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Hot Air: How will fashion adapt to accelerating climate change?

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Introduction

Our *Higher Ground?* analyses—undertaken in 2023 with Schroders—looked ahead at the economic damage that extreme heat and intense flooding can cause for fashion production. We modeled 2030 and 2050 impacts for brands and retailers, manufacturers and workers, governments and investors.

> *The climate vulnerabilities of workers, manufacturers and of fashion's substantial output in tropical and subtropical centers are measurable, and our (and others') projections show them growing. They are cutting deeply into export earnings, employment and worker health. Without rapid adaptation, these falloffs in earnings and jobs will compound. (Judd et al, 2023)*

In our analysis, the falloff in (nominal) earnings by 2030 could be 22 percent across four key producers—Bangladesh, Cambodia, Pakistan and Vietnam—if they fail to make adaptation investments. And nearly one million new apparel and footwear jobs will be foregone. These losses swing out to 68 percent and eight million jobs by 2050. As climate change accelerates, it is possible that our projections under-estimate the scale and speed of losses and harms.

1. Accelerating climate change

As the apparel industry's biggest constituencies develop their responses to climate risks and harms, the levels and intensity of heat and flooding globally have been climbing.

> *Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since [2014] ... Global surface temperature will continue to increase until at least mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades. (IPCC, 2021).*

Heatwaves are more frequent and intense than in the past, and cold weather events now occur less frequently. More than 2.4 billion workers deal with excessive heat every year, ***according to ILO estimates***.

Flooding is also being intensified by climate change. Rising temperatures means increasing evaporation and rainfall events are now more intense than in the past. They also occur more frequently around the globe, but most especially in North America, Europe, and Asia which are witness to ever-more intense riverine (rainfall) and coastal (or storm surge) flooding. (IPCC, 2021).

In this brief, we track accelerations in extreme heat and intense precipitation since 2005 in apparel and footwear production centers to understand where, how, and how quickly climate impacts are changing. We observe from a high level changes across nearly two dozen centers and, more closely, the changes in five production centers that featured in our *Higher Ground?* analyses—Dhaka, Hanoi, Ho Chi Minh City, Karachi and Phnom Penh. First, we analyze in the first section changes in heat-stress risk using both dry- and wet-bulb measures. In Section 2, we analyze how heat—especially wet bulb globe temperatures (WGBT) and heat waves—has been intensifying in major garment producing centers over the past 20 years. Section 3 looks at how flooding is getting worse over the past two decades, and Section 4 details how heat and flooding are already upending the lives of garment workers. Section 5 discusses the need for adaptation and how well prepared major apparel producing nations are for climate change, and Section 6 goes over governance structures in many of these nations. We conclude by advancing new recommendations that build on our recommendations made in the *Higher Ground?* reports.

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2. Fashion’s heat belt

After a two-year run of record-setting heat in 2023 and 2024, we analyze here changes in daily maximum temperatures in top production centers that make up fashion’s Heat Belt. Two broad conclusions emerge. The first is that the average number of high-heat days on which daily maximum outdoor temperatures topped 35 °C (95 °F) has increased in 17 of our 23 cities by over 10 percent over the last 20 years.[1] Cities including Karachi, Ho Chi Minh, Managua, Amman and Prato (Italy) saw consistent and significant increases in exceedance days over each of the five-year periods shown in Figure 1.

Figure 1. Exceedance days over 35 °C by center, 2005 – 2024.

Center	Country	Exceedance days, 2005–2009	Exceedance days, 2010–2014	Exceedance days, 2015–2019	Exceedance days, 2020–2024*	Change (%), 2005–2009 vs. 2020–2024
Delhi	India	141.0	118.2	140.6	115.6	-18.0
Karachi	Pakistan	95.6	83.4	101.2	113.2	18.4
Phnom Penh	Cambodia	34.4	88.2	109.8	112.2	226.2
Yangon	Myanmar	76.4	91.6	98.0	84.6	10.7
Cairo	Egypt	71.8	69.2	88.2	78.6	9.5
Bangkok	Thailand	80.8	68.6	62.0	76.6	-5.2
Ho Chi Minh	Vietnam	28.8	36.4	51.0	74.4	158.3
Managua	Nicaragua	57.8	60.4	71.8	72.4	25.6
Tiruppur	India	39.0	69.6	73.4	67.2	72.3
Hanoi	Vietnam	38.6	32.2	44.4	56.2	45.6
Dhaka	Bangladesh	32.8	66.6	42.2	51.2	56.1
Manila	Philippines	21.8	31.6	42.2	42.4	94.5
San Pedro Sula	Honduras	38.0	32.6	36.2	37.6	-1.1
Amman	Jordan	18.8	21.6	29.2	36.2	92.6
Izmir	Turkey	36.4	25.6	19.2	30.6	-15.9
Monastir	Tunisia	20.4	20.4	23.4	29.4	44.1
Columbo	Sri Lanka	3.6	5.8	26.0	25.2	600.0
Prato	Italy	8.2	9.8	15.6	22.4	173.2
Kuala Lumpur	Malaysia	7.8	14.4	11.6	12.2	56.4
Jakarta	Indonesia	7.6	8.2	6.6	8.6	13.6
Dongguan	China	4.2	5.2	5.6	8.4	100.0
San Salvador	El Salvador	2.8	4.8	9.0	6.8	142.9
Mexico City	Mexico	2.2	4.6	2.0	1.6	-27.3

* Data is up to 30 September 2024.

Source: Direct observation/station data via Visual Crossing

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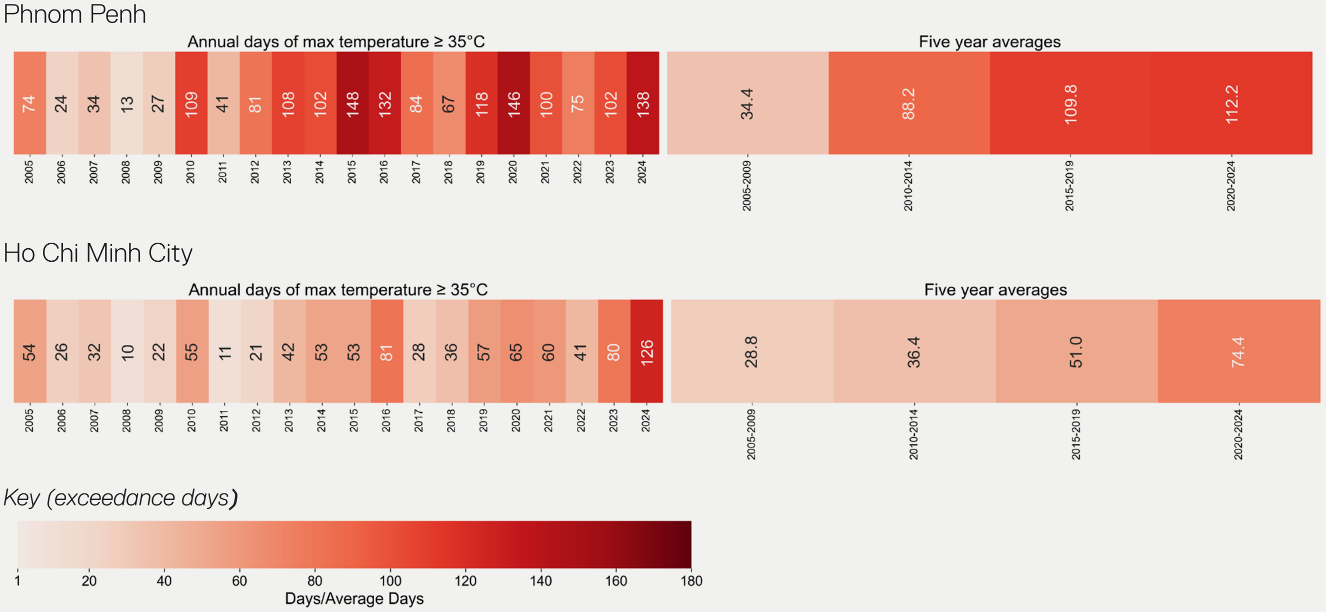
[1] A single year may appear anomalous against the backdrop of our changing climate. We use five-year averages here and elsewhere in this brief as to provide a clearer sense of the changes in heat levels and intensity. Climate science relies on five- and ten-year averages as longer-term warming trends reflect the influence of anthropogenic climate change, short-term fluctuations are natural and expected as the climate system responds to a complex system of drivers.

Tiruppur and Colombo also saw significant increases from 2005 – 2009 exceedance day averages with a slight decrease in the most recent period. But many cities—Delhi is an example—see significant swings in exceedance day averages from period to period, attributable in part to the short-term variability in weather patterns. Finally, two cities—Izmir and Mexico City—saw noticeable and consistent decreases across all of our periods.

Up and down, but mostly up

To illustrate the annual variability, we present here exceedance day data from Ho Chi Minh City and Phnom Penh by year and in five-year averages.

Figure 2. Annual and five-year average exceedance days over 35 °C, 2005 - 2024.



Source: Direct observation/station data from Visual Crossing

Changes in heat stress

Our second broad conclusion is that heat stress for apparel workers in our focus cities is accelerating and that heat waves are, on the whole, more frequent. As in *Higher Ground?*, we use a combined index of outdoor heat and relative humidity, the wet bulb globe temperature (WBGT), as a measure of heat stress for workers.[2] Heat-stress moves from 'discomfort' for apparel workers—even for acclimatized workers—at 28 °C (WBGT) to 'moderate' at 30.5 °C (WBGT), and high heat stress at 32 °C (WBGT). At the 'moderate' heat stress threshold, the ILO recommends that workers rest as much as they work in an hour—that is, 30 minutes of work require 30 minutes of rest—in order to allow their bodies to recover.[3] At the upper reaches of the WBGT index, workers can suffer exhaustion, fainting, heat stroke and worse (Malaysia Ministry of Human Resources, 2016; Schwingshackl et al., 2021; Somanathan, 2021).

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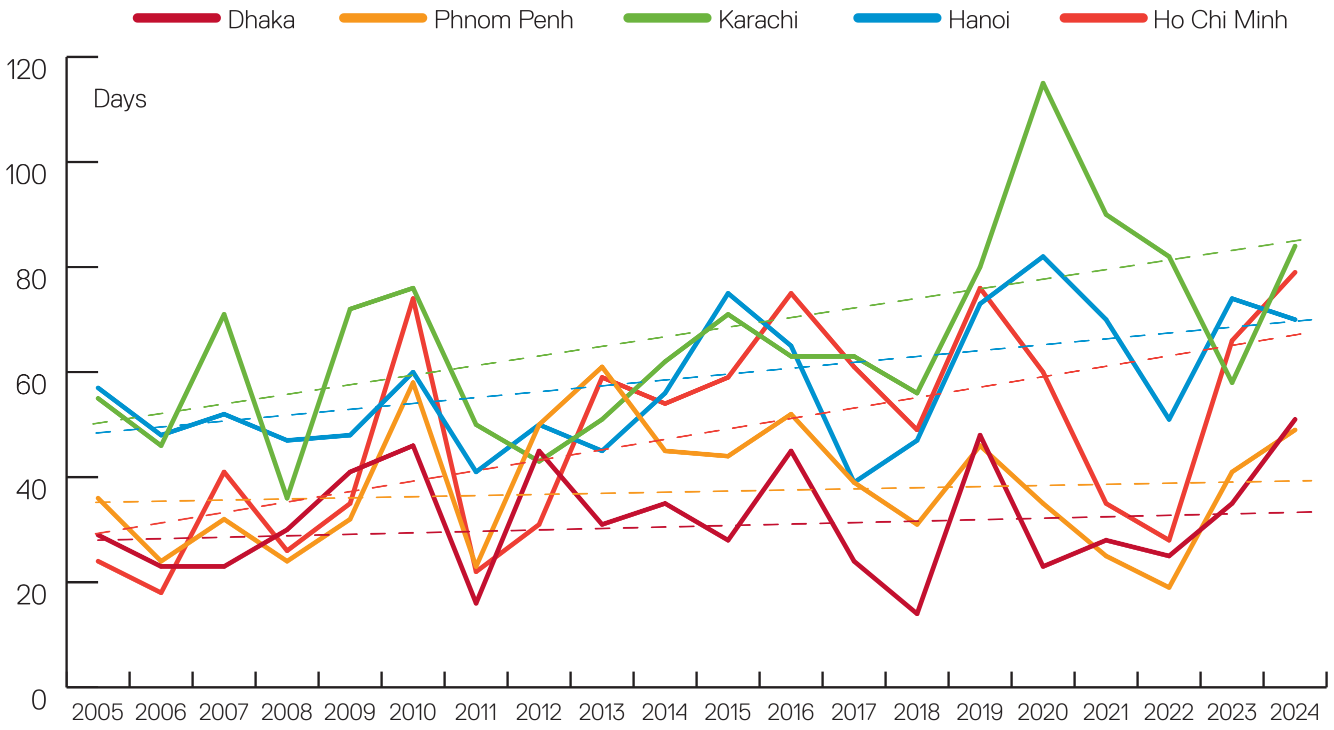
[2] This is different from 'dry-bulb' surface air temperatures (used in Figure 1 above) which are taken with traditional thermometers and are the most common way temperatures are represented. Wet-bulb values are lower on the scale than dry-bulb values but represent higher heat stress. A wet-bulb value of 25 °C at 65 percent humidity, for example, corresponds to a dry-bulb reading of 31 °C in low humidity (Somanathan, 2021).

[3] See ILO, 2019, "Working on a warmer planet: The impact of heat stress on labour productivity and decent work," https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_711919.pdf

Heat stress shows up too in worker productivity and output. Analyses in the academic literature on work and heat estimate that for every increase of 1 °C above 25 °C WBGT, productivity for moderate effort manufacturing work decreases by an average of 1.5 percent (Hsiang, 2010).[4]

Across our five focus centers, the trend is ever-higher wet-bulb 'exceedance days'—days on which WBGT exceed our moderate heat stress threshold of 30.5 °C. Karachi, Hanoi and Ho Chi Minh experienced the most notable rises since 2005, with Karachi peaking at 115 exceedance days in 2020. And four of our five cities, excepting Hanoi, have been reaching towards new heat stress levels over the past two years.

Figure 3. Annual exceedance days >30.5 °C WBGT, by center, 2005 – 2024.



Source: Reanalysis of ERA5 hourly data on single levels from Copernicus Climate Change Service.

Heat (stress) waves

A closer-still measure of the changes in heat stress since 2005 is the frequency and intensity (duration) of high-heat events. We define a heat wave here as three or more consecutive days with outdoor wet-bulb maximums above 30.5 °C. The figures below track the number of heat waves per year by city and their duration. Figure 4 shows that annual volatility is, again, marked but the frequency trend is upward across the five cities.

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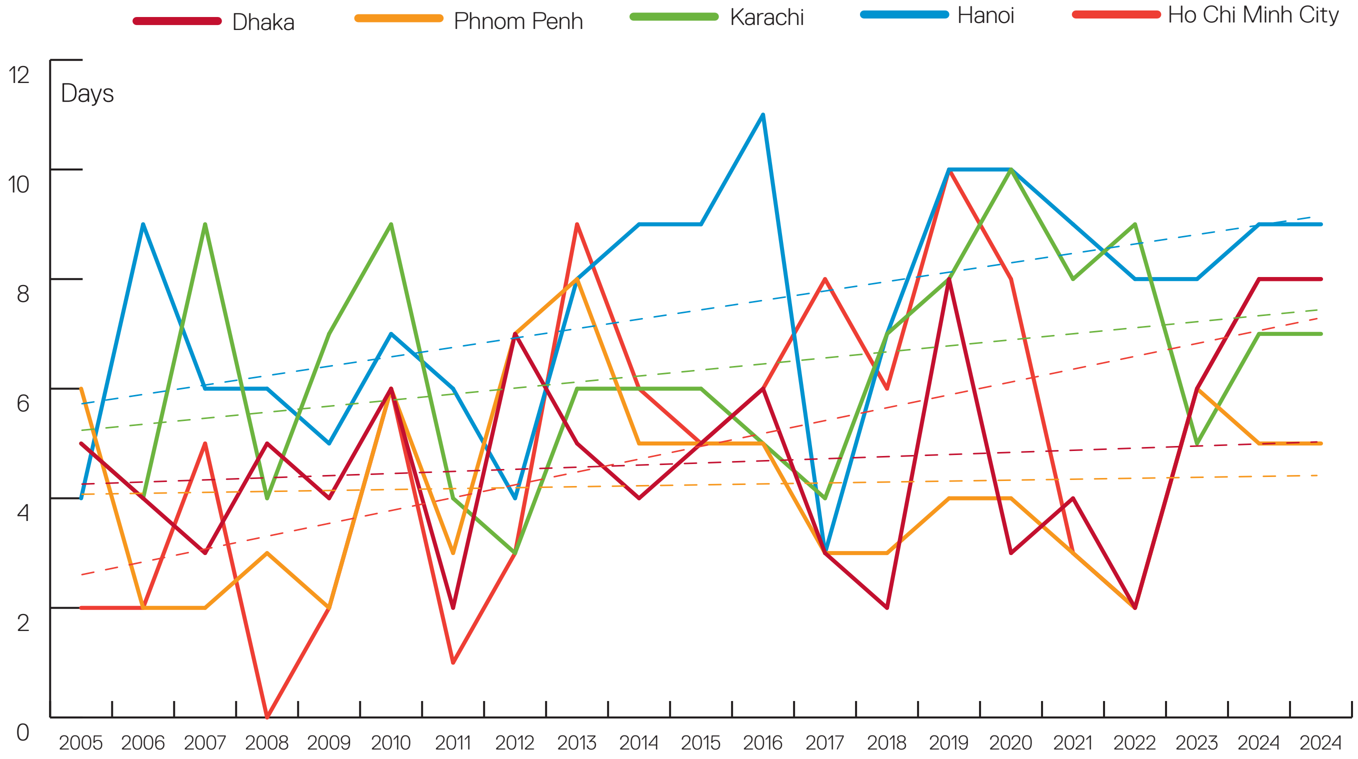
[4] The academic literature includes several long-term studies measuring the effect of heat on labor productivity, including some conducted in apparel production in S. Asia. For a comparison of heat-productivity approaches and studies, see Somanathan et al (2021) at https://www.journals.uchicago.edu/doi/10.1086/713733#1st_rf7R. Our use of Hsiang (2010) and a 1 - 2 °C WBGT decline in manufacturing productivity per degree above 25 CWBGT represents a conservative choice among the approaches.

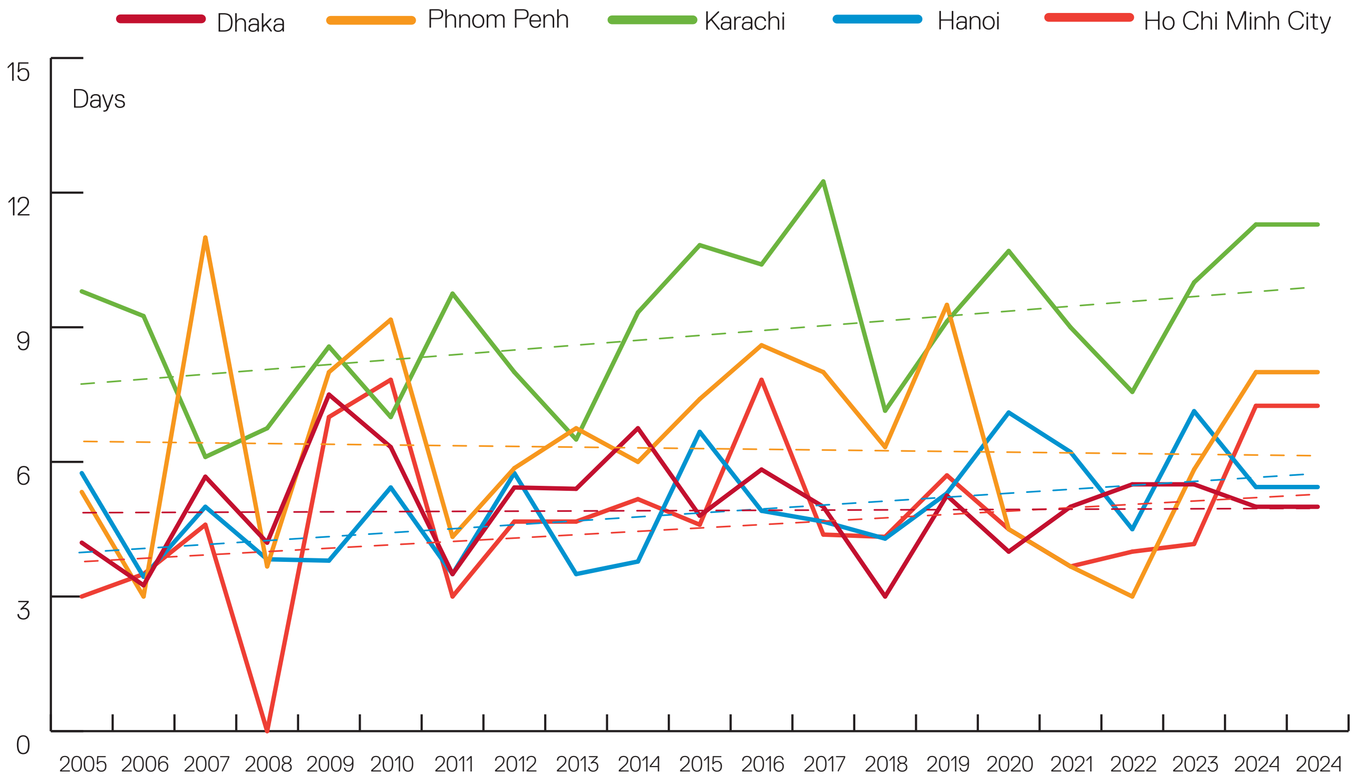
Figure 4. Frequency of heat waves, by center, 2005 – 2024.



Source: Reanalysis of ERA5 hourly data on single levels from Copernicus Climate Change Service.

Across our five cities heat waves have occurred more frequently since 2005. Ho Chi Minh City shows the most marked increase, with Hanoi and Karachi also seeing boosts in the number of heat waves per year. Dhaka and Phnom Penh have seen only slight increases in the number of annual heat waves.

Figure 5. Average duration (days) of heat waves, by center, 2005 – 2024.



Source: Reanalysis of ERA5 hourly data on single levels from Copernicus Climate Change Service.

The average length of wet-bulb heatwaves (or 'heat-stress waves') in our focus cities—excepting Phnom Penh—has also increased over the period, albeit more slowly than their frequency. Karachi alone saw a large jump in the duration of heatwaves from an average of 8.1 days in the first decade to 9.8 days in the years since 2014.

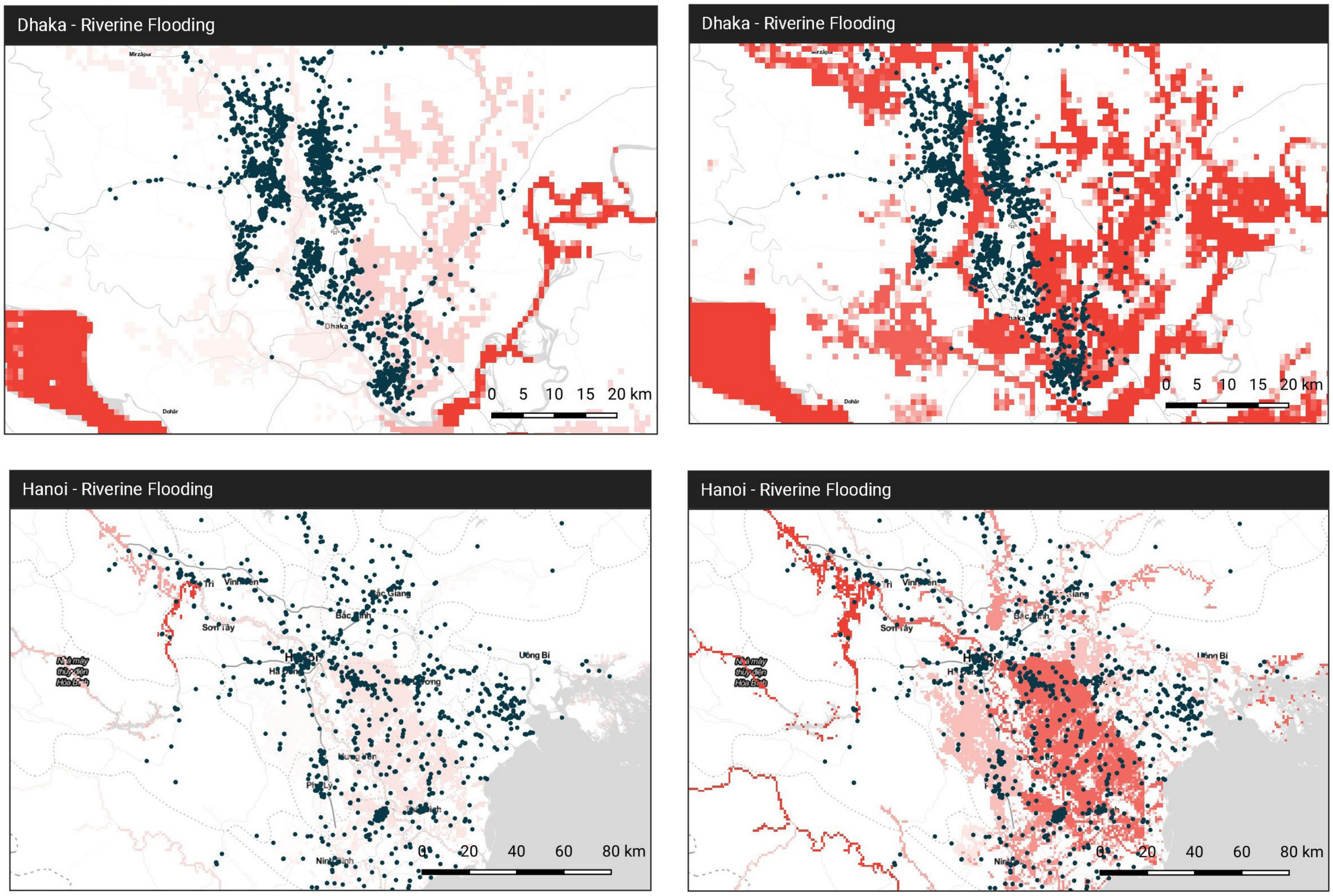
Workers and output in all five cities have experienced the compounding effects of more frequent and generally longer heatwaves. We note, as in *Higher Ground?*, that heat does some of its biggest damage to workers away from the workplace. The **persistently higher night-time temperatures that heat waves bring** interfere with the rest, health and finances of workers and their families:

> Workers [in Dhaka] reported missing three full days of work per month due to heat- and flood-related illness in the hottest and rainiest quarter of the year… [and] more than 10 percent of their income in the highest-cost months of the year… [Apparel workers] estimated spending BDT 3,500 (USD 31) for medicine and BDT 2,000 (USD 18) for electricity at home in the hottest months when fans have to run constantly to allow them to sleep. Monthly bills of this size equal 61 percent of average monthly rent payments of BDT 9,000 (USD 83) and workers reported borrowing against their personal belongings and paying high interest rates to afford electricity and medicines in May, June and July. (Judd et al, 2023)

3. Fashion's flood risk

Heat's impacts are wider and slower-moving than those of intense flooding, which can be very fast-moving, relatively isolated and dramatically destructive. Figure 6 below borrows four flood projection maps from *Higher Ground?* to illustrate the intensity and extent of projected rainfall flooding (in red) for Dhaka and Hanoi region apparel facilities (in blue) from routine flooding events in 2030 and 2050. Worst-case flooding—a major flood event in 2050 or sooner—could inundate to 0.5 meter or more approximately 22 percent and 27 percent of facilities in Vietnam and Bangladesh, respectively.[5]

Figure 6. Riverine flooding projections (RP10), Dhaka and Hanoi, 2030 (left) and 2050 (right)



Source: Higher Ground? RCP 4.5 (2030)[6]

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[5] *In Higher Ground?* we analyze RP 100 events, previously scored as a once-in-a-century flood, that are now liable to occur more often. See: Boumis, G., Moftakhari, H. R., & Moradkhani, H. (2023). Co-evolution of extreme sea levels and sea-level rise under global warming. Earth's Future, 11, e2023EF003649. https://doi.org/10.1029/2023EF003649 and Slater, L., Villarini, G., Archfield, S., Faulkner, D., Lamb, R., Khouakhi, A., & Yin, J. (2021). Global changes in 20-year, 50-year, and 100-year river floods. Geophysical Research Letters, 48, e2020GL091824. https://doi.org/10.1029/2020GL091824

[6] RCP 4.5/SSP2 scenario used the World Resources Institute's Aqueduct Floods Tool corresponds to SSP 2-4.5 used in our heat analyses. Our temperature and flood analyses are based on models developed and data organized by others: chiefly the European Union's Copernicus Climate Change Service for temperature and the World Resources Institute Aqueduct flood model. Both produce datasets using our preferred 'middle-of-the-road' climate scenario, SSP 2-4.5 (and RCP 4.5).

In this brief, we use rainfall as a proxy for riverine flooding risk to measure changes over the last 20 years.[7] We calculate average daily rainfall per year during the heaviest rainfall period—each city's top 30 rainfall days. As with heat above, we show in Figure 7 the changes over five-year periods.

Figure 7. Average daily precipitation (in millimeters) for top 30 rainfall days by center, 2005 – 2024.

Center	Country	2005–2009	2010–2014	2015–2019	2020–2024
Kuala Lumpur	Malaysia	45.1	44.4	44.7	46.2
Dhaka	Bangladesh	41.5	29.4	46.5	42.2
Colombo	Sri Lanka	44.4	44.3	43.4	41.5
Manila	Philippines	37.9	51.2	44.7	39.5
Yangon	Myanmar	20.2	34.2	32.1	39.1
Hanoi	Vietnam	35.0	36.0	35.9	38.9
Dongguan	China	34.1	34.1	37.6	38.6
Jakarta	Indonesia	32.0	34.3	34.7	36.6
Phnom Penh	Cambodia	22.7	23.3	25.2	29.4
Ho Chi Minh City	Vietnam	30.5	29.0	21.9	28.3
Bangkok	Thailand	26.8	24.9	25.4	25.8
Managua	Nicaragua	23.7	21.8	23.6	25.3
Delhi	India	21.0	21.4	18.6	23.7
San Pedro Sula	Honduras	15.1	15.0	16.2	18.3
San Salvador	El Salvador	15.1	15.0	16.2	18.3
Tiruppur	India	15.8	13.4	16.2	16.1
Izmir	Turkey	17.0	20.8	19.0	15.8
Karachi	Pakistan	7.9	4.7	5.9	12.4
Prato	Italy	15.7	15.3	14.8	10.9
Monastir	Tunisia	10.8	9.7	11.9	8.2
Amman	Jordan	6.7	5.6	6.6	6.6
Cairo	Egypt	0.8	0.7	1.8	2.4
Mexico City	Mexico	2.9	1.9	1.8	0.8

Source: Direct observation/station data via Visual Crossing

Higher daily precipitation totals indicate higher flooding risk but, as in our *Higher Ground?* reports, the data does not account for the impacts of flood defenses or water discharge rates around factories. Ten of the 23 cities saw at least a 10 percent increase in average rainfall between the first and the last five-year period. Yangon, Jakarta, and Dongguan are among the cities with significant intensification in rainfall across all of the five-year periods.

In production centers with dry climates and low-intensity rainfall—Amman, Cairo, Mexico City and Monastir—average rainfalls have been generally flat or fallen in the last 20 years.

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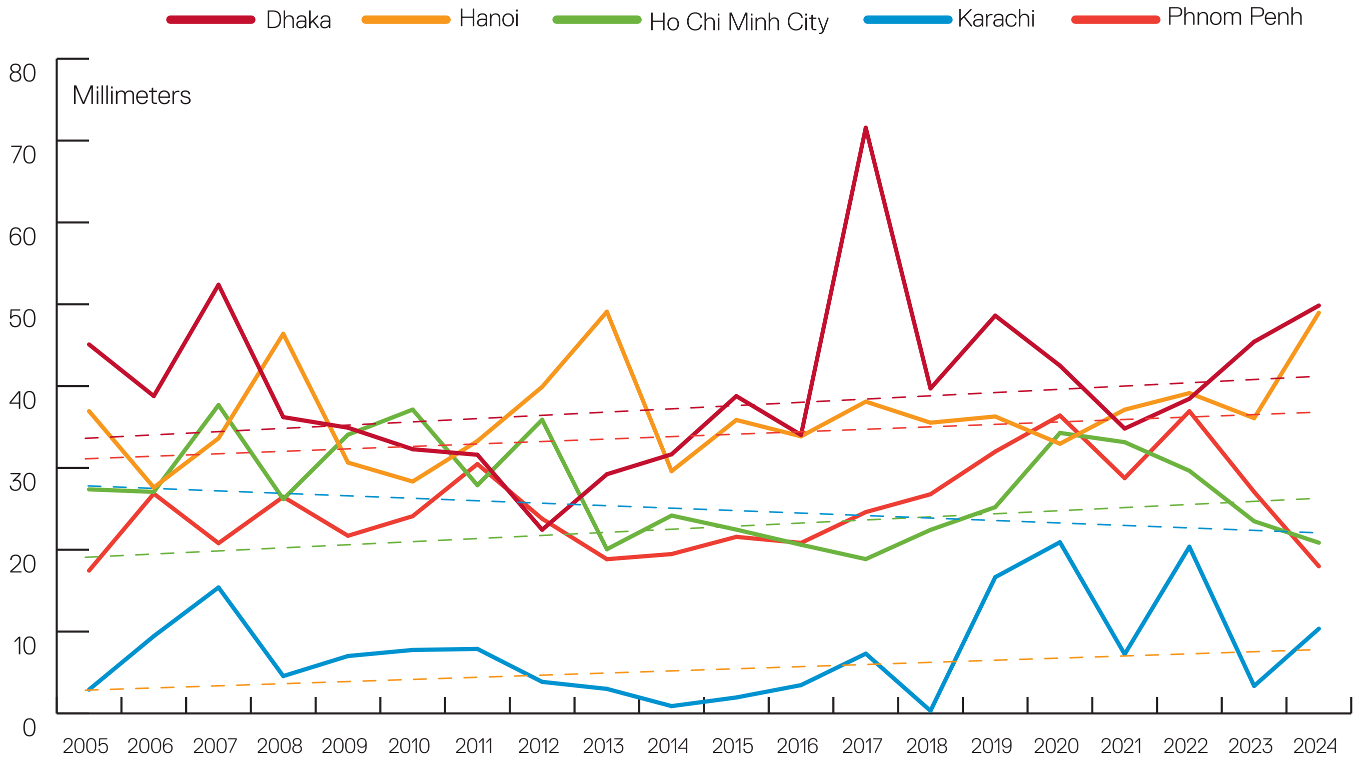
[7] Uniform, reliable flooding data for our 23 production centers is not available.

Figure 8. Average daily precipitation (millimeters), top 30 rainfall days, 2005 – 2024.



Source Direct observation/station data via Visual Crossing

As the trendlines above show, heavy rain days are becoming more intense but less dramatically than long-term changes in heat. In our five focus cities, workers in Dhaka have seen a noticeable increase in the amount of precipitation on their rainiest days while those in Karachi—a city with a semi-arid climate—have seen significant swings in rainfall and consequent flooding over the past few years. Only Ho Chi Minh City has seen an overall decline in rainfall intensity.

4. Heat and flooding in apparel production and workers' lives

The effects of extreme heat and intense flooding can be mitigated by climate-adaptative investments. As a result, similar climate data for Miami and Manila will have different outcomes. And within those cities, differences in topography, infrastructure investment, wealth, wages and plain old luck can mean the difference for inhabitants between disaster and mere discomfort. The same factors can determine—tamp down or ramp up—the impacts of high heat and humidity for workers making apparel and footwear.

In this section we look at how severe weather events in 2023 and 2024—two record-breaking years for heat and flooding around the world—were experienced and reported on the ground in apparel production centers.

South Asia. **Pakistan**, heatwaves have led to power outages and water shortages in Karachi in early July 2024. Later that month, a second heatwave caused the government to extend summer holidays by two weeks in over 100,000 schools to avoid the hot weather.

Temperatures over 42 °C in **Bangladesh** in April 2024 **led to the country** shutting down schools for 33 million children, and **garment workers** in the country suffered heavily with this heatwave, with workers becoming less productive and many having to take sick leave. In Dhaka, workers say that "[f]actories often cut power during extreme heat and give an extra hour of break, but no overtime is provided."

That same heatwave **caused workers in** Tamil Nadu, **India**'s factories to deal with widespread episodes of heat stress and other heat related illnesses. These heat events are not adequately dealt with, **according to** executive director of the Bangladesh Centre for Workers Solidarity Kalpona Akter "because the inside is so crowded and you have all these machines and human bodies. I asked a manager what they did when there's a huge heatwave and he said they sprinkle water outside. And I asked how is that helping workers at all? He didn't have an answer."

Floods. In recent months. **Bangladesh** has seen dramatic and devastating flooding, exacerbating the issues that have cropped up in the wake of their political upheaval. **July saw widespread flooding** across the country, and Bangladesh again saw massive, deadly floods in late August. This **round of flooding caused** production delays in apparel factories, and garment production was estimated to be down significantly for the year. The floods also slowed **down access** to the Chattogram port—the industry's connection to the world—and added stress to supply chains already under pressure.

The severe monsoon season also brought major flooding and mudslides **to Sri Lanka**, where the government closed schools due to the heavy rains. Delhi, **India** also **dealt with** office and school closures due to deadly floods in the capital region.

Southeast Asia. **Millions of children** had disruptions to schooling due to heatwaves earlier this year and workers in **Vietnam's** largest apparel and footwear hub, Ho Chi Minh City, **huddled en masse** under the city's bridges to avoid excessive heat. **Vietnam also had** power cutbacks and asked for manufacturers to work in off-peak hours to prevent power losses.

Garment workers and other **indoor factory workers** in **Cambodia** and **Thailand** were subjected to excessive indoor heat. As one worker **put it**, "[t]he weather has changed so much. Now, there is no air and it is very hot. In the past, the workers could sit and sew for the whole time, but now they cannot work all the time. They have to wash their face. It is very hot.

Floods. Monsoon rains have also wreaked havoc in Southeast Asia. **Vietnam** saw deadly floods and landslides in August, **damaging schools and preventing** a timely start to their schoolyear. Typhoon Yagi inundated **Myanmar**, hampering the nation's water, electrical and education infrastructure, and shut off access for around six million children in Vietnam and **Thailand** to schools, clean water. **Cambodia's** capital Phnom Penh **saw major rainfall** in August that overran their sewage and garbage systems and flooded city streets.

China. Still the world's largest apparel producer, has also dealt with heatwaves and flooding. High heat has caused **school closures and delays** in multiple provinces, and students and families **have been demanding** air conditioning be installed to protect the children. In Guangdong, **flooding in April 2024** **disrupted factory production**, forced 110,00 people to relocate and forced cities to suspend schools.

Middle East/North Africa. **In Egypt**, heatwaves and random power cuts have led to major economic disruptions, and **led to incidents** where people were killed in deadly elevator accidents because of the power shortages. In **Jordan**, high heat of over 40 °C in June 2024 **swept the nation** and prompted farmers to shut off their tractors in the midst of ploughing season because of the risks to themselves and their equipment.

The region has also seen heavy rains and flooding in recent years. **In 2020**, torrential downpours in **Egypt** led to multiple days of deadly flooding and saw water service in the capital city of Cairo shut down, as well as shuttered schools and businesses. Cairo in 2021 **saw a repeat** of that, with rare thunderstorms closing schools and roads throughout the north of the country. **Jordan in 2023** saw the closing of the port city of Aqaba after major flash flooding, that led to casualties and travel disruptions.

Central America and Mexico. High heat, wildfires, and air pollution in **Honduras** forced workers to stay home in places like Tegucigalpa, and drought and heatwaves caused **blackouts in San Pedro Sula**, a major garment manufacturing hub. The heat wave that scorched **Mexico** and parts of Central America in May 2024 **led to blackouts** in Mexico City and caused **schools to be closed** in other areas.

Floods. Central America has seen three major hurricanes in recent years—Iota, Eta, and Julia—bringing widespread destruction in **Honduras** and **Nicaragua**. In 2020, when Iota and Eta came onshore in Honduras, apparel workers in San Pedro Sula were displaced and some of the city's residents were forced to live on the streets due to the devastation. In 2022, many parts of Nicaragua, Honduras, and **Guatemala** had roads destroyed and cut off power by Hurricane Julia.

The similarities here between the experiences of workers and families in these key apparel-producing countries are not surprising. They have been reported widely and are a driver of the debate in recent conference of parties (COP) negotiations over the global climate response. (Also expected is the correspondence with our analyses of heat stress levels and precipitation above). Instead it is the under-investment—both financial and political, by governments and the fashion industry—in climate adaptation that is striking. As our *Higher Ground?* analyses argue, adaptive investments protect workers' health, improve output and earnings, and can save governments at least **five dollars in loss and damage costs for every adaption dollar spent.**

5. Coping with climate breakdown, adaptation

Media reports make clear how much of the climate 'action' takes place away from work. Our *Higher Ground?* reports emphasize the need for climate-adaptive investments that reduce physical ***and*** social risk. Investments to cool workplaces, for example, have to be paired with investments—higher wages, parametric social protection programs and the advancement of organizing and bargaining rights. Parametric social protection is social insurance that provides financial assistance to people and households based on expected impacts of climate events--for example, wet-bulb temperatures or rainfall above set thresholds. These social investments allow workers to pay for electricity to cool their homes, to buy medicine to treat climate-related illnesses in their families and bargain their way to safer workplaces:

> The ultimate lesson of the [Covid-19] pandemic for economies of the Global South with weak social protection systems and fashion brands is that the most adaptive, point-of-impact response to a complex crisis is 'entitlement' for the poor, including apparel workers (Sen, 1981). Entitlement in this context means stable, living wages and basic social protections that allow workers to 'command' access to cooler homes, adequate drinking water, medical care and transport to safer areas. Pay and health protections for apparel workers during a sudden work stoppage—from cancelled orders or pandemics to extreme heat and dangerous flooding—are their most urgent needs (Judd et al, 2023).

Pandemic-era emergency protections for workers and employers revealed both how meager the provisions for workers had been in some key apparel-producing countries, and how they might expand. In the era of climate crisis, how well-placed are workers and their employers to adapt to the effects of the climate crisis? In the table below, we pull together and compare measures of vulnerability and resilience or adaptability: climate vulnerability and readiness ratings, local 'purchasing power' of wages for manufacturing workers and coverage of social protection programs. Taken together, these indices provide a very rough ranking of climate risk and 'entitlement' among low-wage workers.

Climate vulnerability and readiness measures—including for extreme heat and intense flooding—are taken from the University of Notre Dame's GAIN index. The ILO's World Social Protection Report and wage data provide the share of each country's population covered by at least one social protection cash benefit programs and wages' purchasing power by sector. Across the board, major apparel producing nations fare pretty poorly, with a few exceptions including Thailand, China, and Turkey.

Figure 9. Climate vulnerability and readiness, and earnings and social protection, by country. For vulnerability: 0-1, with lower being better. For readiness: 0-1, with higher being better. Social protection is just a percentage of the total population, so 100 is the best possible number

Country	Climate vulnerability score	Climate readiness score	Manufacturing wage (PPP)	Social protection coverage (percent)
Bangladesh	0.55	0.28	389.11	22
Myanmar	0.51	0.25	511.05	6.3
Pakistan	0.5	0.31	517.19	20.2
Cambodia	0.48	0.29	665.59	20.8
Sri Lanka	0.47	0.38	470.73	41.3
Nicaragua	0.46	0.27	917.34	15.3
Vietnam	0.46	0.43	1,094.09	38.3
India	0.45	0.4	827.23	48.8
Honduras	0.45	0.26	1,122.11	30.1
Philippines	0.44	0.34	725.79	34.9
Indonesia	0.43	0.4	575.91	54.3
El Salvador	0.42	0.34	632.75	18.8
Thailand	0.41	0.49	1,445.47	70.1
Egypt	0.4	0.35	715.76	36.6
Tunisia	0.38	0.44	701.91	53.8
Mexico	0.37	0.36	857.25	80.8
Jordan	0.37	0.41	990.73	26.6
Malaysia	0.36	0.51	1,617.15	29.2
Turkey	0.36	0.49	1,782.69	64
China	0.35	0.56	1,327.95	75.6
Italy*	0.34	0.53	5,399.14	88.8

* Italy is an outlier and at USD 5,399.14 is left out of the wage-ranking.

Sources: University of Notre Dame-Global Adaptation Initiative, International Labour Organization "World Social Protection Report, 2024-26," and ILOSTAT data explorer

The nations and workers in this group with the weakest 'entitlement' measures—low purchasing power of manufacturing wages and below average levels of social protection coverage—have high climate vulnerability and low readiness scores: Bangladesh, Myanmar, Pakistan and Cambodia. Honduras and Nicaragua, with relatively high purchasing power of wages, have high vulnerability and low readiness scores as well as relatively low social protection.

Climate adaptation and organizing rights. The third element of effective social adaptation investment—along with living wages and solid social protection floors—is the right to organize and bargain collectively with employers. Workplaces are more resilient where there is collective bargaining with bona fide unions (Kuruvilla, 2021).[8] The suppression of organizing rights in most of fashion's favorite places appears to put workers and production at risk and to increase lead firms' liability under CSDDD.

All of these countries—excepting Italy—engage in "systematic violation of rights" or worse in the ITUC Global Rights Index which ranks nations on how well or how poorly they respect labor rights and the freedom of association. None of them fare better than a "4" ranking, which signals a according to the ITUC survey. Six of these nations—Bangladesh, Egypt, Myanmar, the Philippines, Tunisia, and Turkey—are counted among the ten "worst countries for working people" by the ITUC. (USTIC, 2024 and ILO, 2024).

Section 6. Governance at the intersection of climate and labor issues

How well-placed are national governments and brands and retailers to drive urgent climate adaption? On the national level, rules on access to drinking water, for example, are similar across the apparel-producing world but standards governing heat stress or simply temperature in factories vary widely in terms of specificity and hence, enforceability.

Malaysia is among the handful of countries with spelled-out regulations for factories. Its **Guidelines on Heat Stress Management** lists WBGT thresholds for different levels of work (32 °C for light work, 30 °C for moderate, 29 °C for heavy, and 28 °C for very heavy) that employers need to follow for their factories. It also spells out specific requirements for factory design including insulating materials and white-washing of walls to prevent heat transfer.

In Vietnam, employers are required to monitor the 'microclimate' of the working environment. The law provides specific guidelines including a formula for calculating WBGT indices with or without solar load figures. The law limits heat exposure time based on the level of effort and the WBGT in the workplace.

Figures 10. Indoor manufacturing heat stress (WBGT) thresholds, Vietnam.

Heat exposure duration	Work effort		
	Light work	Medium work	Heavy work
Continuously	30.0	26.7	25.0
75%	30.6	28.0	25.9
50%	31.4	29.4	27.9
25%	32.2	31.4	30.0

Source: Vietnam Ministry of Health, "Technical Regulation on Microclimate - Permissible Value of Microclimate in the Workplace"

Measurement and enforcement of Vietnam's specific indoor temperature standard is left largely in the hands of employers. Environmental audit firms are licensed by the government to record indoor temperatures and certify factory compliance with the legal requirements. Manipulation of this system is easy and certifiers are reported to record early-morning, winter-season temperatures (Judd et al, 2023).

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[8] Recent research from the Solidarity Center in Cambodia shows that union members spend only half as much time working at unsafe temperatures (over 38 °C) as those who are not unionized.

Private regulation lagging

Most brands and retailers operate supplier codes of conduct (and multi-stakeholder programs) that include guidelines for water accessibility, for example, but most do not include requirements protecting workers during extreme climate events.

Only a handful have clear heat thresholds and fewer still have protocols. Access to shade or cooler environments as well as rest breaks when temperatures are high are mandated by **Nike**, **Levi's**, and **VF**. Nike and VF both discuss or list specific heat thresholds that should be avoided and call for worker protocols for excessively high temperatures. **VF** instructs manufacturers to avoid air temperatures below 10 °C or above 35 °C (dry-bulb) with 10 – 15 °C and 30 – 35 °C as 'borderline' and 15 – 30 °C as 'ideal'. **Nike's** range for sedentary work is 16 to 30 °C, and for physically exertive work, 13 – 27 °C. However, these standards and regulations are exceptions and are not normal for or consistent across the industry.

Are brands measuring climate impacts for workers and ensuring compliance with national standards? There is no mention of real-time remote temperature monitoring in these codes of conduct and the multi-stakeholder groups that brands direct—with the exception of the ILO's Better Factories Cambodia program—have no meaningful heat standards or protocols where national law does not provide them.

Thailand **has similar regulations**. The Occupational Standard says there must be rest periods when WBGT goes above specific thresholds for low, moderate, and high intensity work—much like Malaysia's requirement—and mandates PPE and cooling fans to reduce heat stress.

In **Cambodia**, the government largely leaves this work to the employers and environmental audit firms. **Cambodia** relies largely on the ILO Better Factories program to assess heat in apparel, footwear and travel goods factories. The ILO program has no enforcement powers.

China requires that outdoor work cannot continue when temperatures are above 40 °C, and requires that health checks be performed on people working in high temperatures. It also mandates the alteration of working hours and rest periods when temperatures are high, with workers being entitled to workers' compensation if they suffer from heat illnesses and "high-temperature subsidies."

For **Bangladesh**, unregulated third parties certify compliance with indoor 'comfort' standards. The Accord on Fire and Building Safety—agreed by unions and apparel buyers in 2013 after the deaths of more than 1,100 workers in the Rana Plaza building—polices safety and health, but indoor heat is excluded from its remit and that of its successor organization (RSC). The **Labour Act of 2006** requires 'adequate ventilation' and 'comfortable' temperatures for workers but includes no specific temperatures or thresholds.

India and **Pakistan** have factory temperature guidelines but stop short of thresholds like those in Vietnam and China.[9] Sindh Province in Pakistan **does have guidelines** around temperature and humidity, using wet and dry bulb readings, and **says that factories** must maintain "reasonable conditions of comfort." **India's law says** that wet bulb temperatures should not exceed 30 °C, and has added on recent guidelines in recent years to update that 1950 law. Those additional guidelines say that workers should be educated and have proper hydration, and recommends reorganizing working hours for physically demanding jobs.

El Salvador has **extensive guidelines** on temperature, including prescribed formulas on how to calculate WBGT, thresholds for WBGT temperatures based on the intensity of the work being done and a requirements that workers stop working if their internal body temperature goes above 38 °C. El Salvador has requires ventilation, insulation, and other heat protection actions, including guidelines on the speed of the air blown on workers to avoid them getting too cold.

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[9] See Pakistan's Factories Act of 1934 and India's Factories Act of 1948. India: "where the nature of the work carried on in the factory involves, or is likely to involve, the production of excessively high temperature, such adequate measures as are practicable, shall be taken to protect the workers therefrom by separating the process which produces such temperature from the workroom by insulating the hot parts or by other effective means… The Provincial Government may prescribe a standard of adequate ventilation and reasonable temperature for any factory".

Mexico has heat stress guidelines requiring employers to "identify work areas with hazardous heat conditions and implement appropriate risk reduction strategies" such as providing PPE and education about heat stress and working in high temperature environments.

We find significant variation amongst national standards for workplace heat. The relative stringency of standards, if not of enforcement, in several key apparel-producing countries including El Salvador, Malaysia, Pakistan, and Vietnam has important implications for lead firms covered by the European Union's **new corporate accountability regime**. So, too, does the lack of meaningful standards in Bangladesh and Cambodia, for example, pose risks for workers and, hence, for lead firms.

7. What's next?

For workers, the need for urgent adaptation is clear enough: higher earnings, healthier bodies, more jobs. For manufacturers, the recouping of heat- and flood-related shortfalls in earnings makes adaptation feasible, if not attractive. For buyers and investors, unmeasured and unmet climate risk can mean long-term losses. For governments, new jobs and export earnings are crucial. In short, urgent adaptation investments can yield rewards.

Of the changes outlined in *Higher Ground?* none seems more urgent than the setting of heat thresholds and climate-event protocols. Excessive heat in apparel and footwear factories is reducing output and earnings, and damaging worker health. In some key producing countries excessive heat is a violation of national law and the implementation of due diligence legislation in Europe will soon mean that not knowing or not acting on extreme heat creates legal liability for lead firms.

Whatever their motivation—safety concerns, national labor standards, legal liability in Europe, or pressure on earnings—fashion's players should be working urgently towards a standard and enforcement of it. Are they?

With a few important exceptions, no.

Our conversations with brands and retailers and their multistakeholder groups, regulators, investors and worker organizations over the last 12 months end up in the roughly same place. First, acceptance of the growing risks of extreme heat and intense flooding is clouded with concerns—among employers and brands—about who would pay for workplace improvements. This is a familiar problem.

Second, there is an organized pushback by manufacturers to existing workplace requirements from buyers. Preventing new mandates is a priority.

Third, climate adaptation is a growing priority for worker organizations but suppression of organizing rights and a lack of bargaining power in most of fashion's production centers means that most apparel workers are not in positions to bargain over and enforce industry-level standards.

Finally, climate adaptation issues run a very distant second to climate mitigation concerns and still have little-to-no part in the industry's climate response. When the two priorities are set up in a contest—protecting worker health and output on one hand and lowering factory-level carbon emissions on the other—the latter is the likely winner.

We sharpen here recommendations from *Higher Ground?* with the added urgency that accompanies the transposition of CSDDD in Europe. The short-term steps for brands, worker organizations and employers are clear enough. First, ensure compliance with national law in Pakistan, Vietnam, El Salvador and other countries with clear standards. Elsewhere, set a standards—in public policy or bargaining—for acceptable... temperature and humidity levels (WBGT) based on effort levels. Third, collect and share real-time heat and humidity levels in production areas. The technology is centuries old and wifi-enabled digital thermometers are inexpensive and reliable. Manufacturers, unions and brands can find the baseline, begin tracking productivity changes against various WBGT and calculate their individual returns on adaptative investments including cooling systems and flood defenses.

As we noted in *Higher Ground?* fashion brands and retailers, manufacturers and national governments hardly need academic researchers to point them in these directions. They solve much more complex problems on a daily basis. Some actors have begun to move. Among the changes we have seen in the year since the publication of *Higher Ground?* are:

- USDOL is requiring that IFC/World Bank lending proposals respond to and account for the heat and flooding threats presented in *Higher Ground?*
- EU Commission, member States and parliamentary oversight of new CSDD and CSRD requirements are considering Cornell GLI Labor Outcomes Metrics, including requirements for collection and disclosure of heat and flooding outcome measures
- ADB is using GLI's analysis in support of mandatory Environment-Social standards for new investments, including infrastructure projects.
- Unions in some apparel-producing countries have moved climate impacts up the list of priorities among leaders and workers. *Higher Ground?* findings quantified and helped clarify climate risks for the industry generally.
- Apparel brands are planning heat-management pilots with key manufacturers in Cambodia and elsewhere. Brands and multi-stakeholder groups are using our findings to build or strengthen climate standards such as indoor temperature thresholds and high-heat protocols.
- Asset owners and managers including Schroders and Aviva have introduced heat and flood risk questions in engagements with fashion firms.
- Journalists in finance and fashion media now regularly note heat and flooding impacts (including *Higher Ground?* economic damage/headwinds analyses) in reporting on climate impacts for the fashion industry.

Finally, the International Trade Commission's 2024 apparel competitiveness investigation, which included contributions from GLI, noted that since the ILO "enshrined workplace health and safety in its core labor standards … all ILO member states are expected to follow and incorporate the core standards into national law, whether or not they have ratified the convention addressing worker safety and health. Practically, these broad conventions carry standards for heat stress … hygiene … and general worker health… [but apparel producing countries] still lag far behind in compliance with these standards, and governments, buyers, and initiatives often delegate measurement and enforcement to employers."

Will legal liability help fashion adapt?

So far, it has been a slow start for the industry. This is due, in part, to a reliance on a voluntary, business-case approach that neither matches the moment nor produces industry-scale change. Tragedy and trade—specifically, interruptions to firm-level trade—are generally required for industry-scale change in fashion. Climate tragedy in apparel production has almost certainly struck but we do not know the stories. Given what we know about climate breakdown it seems inevitable that we will.

The arrival of legal liability for harms to workers may change the industry's calculus. CSDDD and the accompanying reporting requirements (CSRD) threaten an interruption of sorts to trade for lead firms that do not account for the harms that climate breakdown can cause to workers. This issue sits squarely within definitions of human rights harms to workers in the German Supply Chain Act:

> A human rights risk within the meaning of this Act is a condition in which, on the basis of factual circumstances, there is a sufficient probability that a violation of one of the following prohibitions is imminent… [the] prohibition of disregarding the occupational safety and health obligations applicable under the law of the place of employment if this gives rise to the risk of accidents at work or work-related health hazards

The German act—in effect since 2023—refers specifically to "obviously insufficient safety standards in the provision and maintenance of the workplace... [and a] lack of measures to prevent excessive physical and mental fatigue, in particular through inappropriate work organisation in terms of working hours and rest breaks." (Sec. 2)

Risks and harms to worker health and safety also feature in **CSDDD**: "The right to enjoy just and favourable conditions of work, including… a decent living, safe and healthy working conditions and reasonable limitation of working hours, interpreted in line with Articles 7 and 11 of the International Covenant on Economic, Social and Cultural Rights" (Annex, Part I).

In the accompanying sustainability reporting framework (CSRD), the European Union requires that "[s]ustainability reporting standards should specify the information that undertakings should disclose on social factors, including working conditions… Such information should cover the impacts of the undertaking on people, including workers, and on human health." (Sec. 49)

Finally, the CSRD source code—**European Sustainability Reporting Standards**—"requires [lead firms to provide] an explanation of the general approach the undertaking takes to identify and manage any material actual and potential impacts on value chain workers in relation to working conditions… [including] health and safety."

In a coming round of research from the Global Labor Institute, we will take up questions including the impact of CSDDD and similar legislation for climate adaptation, returns on investment and funding of workplace and community-level physical adaptation investments and—of equal import—funding of social adaptation investments.

Methodology

For the wet bulb globe temperature (WBGT) analysis, we used the European Centre for Medium-Range Forecasts (EMCWF) Reanalysis fifth-generation (ERA5, Hersbach et al., 2020, Herbech et al., 2023). It is a high-resolution global dataset that provides near real time hourly atmospheric data. It synthesizes both historical observations and model output. Hourly data was obtained for the climatologically hottest months of the year for the five cities analyzed (and the specific months): Dhaka (MAMJ), Hanoi (Apr.-Sept.), Ho Chi Minh (Apr.-Oct.), Karachi (Apr.-Oct.), and Phnom Penh (FMAM).

While ERA5 is widely used throughout the literature, it is not without its limitations. Because it integrates model data with observational data, there are uncertainties in regions where direct observations are sparse or unreliable. And changes in the definition of the region—inclusion or exclusion of bodies of water, for example—or grid size can account for variations between analyses. The method for calculating WBGT was based on a method by Carter et al. (2020) and uses temperature, relative humidity, wind speed, and incoming solar radiation.

and uses temperature, relative humidity, wind speed, and incoming solar radiation. The equation for calculating WBGT is below where Tnwb is the natural wet bulb temperature and is calculated using air temperature, globe temperature, wind speed, and psychometric wet bulb temperature (Tpwb). Tpwb is calculated using vapor pressure and temperature. Vapor pressure is calculated using relative humidity and air temperature. Tg is the globe temperature and is calculated using incoming solar radiation and air temperature, and Ta is air temperature. Because relative humidity is not an output of ERA5 it was derived using air temperature and dewpoint temperature.

$$\mathrm{WBGT} = 0.7(\mathrm{Tnwb}) + 0.2(\mathrm{Tg}) + 0.1(\mathrm{Ta})$$

Figure 1 surface-air temperatures between 2005 and 2024 are based not on ERA5 reanalysis data but on direct, weather station observations.

The ERA5 reanalysis data (Herbech et al., 2020, Herbech et al., 2023) provides global atmospheric and climate variables on a 0.25° resolution grid, which inherently includes both land and adjacent bodies of water within a single grid cell in coastal or densely populated areas. Grid cells covering coastal cities, like Karachi, might encompass a mix of urban, suburban, rural, and water regions, depending on the city's proximity to coastlines or rivers. Therefore, ERA5 values represent an average over each cell area rather than being able to strictly isolate urban characteristics and highly localized environmental effects. This could result in lower values for cities near water than what is actually experienced in the city. Additionally, due to the nature of gridded climate data, exact matching coordinates between the cities analyzed and the ERA5 grid are nearly impossible. A table breaking down the exact latitude and longitude of the cities and the closest grid point from ERA5 is below.

Figure 10. Focus city geo-location data

City	Actual Lat/Lon	ERA5 Lat/Lon
Dhaka	23.8°N, 90.4°E	23.75°N, 90.5°E
Hanoi	21.03°N, 105.8°E	21.0°N, 105.75°E
Ho Chi Minh	10.82°N, 106.63°E	10.75°N, 106.75°E
Karachi	24.86°N, 67.0°E	25.0°N, 67.0°E
Phnom Penh	11.55°N, 104.93°E	11.5°N, 105.0°E

Year to year variations in temperature and precipitation are influenced by multiple climate drivers and natural cycles, in addition to the forcing caused by anthropogenic climate change. While many cities across the globe, like Dhaka, have shown a broader warming trend in recent decades, that does not mean each subsequent year will be warmer than the previous, such as is the case in 2022. This interannual variability results from interactions among several key climate drivers, such as oceanic and atmospheric oscillations, land-atmosphere feedbacks, and regional climate influences.

The most consequential mode of atmospheric variability on Earth is the El Niño-Southern Oscillation (ENSO, Alexander et al., 2002). ENSO alternates between a positive (El Niño) and negative (La Niña) phase approximately every 2-7 years. During El Niño years, warmer ocean temperatures in the central and eastern Pacific Ocean tend to increase global temperatures and can shift rainfall patterns across the globe. In contrast, a La Niña, which occurred in 2022 (NCEI, 2024), typically leads to cooler-than-average global temperatures and can result in increased precipitation in parts of South and Southeast Asia, which can contribute to cooler temperatures in the region. Other modes of atmospheric variability include the Indian Ocean Dipole (IOD) and the Madden-Julian Oscillation (MJO) both of which can influence temperature and precipitation over Asia. Here, by way of illustration, are the annual WBGT exceedance days for our five focus cities.

Figure 11. WBGT > 30.5 °C exceedance days, by year

Center	Dhaka	Phnom Penh	Karachi	Hanoi	HCMC
2005	29	36	55	57	24
2006	23	24	46	48	18
2007	23	32	71	52	41
2008	30	24	36	47	26
2009	41	32	72	48	35
2010	46	58	76	60	74
2011	16	23	50	41	22
2012	45	50	43	50	31
2013	31	61	51	45	59
2014	35	45	62	56	54
2015	28	44	71	75	59
2016	45	52	63	65	75
2017	24	39	63	39	61
2018	14	31	56	47	49
2019	48	46	80	73	76
2020	23	35	115	82	60
2021	28	25	90	70	35
2022	25	19	82	51	28
2023	35	41	58	74	66
2024	51	49	84	70	79

For the precipitation analysis, we used the Climate Prediction Center (CPC) Global Unified Gauge-Based Analysis of Daily Precipitation. CPC Global Unified Temperature data provided by the NOAA PSL, Boulder, Colorado, USA, from their website at **https://psl.noaa.gov** (Xie et al., 2007). The CPC dataset collects gauge reports from over 30,000 stations from a variety of sources based on direct daily observations. Its high temporal consistency makes it well-equipped for assessing precipitation patterns and totals. One downside of the CPC product is its spatial resolution. At 0.5° resolution, which could under-represent extremes and localized events due to the grid-based averaging.

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