy. As a first step in the above-described process, local stakeholders should jointly develop a comprehensive National Workplan / Action Plan. The plan should clearly define responsibilities, timelines, financing arrangements, and monitoring mechanisms for implementation. The ILO could provide technical support throughout this process. A potential effective way to initiate the workplan would be to convene a Technical Workshop 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, within the framework of a tripartite Just Transition strategy.

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 the Maldives' 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.[33] This function was derived from field studies across various countries and is calibrated for an "average, experienced, acclimatized worker" operating under typical conditions.[33] While this provides a robust general framework, it may not capture all nuances of Maldivian labour contexts. For instance, actual work-rest behaviours, acclimatization levels, and protective measures in the Maldives 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.[26] 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 the Maldives. 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**. The Maldives' landscape and microclimates – from cooler areas to hotter, humid regions – may not be fully captured by grid-averaged climate data. Small geographic "hotspots" (for example, inner-city districts with urban heat island effects or particular atolls 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 the Maldives' workforce. These workers are often in heat-exposed sectors such as agriculture/fisheries, 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 the Maldives. In reality, the Maldives' future emissions and development path may not neatly correspond to any single SSP. The Maldives' 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 the Maldives. By using one model, the analysis assumes its simulation is representative, but if that

model underestimates (or overestimates) future heat extremes in the Maldives, 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 the Maldives 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 Maldivian 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 the Maldives' 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, Maldivian 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 reports 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 Maldivian 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 the Maldives 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** 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/fisheries 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 Maldivian 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 to hotter regions for work, 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 the Maldives 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 the Maldives' 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 the Maldives' 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[39] was adopted because it is considered the most accurate method when calculating WBGT from meteorological data.[40] 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.[41] Solar radiation was estimated[42] 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.[43] 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.[40] Indoor temperature and humidity were estimated as a function of outdoor conditions.[44] Similarly, for the mining industry, underground temperature[45] and humidity[46] 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,[47] 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.

[39] Liljegren J.C., Carhart R.A., Lawday P., Tschopp S., Sharp R. (2008). Modeling the Wet Bulb Globe Temperature using standard meteorological measurements. Journal of Occupational and Environmental Hygiene; 5(10): 645-655.
[40] Lemke B., Kjellstrom T. (2012). Calculating Workplace WBGT from meteorological data: a tool for climate change assessment. Industrial Health; 50(4): 267-278.
[41] Masters, G.M. (2013). Renewable and efficient electric power systems. John Wiley & Sons.
[42] Khatib T., Elmenreich W. (2016). Modeling of photovoltaic systems using Matlab: Simplified green codes. John Wiley & Sons.
[43] Kasten F., Czeplak G. (1980). Solar and terrestrial radiation dependent on the amount and type of cloud. Solar Energy; 24(2): 177-189.
[44] Lee K, Lee D. (2015). The relationship between indoor and outdoor temperature in two types of residence. Energy Procedia; 78: 2851-2856.
[45] Yi, X., Ren, L., Ma, L. et al. (2019). Effects of seasonal air temperature variation on airflow and surrounding rock temperature of mines. International Journal of Coal Science and Technology; 6: 388–398.
[46] Yasidu U.M., Fujii Y., Kodama J.I., Fukuda D., Maneya G.J., Dandadzi J., Dassanayake A.B. (2019). Influences of water vapor on roof fall accidents in selected underground coal mines in Malawi. Advances in Civil Engineering; 2019(1): 5350686.
[47] Center for International Earth Science Information Network - CIESIN - Columbia University, Gridded Population of the World, Version 4 (GPWv4): Population Count, Revision 11. 2018, NASA Socioeconomic Data and Applications Center (SEDAC): Palisades, New York.

Population projections datasets, based on the SSP1, SSP2, SSP3, SSP4, and SSP5 were obtained from standard sources.[48,49] 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.[50] 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[51] 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,[52] 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.[53,54,55] 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.[56] 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)[57] 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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[48] Jones B., O'Neill B.C. (2016). Spatially explicit global population scenarios consistent with the Shared Socioeconomic Pathways. Environmental Research Letters; 11: 084003.
[49] Jones B., O'Neill B.C. (2020). Global one-eighth degree population base year and projection grids based on the Shared Socioeconomic Pathways, Revision 01. 2020, NASA Socioeconomic Data and Applications Center (SEDAC): Palisades, New York.
[50] Gillies S. et al. (2013). Rasterio: geospatial raster I/O for Python programmers. Mapbox.
[51] GEBCO Bathymetric Compilation Group. The GEBCO_2023 Grid - a continuous terrain model of the global oceans and land. 2023, NERC EDS British Oceanographic Data Centre NOC.
[52] Copernicus Climate Change Service (C3S). CMIP6 climate projections, in Climate Data Store (CDS). 2021.
[53] Karger D.N., Conrad O., Böhner J., Kawohl T., Kreft H., Soria-Auza R.W., Zimmermann N.E., Linder H.P., Kessler M. (2017). Climatologies at high resolution for the earth's land surface areas. Scientific Data; 4: 170122.
[54] Brun P., Zimmermann N.E., Hari C., Pellissier L., Karger D.N. (2022). Global climate-related predictors at kilometre resolution for the past and future. Earth System Science Data Discussions; 2022, 1-44.
[55] Karger D.N., Chauvier Y., Zimmermann N.E. (2023). chelsa-cmip6 1.0: a python package to create high resolution bioclimatic variables based on CHELSA ver. 2.1 and CMIP6 data. Ecography; 2023(6): e06535.
[56] Chambers, J. (2020). Hybrid gridded demographic data for the world, 1950-2020 (1.0), in Zenodo.
[57] Copernicus Climate Change Service (C3S). (2019). Land cover classification gridded maps from 1992 to present derived from satellite observation, in Climate Data Store (CDS).

the urban area cells using xarray's coarsen method.[58] 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[59] and divided across four sectors:

- Agriculture/Fisheries 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.[60] 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,[61] 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.[62] Where the dataset provides no future gridded GDP for the Maldives (due to small island size), grid-cell totals were generated by extrapolating historical GDP ($\leq$2023) from the base dataset. For each grid cell, the best-performing model was auto-selected among linear, quadratic, exponential, CAGR, and constant fits (minimum MSE) to predict future GDP for 2040 and 2060.

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

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[58] Hoyer S., Hamman J., xarray: 1. Arias P, Bellouin N, Coppola E, et al. Technical Summary. In: Masson-Delmotte V, Zhai P, Pirani A, et al, eds. Climate Change 2021: The Physical Science Basis Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; 2021. labeled arrays and datasets in {Python}. Journal of Open Research Software, 2017. 5(1).

[59] EDGAR Community GHG Database v8.0: CO2, CH4, N2O, and F-GASES, in European Commission, Joint Research Centre (JRC) and International Energy Agency (IEA). 2023.

[60] United Nations Statistics Division, Department of Economic and Social Affairs, Statistics Division - National Accounts (Latest Data Upload: January 2025). Value Added by Economic Activity, at constant 2015 prices - US Dollars.

[61] https://unstats.un.org/unsd/snaama/Basic.

[62] Wang, T., & Sun, F. (2023). Global gridded GDP under the historical and future scenarios [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7898409.

Level Ratios (PLR). The PLR for each country was extrapolated to 2040 and 2060 using a linear fit to World Bank historical PLR values (2000-2019).[63] The conversion was performed as follows: GDP_MER=GDP_PPP*PLR

A1.2.8. Employment Dataset

Economic activity data was obtained from ILOSTAT,[64] 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[65] as follows:

- Agriculture (including fisheries) (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).

The ILO dataset included no employment data for mining and quarrying. Therefore, it was not possible to provide labour market impact results for this sector in some cases.

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/Fisheries, 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.[66] 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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[63] https://data.worldbank.org/indicator/PA.NUS.PPPC.RF.
[64] International Labour Organization (ILO). Employment by sex and economic activity -- ILO modelled estimates, Nov. 2023 (thousands) -- Annual, in ILO Modelled Estimates (ILOEST) Database. 2023, ILO, Geneva, Switzerland.
[65] United Nations Statistics Division, Department of Economic and Social Affairs (2008). International Standard Industrial Classification of All Economic Activities (ISIC) - Statistical papers, Series M No. 4/Rev.4. New York, USA.
[66] United States Geological Survey. Global Mines and Minerals dataset: https://mrdata.usgs.gov/mineral-operations. Accessed: October 1, 2024.

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