International Labour Organization

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Impacts of heat stress on jobs and productivity in Ghana

Climate trends in Ghana over the past three decades

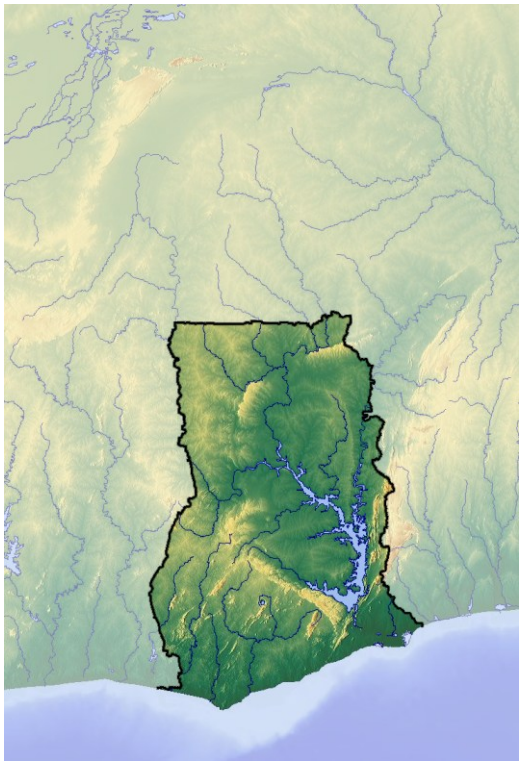
Country background

With nearly 35 million inhabitants, Ghana is the second-most populous country in West Africa. The capital and largest city is Accra, while other significant cities include Kumasi, Tamale, and Sekondi-Takoradi (Fig. 1). Ghana has retained a reputation as one of Africa's stable democracies over the past decade.[i] This stability has enabled consistent governance and the pursuit of long-term development policies of key sectors of the economy.[i] The service sector is the largest contributor to the economy providing over 40% of GDP, followed by manufacturing and mining, notably Gold and increasingly Oil and Gas, with some 30%.[i] However, agriculture, forestry, and fishing are still the most important sectors in terms of employment where more than 40% of the population work.[i] Cocoa is the dominant cash crop cultivated on a significant portion of Ghana's arable land and is an important source of the country's export revenue.[i,ii]

Climate

Ghana has a tropical climate strongly influenced by the West African monsoon. Climate conditions vary by region. The south-eastern coastal belt is warm and relatively dry, the south-west is hot and humid, and the northern interior is hot and more arid.[iii] Temperatures are generally high year-round, with a pronounced north-south gradient in heat stress.[i,iii,iv] Both average maximum temperature and Wet-Bulb Globe Temperature (WBGT)[v] values are notably higher in the northern regions throughout the year, indicating heat stress there (Fig. 2). This results largely from maritime influence, higher cloud cover, and vegetation effects in the forest and coastal belts in the south, creating conditions conducive to lower heat stress. Q1 (Jan-Mar) is the hottest period, with widespread very high maxima over the northern half and the transition zone. In the rest of the year, the north and interior remain very hot, while the south moderates as rains and cloudiness advance from the Gulf of Guinea inland.

Figure 1. Ghana physical map.[vi]

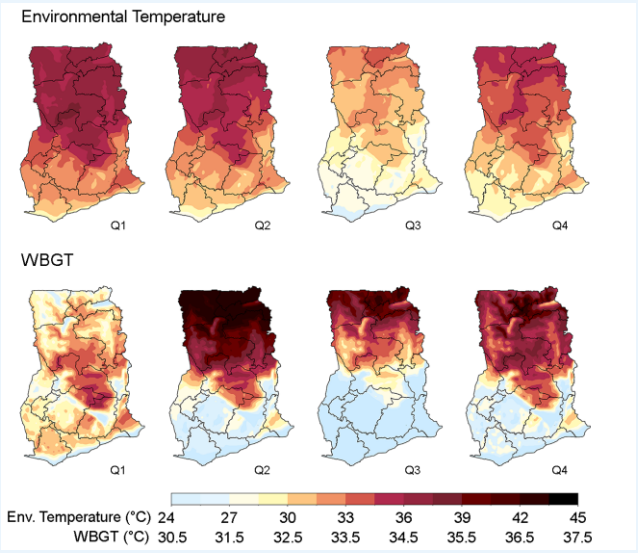


▶ **Temperature vs. WBGT:** Both indicators show the north hotter/riskier than the forest/coastal south, but WBGT expands the risk belt farther south, especially in Q1-Q2, and highlights hot corridors across the transition/middle belt that are less

prominent on the temperature maps. This is evidence of humidity/solar effects.

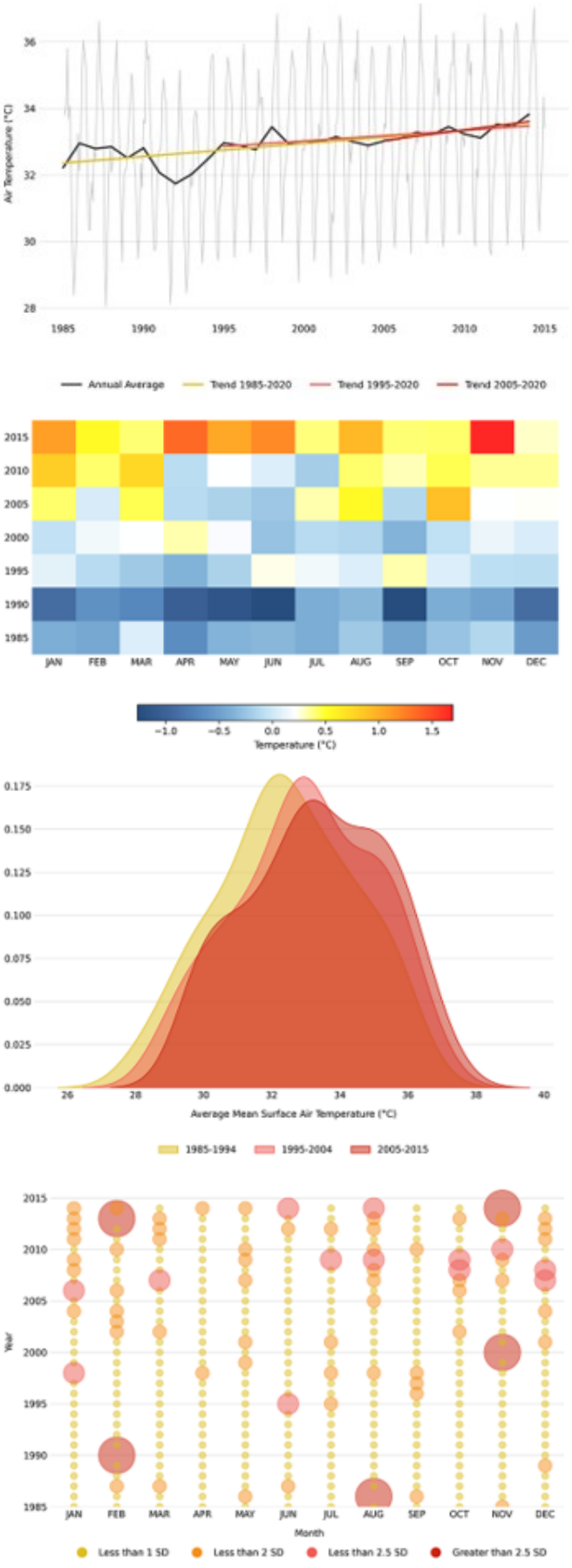
- **Policy implications:** Relying solely on ambient temperature data may understate heat risks in the north during Q3 and the south during other quarters. Employing WBGT as a heat assessment measure can provide a more accurate foundation for developing occupational safety guidelines, especially in labour-intensive sectors.

Figure 2. Quarterly average maximum environmental temperature (top) and WBGT (bottom) across Ghana during the reference historical period (1985-2014).



Climate data covering the last three decades show a clear and accelerating warming trend in Ghana; warming has intensified, particularly in the period 2010-2014, while the frequency and intensity of extreme temperature events are increasing (Fig. 3).

Figure 3. Climatological trends in Ghana during 1985-2015: average daily mean environmental temperature trends (first and second graphs); change in distribution of average mean environmental temperature (third graph); change in intensity of extreme daily maximum temperature events (fourth graph).



Ghana's mean temperature has risen by ~1°C since the 1960s, while rainfall patterns have become more erratic.[i,iii] The main impacts on key industries are:

- **Agriculture:** Agriculture employs 40% of Ghana's workforce and contributes about 21% of GDP.[iii] Primarily rain-fed, it is vulnerable to shifting rainfall and heat, which can lower yields and cause periodic floods, destroying crops and displacing communities.[i,iii]
- **Mining and extractive industries:** Prolonged heat as well as drought-driven water shortages or flooding can disrupt mining operations and refineries, while hydropower limitations affect power production.[i,iii]
- **Manufacturing:** Extreme weather and power shortfalls undermine manufacturing output, which relies on inputs from agriculture and mining as well as robust infrastructure.[i,iii]
- **Services:** Floods often disrupt transport and commerce. Droughts and ecosystem stress diminish wildlife and landscapes, while heritage sites are affected by heavy rains and erosion, straining tourism, a growing sector.

Future heat exposure and impacts on productivity

To understand how future heat conditions might affect working people in Ghana, this analysis uses four "storylines" known as Shared Socioeconomic Pathways (SSPs). These scenarios were used by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report[vii] to describe 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 (SSP1-2.6) to one that continues heavy use of fossil fuels (SSP5-8.5).

By considering these global SSPs, Ghanaian 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) might expose Ghana to extreme heat conditions, with significant repercussions for labour productivity and overall economic resilience. In essence, the global SSPs enable Ghana to tailor its climate adaptation and economic policies to protect its citizens and secure a more stable, sustainable future.

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

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

Key: GHG = greenhouse gas.

Future heat exposure

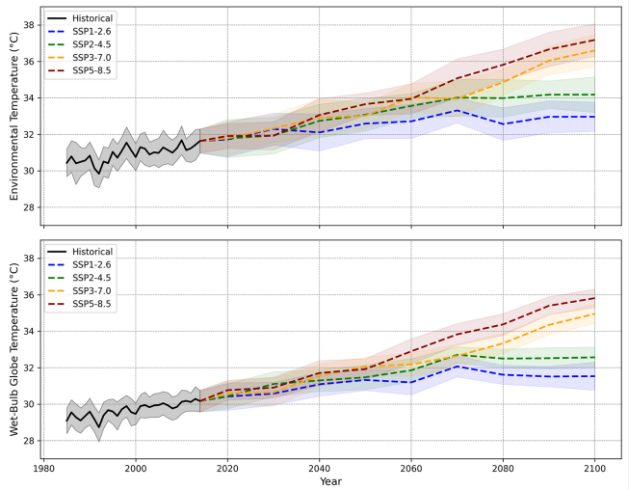
The analyses conducted in the main part of the report indicate that Ghana is projected to experience a significant rise in both ambient temperature and WBGT compared to historical conditions (1985-2014). Even the lower-emission scenarios (SSP1-2.6 and SSP2-4.5) suggest warming of 2-3°C for maximum temperature, while the highest emission pathways (SSP3-7.0 and SSP5-8.5) indicate increases of up to 6°C by late century. The WBGT trends follow a similar pattern, with low-emission trajectories adding around 2-3°C by 2100 and high-emission pathways reaching as high as 5-6°C, denoting severe heat stress.

These projections emphasize that the level of warming that Ghana will face depends largely on global emissions and that more ambitious mitigation leads to less severe impacts. But, even lower-emission scenarios (SSP1-2.6 and SSP2-4.5) pose a substantial risk to health and labour productivity, necessitating the adoption of adaptation measures and strategies to protect workers from rising heat.

Future climate in Ghana

Across all SSPs, the analyses for Ghana suggest a clear warming trend, with varying degrees of severity depending on the scenario (Fig. 4). Even in the most optimistic scenarios (SSP1-2.6 and SSP2-4.5), Ghana will face increases of 1.2°C. The high emission scenarios (SSP3-7.0 and SSP5-8.5) suggest more significant warming of up to 5-6°C. Without effective adaptation strategies, these would lead to significant health impacts and severely reduce the capacity to perform manual labour.

Figure 4. Average maximum environmental temperature (top) and WBGT (bottom) with 95% confidence intervals across the different SSPs in Ghana.



Productivity loss due to rising heat stress from climate change

The physical effort required for high-intensity work naturally increases the body temperature and produces metabolic heat.[viii,ix] When this internal heat generation combines with external (environmental) heat stress, the body's cooling mechanisms can be overwhelmed.[ix] Workers engaged in physical work are, therefore, at a greater risk of experiencing the negative effects of heat.[x] As the body becomes stressed by the combined internal and external heat loads, it responds by slowing down work pace as a protective mechanism. This slowdown can lead to significant loss of labour productivity.[xi,xii,xiii]

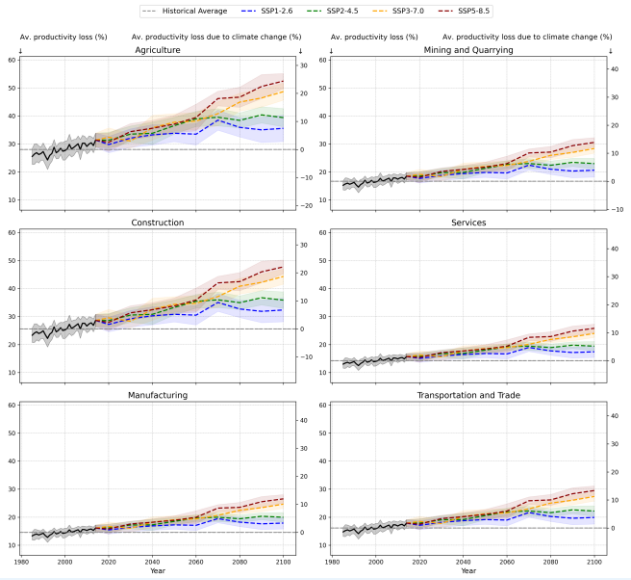
Reduced labour productivity under high heat stress is not only a matter of slower movement; it also includes reduced work output, and increased error rates. This occurs because workers must take more frequent breaks, reduce their pace, or even stop working to avoid heat-related health risks.[xi,xii,xiii] The cumulative effect of these adjustments is a measurable loss in productivity, as well as increased risks of accidents and long-term health impacts.[xi,xii,xiii] This also has particular implications for workers in the informal economy, as well as for micro, small and medium enterprises, which often have limited adaptation capacities.[xiv]

The analysis of productivity loss due to rising heat stress from climate change is illustrated in Fig. 5 (for the average, experienced, and acclimatized worker performing their typical shift). In agriculture and construction, productivity

loss due to heat stress fluctuated between 24% and 31%, during the historical period. Under SSP1-2.6 and SSP2-4.5, climate change is expected to further increase productivity loss by 10% by 2100, reflecting milder 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 25% toward the end of the century. Agriculture and construction are thereby particularly vulnerable sectors to productivity loss due to climate change.

In manufacturing, mining and quarrying, services, as well as transportation and trade, productivity loss due to heat stress remained stable at about 15% to 18% during the historical period. Under SSP1-2.6 and SSP2-4.5, climate change is anticipated to further increase productivity loss by 3-5% 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 14% in these scenarios by 2100, compared to the average year within the reference period.

Figure 5. Average productivity loss in Ghana during the reference historical period (1985-2014) and until 2100 across the different SSPs. Vertical axes in each graph show productivity loss in 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.



The key findings of this analysis are as follows:

- **Vulnerability is unequal:** agriculture and construction show the highest productivity losses due to rising heat stress from climate change, reaching as high as 25% by the end of the century in the worst-case scenario. 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, productivity losses generally increase towards the latter half of the century, reflecting the long-term effects of climate change on productivity in Ghana.

Economic and labour market impacts of climate change

Current economic impacts

Economic production relies on the total available work hours, and when those hours diminish due to rising heat stress from climate change, the overall contribution of the workforce to production is reduced.[xi,xii,xiii] Thus, climate change affects not only individual workers but also has far-reaching implications for national economies. When workers are exposed to higher levels of heat due to climate change, they tend to slow down, take more frequent breaks, or may even be unable to work at all – all of which reduce productivity.[xi,xii,xiii] This reduction in labour input directly translates into lower economic output, which is reflected in a decrease in GDP.[xi,xii,xiii]

The economic impacts of rising heat stress due to climate change in Ghana are significant. The country lost 8.6 billion USD more from heat stress in 2023 compared to the average year during the reference historical period (1985-2014) (Table 2). The added GDP losses in the agriculture and services sectors far outweigh those from all other sectors, representing 37.9% and 22.8% of the climate change-induced GDP losses, respectively.

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.

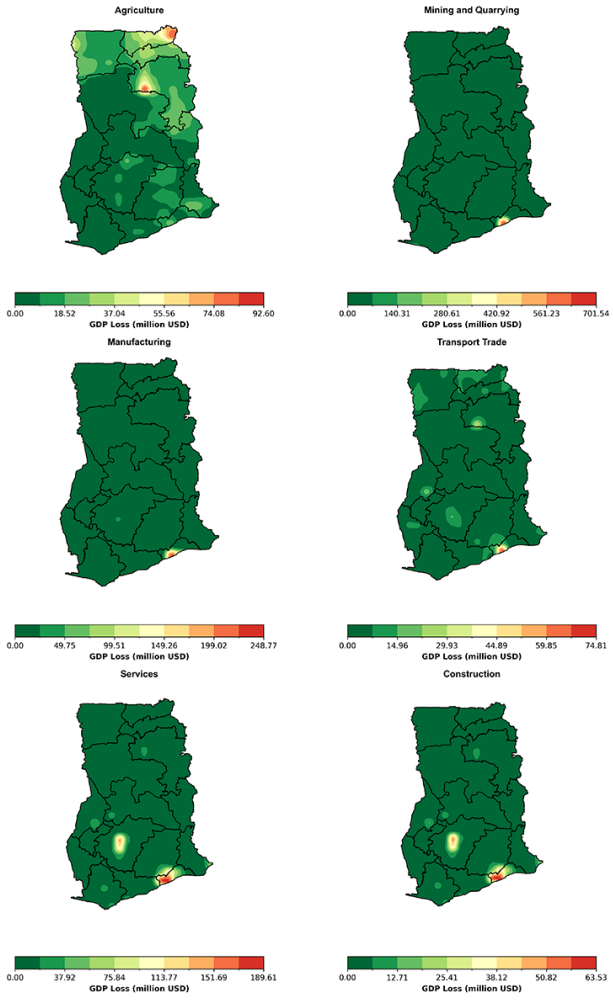
Sector	Change in GDP	
	(million USD) *	*(distribution; %)*
Agriculture	-3,278.3	37.9
Construction	-671.8	7.8
Manufacturing	-537.4	6.2
Mining and quarrying	-1,012.7	11.7
Services	-1,971.1	22.8
Transport and trade	-1,169.9	13.6
Total GDP change	-8,641.2	

* 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 Fig. 6. The maps indicate that workplace heat stress caused by climate change already imposes a measurable economic burden across all sectors in Ghana, with a strongly uneven distribution by both sector and location. Owing to its dominant weight in the economy, agriculture accounts for by far the largest absolute losses, with productivity loss hotspots reaching ~US$93 million more compared to the average year during the historical period concentrated in the northern savannah and in pockets around the Volta basin and parts of the south-west. This pattern mirrors the country's spatial concentration of agricultural activity and high exposure, underscoring that scale effects drive the magnitude of agriculture-sector losses. The key findings are as follows:

- **Agriculture** losses are concentrated in the northern savannah and in pockets around the Volta basin and parts of the south-west. The sector's heavy outdoor work makes it sensitive to high WBGT conditions even when absolute GDP per km^2 is smaller than in urban services.
- **Mining and quarrying** losses are site specific, with a clear focus in the south-west and selected operations elsewhere. While the national total is modest, the local economic effect can be large.
- **Services, manufacturing, transport and trade, as well as construction** show losses centred on Greater Accra and spill into nearby districts, with a second cluster around Kumasi. This mirrors where activity and employment in these industries are concentrated and where heat during peak hours disrupts work. Transport and trade also show losses along major logistics nodes and corridors that link the coast to interior hubs. These activities are hard to reschedule and often occur in exposed loading areas, so heat translates quickly into time lost and lower productivity throughput.

Figure 6. GDP loss across Ghana 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.



Current labour market impacts

The impact of rising heat stress from climate change on Ghana's labour market is significant (Table 3), with varying degrees of productivity and jobs lost across all key economic sectors:

- **Over 345,000 more full-time jobs were lost** due to workplace heat stress during 2023 compared to the average year during the historical period.
- Overall, **36% of the jobs are lost** during the 1st quarter, reflecting the part of the year when heat spreads to the coastal south regions, affecting major industrial nodes, including Accra and Kumasi (Fig.2).
- Climate change impacts are industry-specific. The full-time jobs lost were:
  - **66% in agriculture**
  - **21% in services**
  - **5% in construction**
  - **4% in manufacturing**
  - **3% in transport and trade.**
- 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 Ghana.

Table 3. 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 Ghana, calculated as the change between 2023 and the reference historical period 1985-2014.

Sector	Available Work Hours	Change in Work Hours		Change in Jobs
	(n)	(n)	(% FTE)	(FTE)
Agriculture	11,185,583,760	-457,209,001	-4.09	-227,921
Construction	1,389,829,629	-35,542,544	-2.56	-17,718
Manufacturing	2,444,837,349	-30,659,520	-1.25	-15,284
Mining and quarrying	291,701,057	-3,843,193	-1.32	-1,916
Services	10,569,516,583	-145,183,815	-1.37	-72,375
Transport and trade	1,044,277,149	-19,638,155	-1.88	-9,790
TOTAL	26,925,745,526	-692,076,228	-2.57	-345,003

n: number; FTE: full-time equivalent.

Future economic and labour market impacts

Ghana's macro-economic exposure to rising workplace heat stress is set to intensify between 2040 and 2060, with outcomes highly sensitive to global emissions scenarios (Table 4). Even on a Paris-aligned trajectory (SSP1-2.6), heat-related productivity losses will reduce GDP by about 13.1% and 14.8% 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 23.2 billion USD in 2040 and 100.2 billion USD in 2060. Under a "middle-of-the-road" scenario (SSP2-4.5), the contraction deepens from 13.4% (19 billion USD) in 2040 to 16.5% (82.3 billion USD) in 2060. Should fossil-fuel development continue unabated (SSP5-8.5), rising workplace heat stress could cut 18% (165.2 billion USD) off annual national output by 2060, eliminating the cumulative GDP value of several medium-sized manufacturing subsectors.

The projected labour market impacts attributable to heat stress rise from climate change will grow markedly with the global emissions trajectory and become substantial for Ghana by 2040 (Table 5). Relative to the 1985-2014 baseline, the economy will lose the equivalent of 550,000 full-time jobs under a low-emissions pathway (SSP1-2.6). The losses rise to nearly 753,000 full-time jobs under SSP2-4.5 and peak at 800,000 to 1.1 million under the high-emissions scenarios (SSP3-7.0 and SSP5-8.5). In proportional terms this represents a 6.4% contraction in total labour force under the most optimistic scenario and 9.3% under unabated fossil-fuel development.

By 2060, the rise in heat stress driven by climate change will remove the equivalent of 0.63 to 1.97 million full-time jobs from Ghana's economy each year, depending on the global emissions pathway (Table 5). Estimates suggest that under the Paris-consistent trajectory (SSP1-2.6) Ghana will lose 633,000 full-time jobs, or about 7.4% of total labour force. The toll rises sharply to 1.61 million full-time jobs under SSP2-4.5, 1.97 million under SSP3-7.0, and 1.38 million under SSP5-8.5, where heat cuts 16.2% more aggregate work hours compared to the average year within the historical period.

Table 4. Annual impact of rising workplace heat stress caused by climate change on GDP in Ghana during 2040 and 2060 across different SSPs, compared to the historical period 1985-2014.

	Change in GDP			
	2040		2060	
	*(M USD)**	*(%)*	*(M USD)**	*(%)*
SSP1-2.6	-23,187.4	-13.08	-100,170.9	-14.80
SSP2-4.5	-19,021.6	-13.41	-82,274.9	-16.54
SSP3-7.0	-14,380.1	-12.82	-45,388.3	-16.16
SSP5-8.5	-31,090.4	-14.63	-165,222.8	-17.97

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

Table 5. Annual impact of rising heat stress during 2040 and 2060 due to climate change on full-time equivalent jobs lost across different SSPs, calculated as the change from the historical period 1985-2014.

Scenario	Period	Change in Work Hours		Change in Jobs
		(n)	(% FTE)	(FTE)
SSP1-2.6	2040	-1,104,081,309	-6.42	-550,389
	2060	-1,268,387,189	-7.38	-632,297
SSP2-4.5	2040	-1,510,374,507	-8.79	-752,928
	2060	-3,221,907,531	-18.74	-1,606,135
SSP3-7.0	2040	-2,194,828,905	-12.77	-1,094,132
	2060	-3,945,518,516	-22.95	-1,966,859
SSP5-8.5	2040	-1,597,177,343	-9.29	-796,200
	2060	-2,776,631,095	-16.15	-1,384,163

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

Key recommendations per sector

Rising heat stress is already undermining worker health, productivity, and overall economic resilience in Ghana. In light of the evidence presented in this analysis, it is imperative 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 in this analysis 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. Importantly, these recommendations should be applied in addition to – not in place of – the general occupational safety and health protection framework for heat stress recommended by the ILO.[xiv] A comprehensive list of recommendations is available in the main text of the country study.

Agriculture: In agriculture, where the majority of work is performed outdoors and workers are directly exposed to the sun and natural environment, adaptation strategies must focus on minimizing heat exposure. 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 heat exposure. Engineering controls, such as using reflective materials or temporary 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. Recommendations 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 formal services sector is predominantly indoor, many subsectors (including retail, hospitality, and tourism) and the large informal street vendors are vulnerable to environmental and work-related heat stress. Especially in facilities with inadequate climate control or in areas where outdoor work is required heat stress reduces productivity. Employers should consider fitting workplaces with efficient cooling and ventilation systems, to ensure that indoor temperatures remain within safe limits during heat waves. Social protection programs for informal service sector jobs, notably street vendors, small outdoor shops, and hawkers, are required to allow workers to shift work hours, protect lost income, and potentially search for less exposed job opportunities. Flexible scheduling and remote work options can also help mitigate risks for employees, 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 is essential. 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.

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

This factsheet is based on a study (Impacts of heat stress on jobs and productivity in Ghana: Quantitative and qualitative employment estimates for evidence-based decision-making) commissioned by the ILO with support from the Climate Vulnerable Forum and the Vulnerable 20 Finance Ministers (CVF–V20), and with funding provided through the CVF–V20 Joint Multi-Donor Fund.

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[i] World Bank (2022). Country Climate and Development Report for Ghana. Washington, DC: The World Bank.
[ii] Observatory of Economic Complexity (2023). Cocoa Beans (HS: 1801) Product Trade, Exporters. https://oec.world/en/profile/hs/cocoa-beans. Accessed: 6/12/2024.
[iii] World Bank (2021). Climate risk country profile: Ghana. Washington, DC: The World Bank.
[iv] Food and Agriculture Organization of the United Nations (2005). Fertilizer use by crop in Ghana. Rome, Italy.
[v] WBGT is an important measure of heat stress, considering 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.
[vi] The map was made using http://www.maps-for-free.com
[vii] 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.
[viii] 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.
[ix] Flouris A.D. (2019). Human thermoregulation. in: Périard J., Racinais S., eds. Heat stress in sport and exercise: Springer.
[x] 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.
[xi] 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.
[xii] 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.
[xiii] 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.
[xiv] 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.