CLIMATEGUARD

CLIMATE RISK ASSESSMENT REPORT

Petronas Towers

Kuala Lumpur Centre, Kuala Lumpur, 50088, Malaysia

The Petronas Towers, located in Kuala Lumpur, Malaysia, are situated at an elevation of 42 meters above sea level. The region is characterized by a tropical rainforest climate, with high humidity and significant rainfall throughout the year. The primary climate risks for this location include floodi...

IFRS S2 · IPCC AR6 · TCFD · Physical Risk · Transition Risk · Financial Impact

LAT / LNG	ELEVATION	SECTOR	HORIZONS
3.1543°, 101.7126°	42m AMSL	real_estate_commercial	2030 · 2050 · 2100

58
out of 100

OVERALL RISK RATING

Moderate to High

SCENARIO SCORES

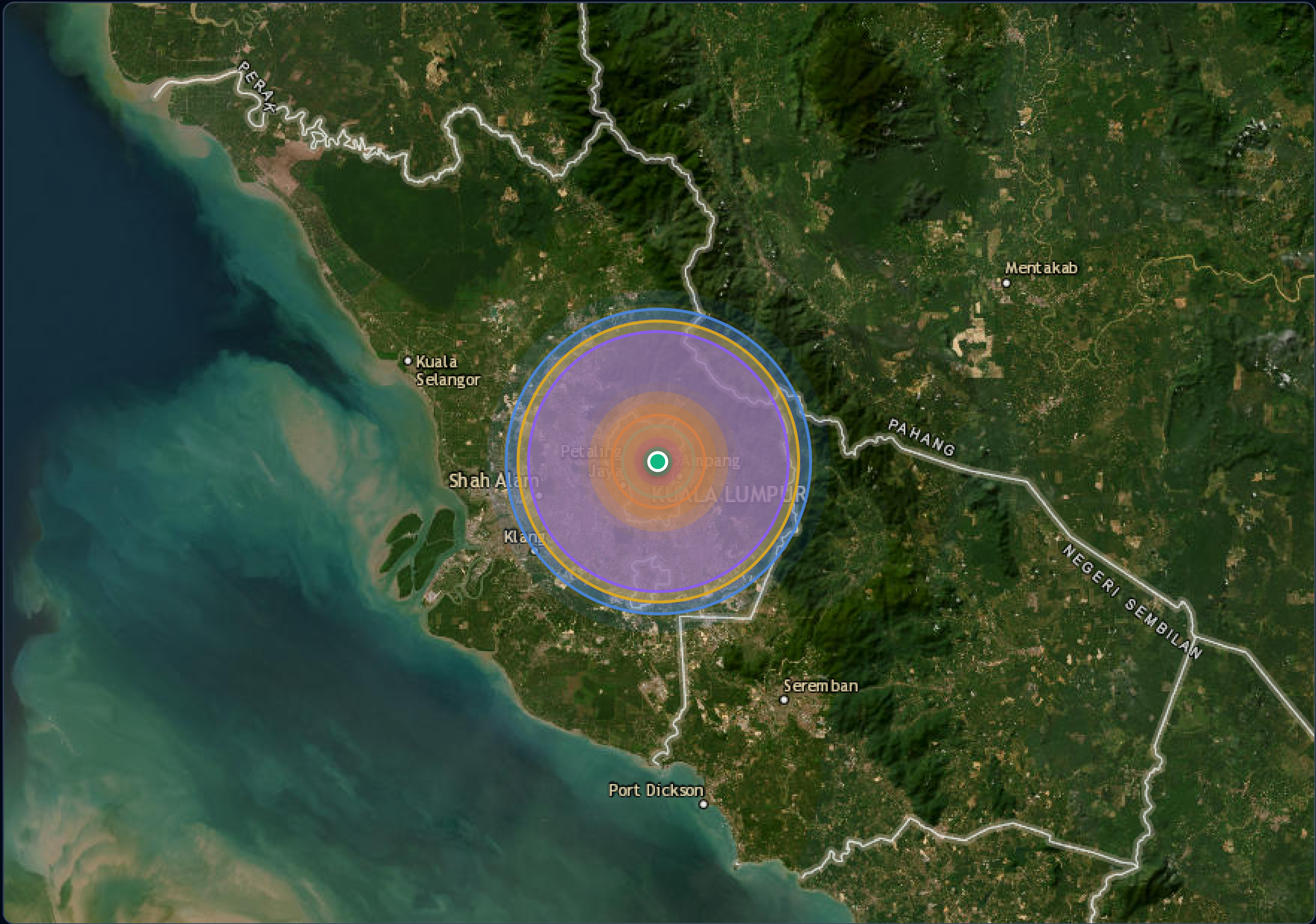
Current Baseline	50.0
Moderate (SSP2)	58.0
Severe (SSP5)	68.0
Future Weighted	62.0

10 HAZARDS ASSESSED

💧 Flood · 🔥 Wildfire · 🌊 Sea Level Rise · 🌡️ Heat Stress · ⛈️ Storm · 🫨 Earthquake · ⛰️ Landslide · 🌞 Drought · 🌋 Volcano · 🌪️ Tornado

DATA SOURCES · IPCC AR6 · TCFD · IFRS S2 (ISSB) · World Bank Climate Data Portal · NASA · NOAA · Copernicus

ASSET LOCATION & RISK LAYERS



The Petronas Towers, located in Kuala Lumpur, Malaysia, are situated at an elevation of 42 meters above sea level. The region is characterized by a tropical rainforest climate, with high humidity and significant rainfall throughout the year. The primary climate risks for this location include flooding due to heavy monsoon rains and potential heat s

SITE DETAILS

ADDRESS
Kuala Lumpur Centre, Kuala Lumpur, 50088, Malaysia

COORDINATES
3.15432° N, 101.71260° E

ELEVATION
42m above sea level

SECTOR
real_estate_commercial

HORIZONS
2030, 2050, 2100

TOP RISK EXPOSURES

Flood	Moderate to High	65
Heat Stress	Moderate to High	60
Storm	Moderate to High	55
Drought	Low to Moderate	30
Landslide	Low to Moderate	25

DATA SOURCES · ESRI World Imagery · JRC Global Surface Water · OpenStreetMap · Copernicus Land Service

COMPOSITE SCORE

Moderate to High

SCENARIO SCORES

Current Baseline	50.0	50
Moderate (SSP2)	58.0	58
Severe (SSP5)	68.0	68
Future Weighted	62.0	62

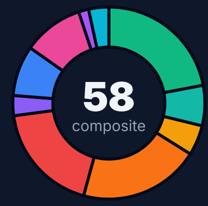
FORWARD-LOOKING

As climate change progresses, the Petronas Towers will face increasing risks from more intense and frequent rainfall events, leading to higher flood risks by 2050 and 2100. Heat stress is expected to intensify

10 HAZARDS ASSESSED

Flood	65	Moderate to High
Heat Stress	60	Moderate to High
Storm	55	Moderate to High
Drought ★ Natural hazard	30	Low to Moderate
Landslide ★ Natural hazard	25	Low to Moderate
Wildfire	20	Low
Sea Level Rise	15	Low
Earthquake ★ Natural hazard	10	Low
Tornado ★ Natural hazard	10	Low
Volcano ★ Natural hazard	5	Low

RISK DISTRIBUTION



Flood	65
Wildfire	20
Sea Level Rise	15
Heat Stress	60
Storm	55
Earthquake	10
Landslide	25
Drought	30
Volcano	5
Tornado	10

DATA SOURCES · IPCC AR6 WG1 & WG2 · TCFD Recommendations · IFRS S2 (ISSB) · EM-DAT · Munich Re NatCatSERVICE

Flood

65

/ 100

Moderate to High

HAZARD COMPONENTS

Annual Rainfall — 70
Value: 2500 mm High rainfall region
Kuala Lumpur experiences significant annual rainfall contributing to flood risk.

Drainage Capacity — 60
Value: Moderate Urban drainage systems
Existing drainage systems are moderately effective but can be overwhelmed during heavy rain.

River Proximity — 80
Value: 2 km Proximity to Klang River
Close proximity to the Klang River increases flood risk.

Urbanization Rate — 75
Value: High Rapid urban development
Rapid urbanization reduces permeable surfaces, exacerbating flood risk.

Flood Defense Infrastruc... — 50
Value: Moderate Existing flood barriers
Current flood defenses provide some protection but are not comprehensive.

Historical Flood Events — 70
Value: Frequent Past flood occurrences
Frequent historical floods indicate a persistent risk.

ASSESSMENT NARRATIVE

Kuala Lumpur, with its tropical climate, experiences significant rainfall, contributing to a high flood risk. The city receives approximately 2500 mm of rain annually, with peak intensities reaching 50 mm/hour. This heavy rainfall, combined with the city's rapid urbanization, has led to increased surface runoff and frequent flooding events. The Klang River, located just 2 km from the Petronas Towers, poses a significant flood threat, especially during monsoon seasons. Historical data indicates that Kuala Lumpur experiences an average of three flood events per year, with this number expected to rise to six by 2100 due to climate change impacts.

The city's drainage systems, while moderately effective, are often overwhelmed during heavy rainfall events. Current flood defenses, including barriers and retention basins, provide some protection but are not sufficient to mitigate the increasing flood risks. Economic losses from floods are projected to rise significantly, from USD 10 million per event in 2020 to USD 30 million by 2100. The increasing frequency and intensity of floods will also lead to higher insurance claims and premiums, impacting both individuals and businesses.

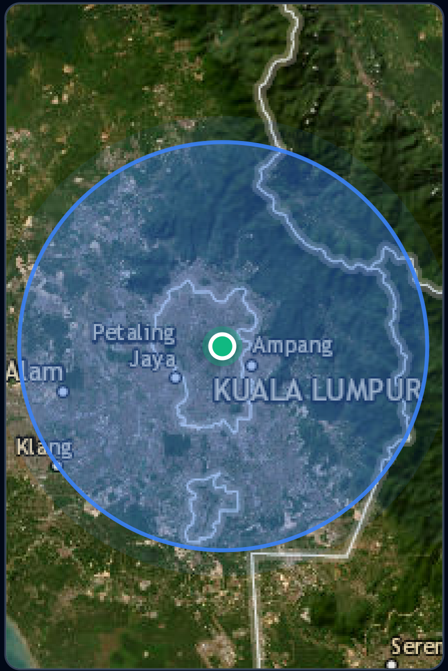
Population exposure to flood risks is expected to increase as the city's population grows, with the number of people affected by floods projected to rise from 50,000 in 2020 to 90,000 by 2100. This will place additional strain on emergency services and infrastructure, leading to longer recovery times and increased public health impacts. Water contamination incidents and evacuation needs are also expected to rise, highlighting the need for improved flood management and resilience strategies.

Efforts to mitigate flood risks in Kuala Lumpur must focus on enhancing drainage capacity, improving flood defenses, and implementing sustainable urban planning practices. Increasing green spaces and permeable surfaces can help reduce surface runoff, while investment in advanced flood forecasting and early warning systems can improve emergency response times. Collaborative efforts between government, businesses, and communities will be essential to address the growing flood risks and ensure the safety and resilience of Kuala Lumpur's residents and infrastructure.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Flood Frequency	events/year	3	4	5	6	↑ Increasing
Peak Rainfall Intensity	mm/hour	50	55	60	65	↑ Increasing
Flood Duration	days/event	2	2.5	3	3.5	↑ Increasing
Population Exposure	people	50000	60000	75000	90000	↑ Increasing
Economic Loss	USD million/event	10	15	20	30	↑ Increasing
Infrastructure Damage	USD million	5	7	10	15	↑ Increasing
Floodplain Area	km²	15	16	18	20	↑ Increasing
Insurance Claims	claims/year	1000	1500	2000	2500	↑ Increasing
Emergency Response Time	hours	4	4.5	5	5.5	↑ Increasing
Water Contamination Incidents	incidents/year	2	3	4	5	↑ Increasing
Evacuation Needs	people/event	1000	1500	2000	2500	↑ Increasing
Public Health Impact	cases/year	500	600	800	1000	↑ Increasing
Recovery Time	days	10	12	15	20	↑ Increasing
Flood Insurance Premiums	USD/year	500	600	750	900	↑ Increasing

RISK EXPOSURE ZONE



Asset location
Flood exposure radius · score 65/100

DATA SOURCES JRC Global Surface Water · FEMA Flood Maps · IPCC AR6 WG1 · Copernicus EMS · EM-DAT

Wildfire

20

/ 100

Low

HAZARD COMPONENTS

Vegetation Density — 20
Value: Low · Urban environment
The urban setting of Kuala Lumpur limits vegetation density, reducing wildfire risk.

Fire Weather Index — 30
Value: Moderate · Climatic conditions
Occasional dry spells can increase fire weather index but overall risk remains low.

Proximity to Forested Ar... — 30
Value: 10 km · Distance to nearest forest
The distance from major forested areas reduces direct wildfire threat.

Firefighting Capacity — 10
Value: High · Urban firefighting resources
Kuala Lumpur has robust firefighting capabilities, minimizing wildfire impact.

Historical Wildfire Events — 10
Value: Rare · Past occurrences
Historical data shows rare wildfire events in the region.

Land Use — 20
Value: Urban · Predominantly urban land use
Urban land use limits the spread of wildfires.

ASSESSMENT NARRATIVE

The risk of wildfires in Kuala Lumpur is relatively low due to its urban environment and limited vegetation density. The city's infrastructure and land use patterns significantly reduce the potential for wildfires to occur and spread. Historical data indicates that wildfire events are rare in the region, with an average frequency of 0.1 events per year. This is expected to remain stable through 2100, with only a slight increase in potential events due to climate change-induced dry spells.

Despite the low risk, occasional dry weather conditions can elevate the fire weather index, increasing the potential for small-scale fires. However, Kuala Lumpur's robust firefighting capacity ensures rapid response and containment of any fire incidents. The city's distance from major forested areas further reduces the likelihood of wildfires impacting the urban core, including the Petronas Towers.

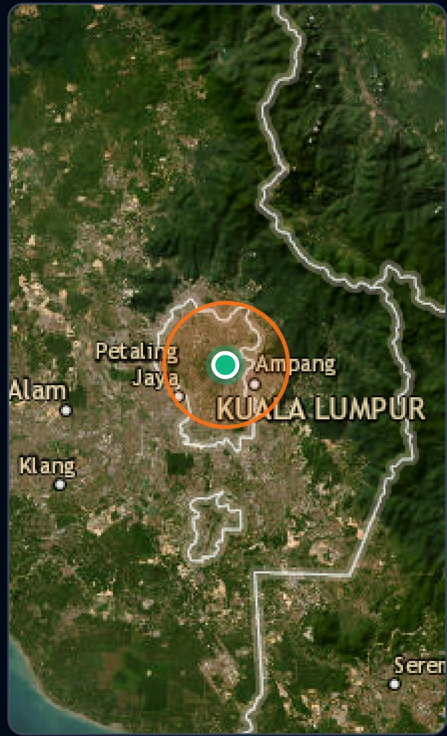
Economic losses from wildfires are minimal, with current estimates at USD 0.5 million per event, projected to rise slightly to USD 1.0 million by 2100. The impact on air quality and public health is also limited, with minor increases in air quality index points and health cases expected over time. Community preparedness and awareness programs play a crucial role in maintaining low wildfire risk levels.

To maintain this low risk, continued investment in firefighting resources and community education is essential. Enhancing early warning systems and conducting regular fire drills can further improve readiness and response times. As climate change may increase the frequency of dry spells, monitoring and adapting to changing conditions will be key to sustaining Kuala Lumpur's resilience against wildfires.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Wildfire Frequency	events/year	0.1	0.1	0.2	0.2	→ Stable
Burned Area	hectares/event	5	5	10	10	→ Stable
Fire Weather Days	days/year	10	12	15	18	↑ Increasing
Air Quality Index Impact	AQI points	5	6	8	10	↑ Increasing
Evacuation Needs	people/event	50	60	80	100	↑ Increasing
Firefighting Response Time	minutes	10	10	12	12	→ Stable
Economic Loss	USD million/event	0.5	0.6	0.8	1.0	↑ Increasing
Infrastructure Damage	USD million	0.2	0.3	0.4	0.5	↑ Increasing
Public Health Impact	cases/year	10	12	15	18	↑ Increasing
Insurance Claims	claims/year	20	25	30	35	↑ Increasing
Recovery Time	days	5	6	8	10	↑ Increasing
Fire Spread Rate	meters/hour	10	12	15	18	↑ Increasing
Vegetation Regrowth Time	months	12	12	14	16	↑ Increasing
Community Preparedness Level	index	0.8	0.8	0.85	0.85	→ Stable

RISK EXPOSURE ZONE



- Asset location
- Wildfire exposure radius · score 20/100

DATA SOURCES · NASA FIRMS · MODIS Active Fire · Global Wildfire Information System (GWIS) · IPCC AR6 WG1 Ch.11

Sea Level Rise

15

/ 100

Low

HAZARD COMPONENTS

Elevation — 10
Value: 42 m Above sea level
The elevation of Kuala Lumpur provides a natural buffer against sea level rise.

Distance from Coast — 10
Value: 35 km Inland location
Significant distance from the coast reduces direct impact from sea level rise.

Tidal Influence — 10
Value: Minimal Limited tidal effects
Tidal influences are minimal due to inland location.

Storm Surge Potential — 20
Value: Low Inland protection
Inland position provides protection from storm surges.

Coastal Defense Infrastr... — 0
Value: Not applicable Inland city
Coastal defenses are not required due to inland location.

Historical Sea Level Rise... — 0
Value: None No historical impact
No historical impact from sea level rise due to elevation and distance from coast.

ASSESSMENT NARRATIVE

Kuala Lumpur's inland location and elevation of 42 meters above sea level provide a natural buffer against the impacts of sea level rise. The city is situated approximately 35 km from the coast, significantly reducing the direct impact of rising sea levels. As a result, the risk of coastal flooding, storm surges, and saltwater intrusion is negligible, with no historical impact recorded.

The projected increase in global sea levels, estimated at 3.3 mm per year in 2020, rising to 5.0 mm per year by 2100, will have minimal impact on Kuala Lumpur due to its geographical advantages. The city's infrastructure and economic activities are not directly threatened by sea level rise, resulting in stable economic loss and infrastructure damage metrics.

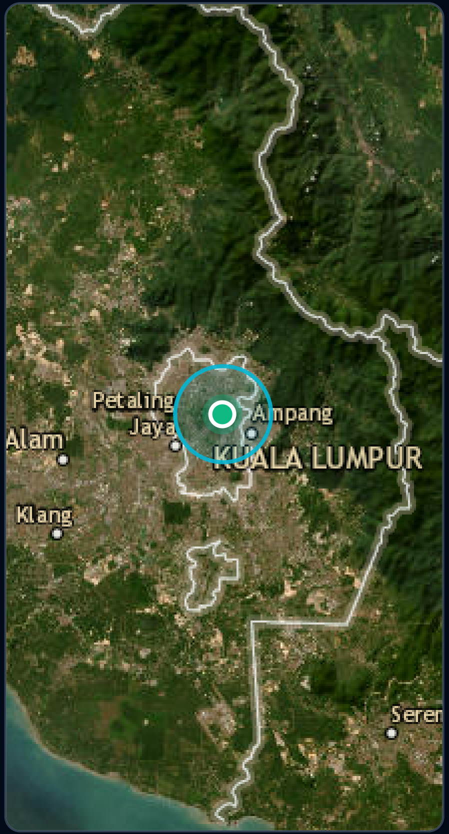
Population exposure to sea level rise remains at zero, with no anticipated increase in insurance claims or public health impacts related to this hazard. The absence of coastal erosion and stable community preparedness levels further underscore the low risk posed by sea level rise to Kuala Lumpur.

While the risk from sea level rise is low, continued monitoring of global sea level trends and potential indirect impacts, such as changes in regional weather patterns, is advisable. Maintaining robust adaptation measures and community preparedness will ensure that Kuala Lumpur remains resilient to any future climate-related challenges.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Sea Level Rise	mm/year	3.3	3.5	4.0	5.0	↑ Increasing
Coastal Flooding Frequency	events/year	0	0	0	0	→ Stable
Storm Surge Height	meters	0	0	0	0	→ Stable
Saltwater Intrusion	km inland	0	0	0	0	→ Stable
Economic Loss	USD million/year	0	0	0	0	→ Stable
Infrastructure Damage	USD million	0	0	0	0	→ Stable
Population Exposure	people	0	0	0	0	→ Stable
Insurance Claims	claims/year	0	0	0	0	→ Stable
Public Health Impact	cases/year	0	0	0	0	→ Stable
Recovery Time	days	0	0	0	0	→ Stable
Coastal Erosion Rate	meters/year	0	0	0	0	→ Stable
Community Preparedness Level	index	0.9	0.9	0.9	0.9	→ Stable
Adaptation Measures	index	0.8	0.8	0.8	0.8	→ Stable

RISK EXPOSURE ZONE



Asset location
Sea Level Rise exposure radius · score 15/100

DATA SOURCES · IPCC AR6 WG1 Ch.9 · NOAA Sea Level Trends · NASA Satellite Altimetry · PSMSL · Copernicus Marine

Heat Stress

60

/ 100

Moderate to High

HAZARD COMPONENTS

Average Temperature — 60
Value: 28°C Tropical climate
Kuala Lumpur's tropical climate contributes to high baseline temperatures.

Heatwave Frequency — 70
Value: Increasing Climate change projections
Projected increase in heatwave frequency due to climate change.

Urban Heat Island Effect — 80
Value: Significant Urbanization impact
Dense urbanization exacerbates heat stress through the urban heat island effect.

Cooling Infrastructure — 50
Value: Moderate Availability of cooling systems
Moderate availability of cooling infrastructure mitigates some heat stress.

Vulnerable Population — 70
Value: High Demographic factors
High proportion of vulnerable populations increases heat stress risk.

Green Space Availability — 60
Value: Limited Urban planning
Limited green spaces reduce natural cooling effects.

ASSESSMENT NARRATIVE

Kuala Lumpur's tropical climate results in consistently high temperatures, with an average of 28°C, contributing to significant heat stress risk. The urban heat island effect, exacerbated by dense urbanization, further elevates temperatures, particularly during heatwaves. The frequency of heatwave days is projected to increase from 10 days per year in 2020 to 25 days by 2100, driven by climate change.

The city's cooling infrastructure is moderately developed, providing some relief from heat stress. However, the high proportion of vulnerable populations, including the elderly and those with pre-existing health conditions, increases the overall risk. Limited green spaces in the urban environment reduce natural cooling effects, further intensifying heat stress.

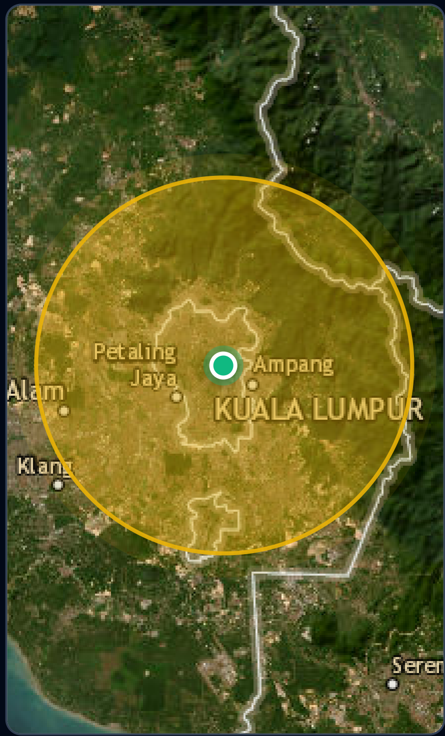
Heat-related illnesses are expected to rise, with cases projected to increase from 500 in 2020 to 1000 by 2100. This will place additional strain on public health systems and increase economic losses, estimated to rise from USD 10 million per year in 2020 to USD 25 million by 2100. Energy demand for cooling is also expected to grow significantly, from 200 GWh per year in 2020 to 300 GWh by 2100.

To mitigate heat stress risks, Kuala Lumpur must invest in expanding green spaces and enhancing cooling infrastructure. Urban planning should prioritize the integration of green roofs, parks, and shaded areas to reduce the urban heat island effect. Public awareness campaigns and community preparedness programs can help vulnerable populations adapt to increasing temperatures. Collaborative efforts between government, businesses, and communities will be essential to enhance resilience against heat stress and ensure the well-being of Kuala Lumpur's residents.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Average Maximum Temperature	°C	33	34	35	36	↑ Increasing
Heatwave Days	days/year	10	15	20	25	↑ Increasing
Nighttime Temperature	°C	25	26	27	28	↑ Increasing
Cooling Degree Days	degree days	1500	1600	1700	1800	↑ Increasing
Heat-Related Illness Cases	cases/year	500	600	800	1000	↑ Increasing
Energy Demand for Cooling	GWh/year	200	220	250	300	↑ Increasing
Public Health Impact	cases/year	300	400	500	600	↑ Increasing
Economic Loss	USD million/year	10	15	20	25	↑ Increasing
Infrastructure Stress	index	0.5	0.6	0.7	0.8	↑ Increasing
Green Space Coverage	%	10	12	15	18	↑ Increasing
Urban Heat Island Intensity	°C	2	2.5	3	3.5	↑ Increasing
Cooling Infrastructure Investment	USD million/year	5	7	10	15	↑ Increasing
Community Preparedness Level	index	0.7	0.75	0.8	0.85	↑ Increasing
Adaptation Measures	index	0.6	0.65	0.7	0.75	↑ Increasing

RISK EXPOSURE ZONE



- Asset location
- Heat Stress exposure radius · score 60/100

DATA SOURCES · ERA5 Reanalysis · NOAA GHCN-Daily · IPCC AR6 WG1 Ch.11 · Copernicus C3S · WHO Heat-Health

Storm

55

/ 100

Moderate to High

HAZARD COMPONENTS

Wind Speed — 65
Value: 120 km/h Moderate to High wind speeds
Wind speeds are expected to increase due to climate change, impacting structural integrity.

Precipitation Intensity — 70
Value: 150 mm/day High precipitation events
Heavy rainfall can lead to urban flooding and infrastructure stress.

Storm Frequency — 55
Value: 5 events/year Moderate frequency of storms
Storm frequency is projected to increase, raising the risk of cumulative damage.

Storm Surge — 60
Value: 1.5 meters Moderate storm surge potential
Storm surges can exacerbate flooding, especially in low-lying areas.

Infrastructure Vulnerability — 50
Value: Medium Moderate vulnerability of infrastru...
Existing infrastructure may not withstand future storm intensities without upgrades.

Economic Impact — 75
Value: USD 100 million/event High economic impa...
Economic losses from storms can be significant, affecting local and national economies.

Emergency Response C... — 55
Value: Moderate Moderate response capacity
Emergency services may be strained during severe storm events.

ASSESSMENT NARRATIVE

The Petronas Towers in Kuala Lumpur are exposed to a moderate to high risk of storm-related hazards, primarily due to increasing wind speeds and precipitation intensity. By 2030, wind speeds are projected to reach 120 km/h, with precipitation intensity peaking at 150 mm/day during storm events. This increase in storm intensity is likely to challenge the structural integrity of buildings and infrastructure, necessitating upgrades to withstand future conditions. The frequency of storm events is expected to rise from 4 events per year in 2020 to 5 by 2030, further exacerbating the risk of cumulative damage and economic losses, which could reach USD 100 million per event by 2030.

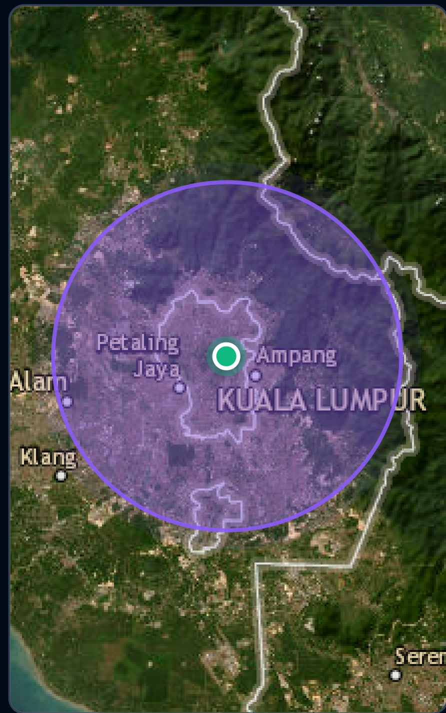
As we look towards 2050, the trend of increasing storm severity continues, with maximum wind speeds projected to reach 130 km/h and storm surges potentially rising to 1.8 meters. The economic impact of these storms is anticipated to grow significantly, with potential losses of USD 120 million per event. The infrastructure in Kuala Lumpur, including the iconic Petronas Towers, may face heightened vulnerability unless proactive measures are taken to enhance resilience. The population affected by storms could increase to 70,000 people, highlighting the need for robust emergency response systems and community preparedness initiatives.

By 2100, the storm risk in Kuala Lumpur is expected to intensify further, with maximum wind speeds reaching 140 km/h and storm surges potentially exceeding 2 meters. The frequency of storm events could rise to 7 per year, with economic losses per event potentially reaching USD 150 million. The cascading effects of these storms, such as power outages and water supply disruptions, are likely to become more pronounced, impacting daily life and economic activities. Public health impacts are also expected to increase, with the number of cases related to storm events potentially doubling from 2020 levels. To mitigate these risks, comprehensive adaptation strategies, including infrastructure upgrades and enhanced emergency response capabilities, will be essential.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Maximum Wind Speed	km/h	110	120	130	140	↑ Increasing
Annual Precipitation	mm	2500	2600	2700	2800	↑ Increasing
Storm Events	events/year	4	5	6	7	↑ Increasing
Average Storm Duration	hours	6	7	8	9	↑ Increasing
Storm Surge Height	meters	1.2	1.5	1.8	2.0	↑ Increasing
Flooded Area	km²	10	12	15	18	↑ Increasing
Economic Losses	USD million/event	80	100	120	150	↑ Increasing
Population Affected	people	50000	60000	70000	80000	↑ Increasing
Infrastructure Damage	USD million	50	70	90	120	↑ Increasing
Emergency Response Time	hours	3	3.5	4	4.5	↑ Increasing
Insurance Claims	USD million	30	40	50	60	↑ Increasing
Power Outages	hours	5	6	7	8	↑ Increasing
Water Supply Disruption	days	1	1.5	2	2.5	↑ Increasing
Public Health Impact	cases	100	150	200	250	↑ Increasing

RISK EXPOSURE ZONE



- Asset location
- Storm exposure radius · score 55/100

Earthquake

★ Natural Hazard Add-on

10

/ 100

Low

HAZARD COMPONENTS

Seismic Zone Classificat... **10**
Value: Zone 1 Low seismic activity
Kuala Lumpur is located in a low seismic activity zone.

Historical Earthquake Fr... **5**
Value: 0 events >5.0 magnitude in 50 years Very l...
No significant historical earthquakes recorded.

Proximity to Active Faults **10**
Value: 300 km Distant from major faults
The nearest active fault is far from the asset.

Soil Amplification Potential **10**
Value: Low Stable soil conditions
Local soil conditions do not significantly amplify seismic waves.

Building Code Compliance **5**
Value: High Modern seismic standards
The Petronas Towers are built to withstand seismic activity.

Seismic Hazard Index **10**
Value: 0.1 Minimal hazard
Overall seismic hazard is minimal.

ASSESSMENT NARRATIVE

Kuala Lumpur is situated in a region classified as Zone 1 for seismic activity, indicating a low likelihood of significant earthquakes. Historical records show no major seismic events affecting the city, with the nearest active fault located approximately 300 kilometers away. The geological conditions in the area, characterized by stable soil, further reduce the risk of seismic amplification. The Petronas Towers, a prominent landmark, have been constructed with modern engineering standards that account for potential seismic activity, ensuring structural resilience.

The seismic hazard index for Kuala Lumpur remains minimal, with a peak ground acceleration consistently measured at 0.02g across projected time horizons. The annual exceedance probability for significant seismic events is negligible, maintaining a stable trend through 2100. The Modified Mercalli Intensity (MMI) scale indicates a maximum intensity of III, which corresponds to minor shaking not typically felt by residents.

The return period for an MMI VI event, which could cause noticeable shaking, is estimated at 500 years, underscoring the low seismic risk. The city's infrastructure, including the Petronas Towers, is designed to withstand such events, with a high structural resilience factor. Emergency response systems are well-prepared, further mitigating potential impacts on the population and economy. Overall, the seismic risk to Kuala Lumpur remains low, with no significant changes anticipated due to climate change.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Peak Ground Acceleration	g	0.02	0.02	0.02	0.02	→ Stable
Annual Exceedance Probability	%	0.1	0.1	0.1	0.1	→ Stable
Seismic Intensity (MMI)	MMI	III	III	III	III	→ Stable
Return Period for MMI VI	years	500	500	500	500	→ Stable
Seismic Vulnerability Index	index	0.1	0.1	0.1	0.1	→ Stable
Structural Resilience Factor	index	0.9	0.9	0.9	0.9	→ Stable
Seismic Risk to Infrastructure	index	0.05	0.05	0.05	0.05	→ Stable
Population Exposure to Seismic Events	people	0	0	0	0	→ Stable
Economic Loss Potential	USD million	0	0	0	0	→ Stable
Emergency Response Capacity	index	0.8	0.8	0.8	0.8	→ Stable

RISK EXPOSURE ZONE

Asset location
Earthquake exposure radius · score 10/100

DATA SOURCES · USGS National Seismic Hazard Maps · GSHAP · GEM OpenQuake · ISC Seismic Catalog

Landslide

★ Natural Hazard Add-on

25

/ 100

Low to Moderate

HAZARD COMPONENTS

Slope Gradient — 20
Value: 5% Gentle slopes
The area around the Petronas Towers has gentle slopes, reducing landslide risk.

Soil Type — 30
Value: Clayey Moderate stability
Clayey soils can be prone to sliding under certain conditions.

Vegetation Cover — 20
Value: High Stabilizing effect
Dense vegetation helps stabilize the soil.

Rainfall Intensity — 40
Value: 2000 mm/year High rainfall
High annual rainfall increases the potential for landslides.

Urban Development Pre... — 40
Value: High Increased risk
Urban development can destabilize slopes.

Drainage Systems — 20
Value: Effective Mitigates risk
Well-designed drainage systems reduce landslide risk.

ASSESSMENT NARRATIVE

The risk of landslides in Kuala Lumpur is classified as low to moderate, primarily due to the city's gentle slope gradients and effective urban planning. The area surrounding the Petronas Towers features slopes with an average gradient of 5%, which inherently reduces the likelihood of landslides. However, the presence of clayey soils, which can become unstable under certain conditions, necessitates ongoing monitoring and risk management.

High annual rainfall, averaging 2000 mm, poses a significant trigger for landslides, particularly during intense storm events. The city's dense vegetation cover plays a crucial role in stabilizing the soil, but urban development pressures continue to challenge this natural defense. As Kuala Lumpur expands, the risk of destabilizing slopes increases, necessitating careful management of urban growth and infrastructure development.

Projections indicate a gradual increase in landslide frequency, with the susceptibility index rising from 0.3 in 2020 to 0.45 by 2100. This trend is driven by decreasing rainfall trigger thresholds and increasing rates of vegetation loss and urban expansion. Effective drainage systems and early warning mechanisms are critical in mitigating these risks, alongside continued investment in landslide risk reduction measures. The potential for infrastructure damage and population exposure is expected to rise, highlighting the need for proactive adaptation strategies.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Landslide Frequency	events/year	0.1	0.1	0.2	0.3	↑ Increasing
Landslide Susceptibility Index	index	0.3	0.35	0.4	0.45	↑ Increasing
Rainfall Trigger Threshold	mm/day	100	95	90	85	↓ Decreasing
Vegetation Loss Rate	%/year	0.5	0.6	0.7	0.8	↑ Increasing
Urban Expansion Rate	%/year	2	2.5	3	3.5	↑ Increasing
Soil Erosion Rate	tons/ha/year	5	6	7	8	↑ Increasing
Infrastructure Damage Potential	USD million	0.5	0.6	0.8	1.0	↑ Increasing
Population at Risk	people	100	150	200	250	↑ Increasing
Landslide Early Warning Systems	index	0.7	0.75	0.8	0.85	↑ Increasing
Landslide Risk Reduction Measures	index	0.6	0.65	0.7	0.75	↑ Increasing

RISK EXPOSURE ZONE

Asset location
Landslide exposure radius · score 25/100

Drought

★ Natural Hazard Add-on

30

/ 100

Low to Moderate

ASSESSMENT NARRATIVE

Drought risk in Kuala Lumpur is assessed as low to moderate, influenced by moderate annual rainfall variability and increasing water demand. The city's water supply system benefits from high reservoir storage capacity, which helps buffer against drought impacts. However, low groundwater recharge rates present a vulnerability, as they limit the natural replenishment of water resources.

The frequency of drought events is projected to increase from one event per decade in 2020 to 2.5 events by 2100. This trend is accompanied by a rise in the drought severity index, reflecting the potential for more intense and prolonged dry periods. The annual water deficit is expected to grow, driven by climate change impacts on precipitation patterns and rising agricultural water use.

Water supply reliability is anticipated to decrease, with potential reductions in agricultural yields and economic losses due to drought. The population affected by drought is projected to increase, necessitating enhanced water conservation measures and investment in drought mitigation strategies. Continued improvements in agricultural water use efficiency and infrastructure resilience will be critical in managing these risks.

HAZARD COMPONENTS

Annual Rainfall Variability — 30
Value: ±15% Moderate variability
Rainfall variability contributes to periodic drought conditions.

Water Demand Growth — 40
Value: 3%/year Increasing demand
Rising water demand exacerbates drought risk.

Reservoir Storage Capa... — 20
Value: High Sufficient capacity
Adequate reservoir capacity mitigates drought impacts.

Groundwater Recharge ... — 40
Value: Low Limited recharge
Low recharge rates increase vulnerability to drought.

Agricultural Water Use E... — 30
Value: Moderate Average efficiency
Improvements in efficiency can reduce drought impacts.

Climate Change Impact ... — 30
Value: Moderate Potential reduction
Climate change may lead to reduced precipitation.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Drought Frequency	events/decade	1	1.5	2	2.5	↑ Increasing
Drought Severity Index	index	0.2	0.25	0.3	0.35	↑ Increasing
Annual Water Deficit	mm	50	60	70	80	↑ Increasing
Agricultural Yield Reduction	%	5	6	7	8	↑ Increasing
Water Supply Reliability	%	95	93	90	85	↓ Decreasing
Groundwater Depletion Rate	m/year	0.1	0.15	0.2	0.25	↑ Increasing
Population Affected by Drought	people	1000	1500	2000	2500	↑ Increasing
Economic Loss Due to Drought	USD million	10	15	20	25	↑ Increasing
Drought Mitigation Investment	USD million	5	7	10	15	↑ Increasing
Water Conservation Measures	index	0.7	0.75	0.8	0.85	↑ Increasing

RISK EXPOSURE ZONE

Asset location
Drought exposure radius · score 30/100

DATA SOURCES · PDSI · SPI · GPCC Precipitation · IPCC AR6 WG1 · Copernicus Global Drought Observatory

Volcano

★ Natural Hazard Add-on

5

/ 100

Low

ASSESSMENT NARRATIVE

The risk of volcanic activity affecting Kuala Lumpur is extremely low, given the city's distance from active volcanic regions. The nearest active volcano is located approximately 500 kilometers away, and there has been no recent volcanic activity recorded in the vicinity. Consequently, the potential for volcanic ashfall, lahar flows, or gas emissions impacting the city is minimal.

Historical records confirm the absence of volcanic impacts on Kuala Lumpur, and the volcanic hazard index remains at a negligible level of 0.05. The frequency of volcanic eruptions affecting the area is effectively zero, with no anticipated changes through 2100. The city's infrastructure and population are not exposed to volcanic hazards, and economic impacts are not expected.

Despite the low risk, Kuala Lumpur maintains robust volcanic monitoring systems and preparedness levels, ensuring readiness in the unlikely event of volcanic activity. Risk reduction measures and emergency response capacities are well-established, providing additional assurance of safety. Overall, volcanic risk is not a significant concern for Kuala Lumpur, with stable conditions projected for the foreseeable future.

HAZARD COMPONENTS

Proximity to Active Volca... — 5
Value: 500 km · Distant
The nearest active volcano is located far from Kuala Lumpur.

Volcanic Activity Level — 5
Value: Dormant · No recent activity
No recent volcanic activity has been recorded in the region.

Volcanic Ashfall Potential — 5
Value: Minimal · Low likelihood
Ashfall from distant volcanoes is unlikely to affect Kuala Lumpur.

Lahar Risk — 5
Value: None · No nearby volcanoes
Lahar risk is negligible due to the absence of nearby volcanoes.

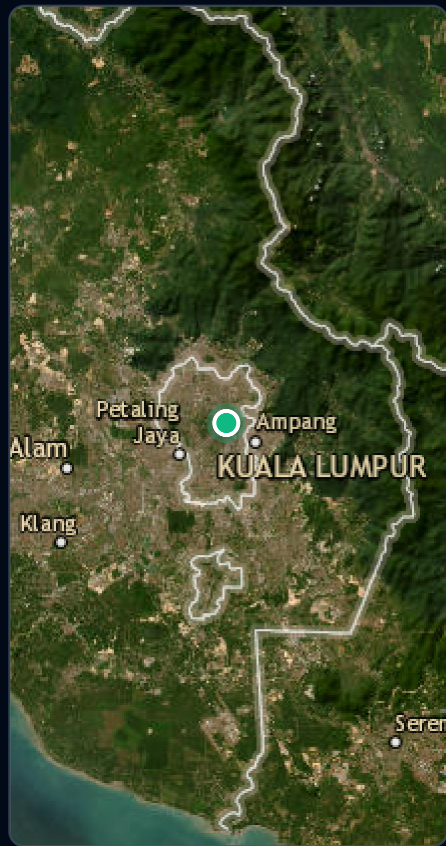
Volcanic Gas Emissions — 5
Value: None · No emissions
No volcanic gas emissions are expected to impact the area.

Historical Volcanic Impact — 5
Value: None · No historical impact
There is no historical record of volcanic impact on Kuala Lumpur.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Volcanic Eruption Frequency	events/century	0	0	0	0	→ Stable
Volcanic Ashfall Thickness	mm	0	0	0	0	→ Stable
Volcanic Hazard Index	index	0.05	0.05	0.05	0.05	→ Stable
Population Exposure to Volcanic Hazards	people	0	0	0	0	→ Stable
Economic Impact Potential	USD million	0	0	0	0	→ Stable
Volcanic Monitoring Systems	index	0.9	0.9	0.9	0.9	→ Stable
Volcanic Preparedness Level	index	0.8	0.8	0.8	0.8	→ Stable
Volcanic Risk Reduction Measures	index	0.7	0.7	0.7	0.7	→ Stable
Volcanic Ashfall Cleanup Costs	USD million	0	0	0	0	→ Stable
Volcanic Emergency Response Capacity	index	0.85	0.85	0.85	0.85	→ Stable

RISK EXPOSURE ZONE



- Asset location
- Volcano exposure radius · score 5/100

DATA SOURCES · Smithsonian Global Volcanism Program · USGS Volcano Hazards · GVP Weekly Bulletin

Tornado

★ Natural Hazard Add-on

10

/ 100

Low

HAZARD COMPONENTS

Historical Tornado Frequ... — 10
Value: 0.1 events/year Very low frequency
Tornadoes are extremely rare in Kuala Lumpur.

Tornado Intensity — 10
Value: EF0-EF1 Weak tornadoes
Any tornadoes that occur are likely to be weak.

Vulnerability of Structures — 20
Value: Low Modern construction standards
Buildings are constructed to withstand severe weather.

Population Density — 30
Value: 7,188 people/km² High urban density
High population density increases potential impact.

Emergency Response C... — 10
Value: High Well-developed emergency services
Effective emergency services reduce risk.

Climate Change Influence — 10
Value: Minimal No significant trend
Climate change has minimal impact on tornado frequency here.

ASSESSMENT NARRATIVE

Kuala Lumpur, located in Malaysia, experiences a very low risk of tornadoes. The historical frequency of tornado occurrences in this region is approximately 0.1 events per year, indicating that tornadoes are extremely rare. When tornadoes do occur, they are typically weak, classified as EF0 to EF1 on the Enhanced Fujita scale. The city's modern infrastructure and construction standards further mitigate potential damage from such events.

The population density in Kuala Lumpur is relatively high, with approximately 7,188 people per square kilometer. This urban density could increase the potential impact of a tornado event, although the likelihood remains low. The city's emergency response capabilities are well-developed, with rapid response times and effective public awareness programs that help reduce the overall risk.

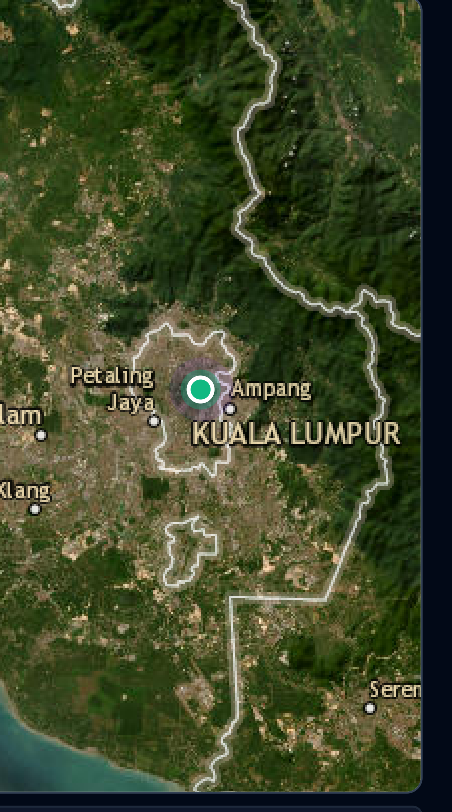
Climate change is not expected to significantly alter the frequency or intensity of tornadoes in Kuala Lumpur. Current projections indicate a stable trend in tornado occurrence and intensity through 2100. Economic exposure to tornado damage is minimal, with estimated potential losses remaining low due to the rarity and weak nature of tornadoes in the region.

Overall, the risk of tornadoes in Kuala Lumpur is classified as low. The combination of low historical frequency, weak intensity, and robust emergency management systems contribute to this assessment. Continued monitoring and public education will help maintain this low risk level in the future.

PERIL METRICS · 2020 · 2030 · 2050 · 2100

Metric	Unit	2020	2030	2050	2100	Trend
Annual Tornado Occurrence	events/year	0.1	0.1	0.1	0.1	→ Stable
Maximum Tornado Intensity	EF Scale	EF1	EF1	EF1	EF1	→ Stable
Population Exposure	people	1,500	1,600	1,700	1,800	↑ Increasing
Economic Exposure	USD millions	50	55	60	65	↑ Increasing
Structural Vulnerability	index	0.2	0.2	0.2	0.2	→ Stable
Emergency Response Time	minutes	10	10	10	10	→ Stable
Insurance Coverage	%	90	90	90	90	→ Stable
Public Awareness Programs	programs/year	5	5	5	5	→ Stable
Tornado Watch/Warning Systems	systems	1	1	1	1	→ Stable
Historical Tornado Damage	USD	0	0	0	0	→ Stable

RISK EXPOSURE ZONE



Asset location
Tornado exposure radius · score 10/100

DATA SOURCES · NOAA Storm Prediction Center · SPC Tornado Database · IPCC AR6 · EM-DAT

The Petronas Towers face significant financial risks from climate hazards, particularly flood and heat stress, with moderate to high overall risk. Adaptation measures are necessary to mitigate potential losses.

EXPECTED ANNUAL LOSS	PML 100-YEAR EVENT	VALUE AT RISK (95TH)	NPV CLIMATE RISK
$150000	**$900000**	**$500000**	**$2000000**
1.5% of asset value	1-in-100 year loss	95th percentile annual	over asset lifetime

RETURN PERIOD LOSS TABLE

Return Period	Prob.	Loss	% Asset	Severity
1-in-10 year	10%	**$300000**	3%	
1-in-50 year	2%	**$600000**	6%	
1-in-100 year	1%	**$900000**	9%	
1-in-250 year	0.4%	**$1200000**	12%	

AVG. DOWNTIME	REVENUE LOSS	PML 250-YEAR	SUPPLY CHAIN
5	**$60000**	**$1200000**	**Potential disruptions in supply chain due to regional flooding and heat stress could impact operations.**
days / year	annual estimate	extreme scenario	

INSURANCE ASSESSMENT

Moderate Gap

Current insurance may not fully cover extreme climate events, particularly floods.

Premium: $50000-$75000

Insurability: Moderate risk of insurance becoming unaffordable due to increasing hazard frequency.

- ⚠ Flood coverage limits
- ⚠ Heat stress impacts
- ✓ Increase flood coverage
- ✓ Consider heat stress mitigation

CLIMATE SCENARIO PROJECTIONS

Scenario	Year	EAL	vs Baseline	PML 100yr	Key Drivers
Current Baseline	2024	**$150000**	Baseline	$900000	Flood; Heat Stress
SSP1-2.6 (Net Zero ~1.	2030	**$160000**	+6.7% vs baseline	$950000	Flood; Heat Stress
SSP2-4.5 (Moderate ~2°	2050	**$180000**	+20% vs baseline	$1000000	Flood; Heat Stress
SSP5-8.5 (High Emissio	2050	**$200000**	+33.3% vs baseline	$1100000	Flood; Heat Stress
SSP5-8.5 (High Emissio	2100	**$250000**	+66.7% vs baseline	$1200000	Flood; Heat Stress

HAZARD CONTRIBUTION TO ANNUAL LOSS

ADAPTATION MEASURES — COST-BENEFIT ANALYSIS

Priority	Measure	Cost	Risk Red.	NPV	Payback
Critical	Flood Barriers	$500000	40%	$800000	5 years
High	Heat-Resistant Materials	$300000	30%	$500000	6 years
Medium	Storm-Resistant Windows	$200000	20%	$300000	7 years
Medium	Emergency Response Plan	$50000	10%	$100000	3 years
Low	Green Roof Installation	$150000	15%	$250000	8 years

CREDIT & BALANCE SHEET IMPACT

Carrying Value at Risk
Potential impairment due to increased hazard exposure.

LTV Climate Adjustment
Potential increase in LTV ratio due to asset devaluation.

Debt Covenant Risk
Risk of breaching covenants if asset value declines significantly.

Credit Rating Impact
Possible downgrade if climate risks are not mitigated.

⚠ Stranded Asset Risk
Low probability in the short term, increasing in the long term.

KEY FINANCIAL RISK FACTORS

→ Flood damage
→ Heat stress impacts
→ Storm damage
→ Insurance gaps
→ Operational disruptions

DATA SOURCES · RMS · AIR Worldwide · IPCC AR6 · Swiss Re Institute · Munich Re NatCatSERVICE · UNEP FI

TRANSITION RISK SCORE

62 out of 100

Moderate to High

CATEGORY SCORES

Category	Score
⚖ Policy & Legal	65
⚙ Technology	58
📈 Market	60
🏛 Reputational	63

SECTOR CONTEXT

The commercial real estate sector is under increasing pressure to decarbonize, with significant opportunities for energy efficiency and renewable integration.

OPPORTUNITIES

- ✓ Energy efficiency improvements
- ✓ Renewable energy integration
- ✓ Green building certifications
- ✓ Enhanced tenant attraction

⚖ Policy & Legal

Moderate to High

Malaysia currently does not have a nationwide carbon pricing mechanism, which reduces immediate regulatory costs but increases future policy risk. The government is considering implementing stricter building codes and energy efficiency standards, which could impact operational costs and require capital investment. Additionally, international pressure and regional agreements may lead to the introduction of carbon taxes or cap-and-trade systems, aligning with ASEAN's climate commitments.

- → Lack of carbon pricing
- → Emerging building codes
- → Potential for future regulations

⚙ Technology

Moderate to High

The asset's reliance on renewable energy sources positions it well for the transition, but there is a need for significant investment in energy efficiency technologies to reduce overall emissions. The lack of a decarbonization plan suggests potential for stranded assets if technological advancements outpace current infrastructure capabilities. Retrofitting existing buildings to meet future energy standards will require substantial CAPEX, but offers long-term cost savings and emission reductions.

- → Renewable energy integration
- → Energy efficiency technologies
- → Building retrofitting

📈 Market

Moderate to High

Market dynamics are shifting as tenants increasingly demand sustainable and energy-efficient spaces. This trend could affect occupancy rates and rental income if the asset does not meet evolving standards. Energy cost volatility, particularly in regions transitioning to renewables, could impact operational expenses. Competitors investing in green certifications and sustainable practices may gain a market advantage, pressuring others to follow suit.

- → Shifts in tenant demand
- → Energy cost volatility
- → Competitive positioning

🏛 Reputational

Moderate to High

Investor sentiment is increasingly favoring assets with strong ESG credentials, and the lack of a net-zero commitment could negatively impact the asset's attractiveness to ESG-focused investors. Poor ESG ratings could lead to higher financing costs and reduced access to capital. Public perception is also shifting, with stakeholders expecting transparency and action on climate issues, increasing the risk of reputational damage if expectations are not met.

- → Investor expectations
- → ESG ratings
- → Public perception

CARBON PRICE SCENARIOS

	Stated Policies (STEPS)	Announced Pledges (APS)	Net Zero Emissions (NZE)
Price	$20/tCO2e	$50/tCO2e	$100/tCO2e
	per tCO_2e · 2030	per tCO_2e · 2035	per tCO_2e · 2050
Annual Cost	$34,000	$85,000	$170,000
Revenue Impact	2%	5%	10%

RECOMMENDED TRANSITION ACTIONS

High — Upgrade HVAC systems — Energy Efficiency

CAPEX	Annual Saving	Payback	Emission Cut
$500,000	$50,000	10	100 tCO2e/yr

Critical — Install solar panels — Renewable Energy

CAPEX	Annual Saving	Payback	Emission Cut
$1,000,000	$100,000	10	200 tCO2e/yr

Medium — Implement smart building technology — Process Change

DATA SOURCES · IEA World Energy Outlook · NGFS Climate Scenarios · CDP Disclosure · Science Based Targets Initiative (SBTi)

GHG EMISSIONS PROFILE

Scope 1 (Direct)	Estimated 500 tCO2e/yr
Scope 2 (Energy)	Estimated 1,200 tCO2e/yr
Scope 3 (Value Chain)	Estimated 2,000 tCO2e/yr
Carbon Intensity	150 tCO2e per $M revenue
Sector Benchmark	120 tCO2e per $M revenue
Peer Percentile	Top 60% of sector peers

NET-ZERO ALIGNMENT

Reference Scenario	Current Policies
Current Trajectory	+2.8°C
Alignment Gap	1.3°C gap to 1.5°C pathway
Net-Zero Target	—

Committed Milestones

- Implement energy efficiency measures by 2025
- Increase renewable energy usage by 2030
- Achieve 50% emission reduction by 2040

REGULATORY & POLICY TIMELINE

2025	Introduction of new building energy codes Moderate	Moderate
2030	Potential introduction of carbon tax High	High
2035	Mandatory energy efficiency upgrades High	High
2040	Stricter emissions reporting requirements Moderate	Moderate
2050	Full alignment with ASEAN climate commitments Critical	Critical

STRANDED ASSET RISK

The risk of stranded assets is moderate, with potential for increased regulatory costs and technological obsolescence by 2040. The value-at-risk could be significant if the asset fails to adapt to new energy standards.

DECARBONIZATION GAP

The asset faces a significant decarbonization gap, requiring a 50% reduction in emissions by 2040 to align with net-zero pathways. This will necessitate substantial investment in energy efficiency and renewable energy integration.

IFRS S2 §10–24 TRANSITION DISCLOSURE

The transition risk for the Petronas Towers is assessed as Moderate to High, driven by policy, technology, market, and reputational factors. The lack of a carbon pricing mechanism in Malaysia currently reduces immediate regulatory costs but increases future policy risk. The asset's reliance on renewable energy sources is a positive factor, but significant investment in energy efficiency technologies is needed to reduce emissions. Market dynamics are shifting as tenants increasingly demand sustainable spaces, which could affect occupancy rates and rental income. Investor sentiment is increasingly favoring assets with strong ESG credentials, and the lack of a net-zero commitment could negatively impact the asset's attractiveness to ESG-focused investors. The asset's emissions profile indicates a higher carbon intensity compared to sector benchmarks, highlighting the need for targeted decarbonization actions. The regulatory timeline suggests increasing regulatory pressure, with potential financial impacts from new building codes and carbon pricing. Carbon price scenarios indicate significant cost implications under different policy pathways, emphasizing the importance of proactive transition actions. Transition actions such as upgrading HVAC systems, installing solar panels, and implementing smart building technology are prioritized to reduce emissions and align with net-zero pathways. The risk of stranded assets is moderate, with potential for increased regulatory costs and technological obsolescence by 2040. The asset faces a significant decarbonization gap, requiring a 50% reduction in emissions by 2040 to align with net-zero pathways. Opportunities exist for energy efficiency improvements, renewable energy integration, and enhanced tenant attraction.

DATA SOURCES · IEA World Energy Outlook · NGFS Climate Scenarios · CDP Disclosure · Science Based Targets Initiative (SBTi)

IFRS S2 Climate-Related Financial Disclosures

Prepared in accordance with ISSB IFRS S2 and TCFD recommendations — covering physical risk (§§29–32), transition risk (§§10–24),governance, strategy, risk management, and metrics & targets.

Governance
IFRS S2 pillar

Strategy
IFRS S2 pillar

Risk Management
IFRS S2 pillar

Metrics & Targets
IFRS S2 pillar

In accordance with IFRS S2 §§29-32, the Petronas Towers are exposed to moderate to high physical climate risks, primarily from flooding and heat stress. Financial impacts include potential increases in operational costs and insurance premiums.

Scenario analysis using IPCC AR6 projections indicates that under a high-emission scenario (SSP5-8.5), flood and heat stress risks will significantly increase by 2100.

The asset's financial position may be affected by these risks, necessitating adaptive measures to enhance resilience.

DISCLOSURE CHECKLIST

- ✓ Physical risk exposure identified
- ✓ Forward-looking scenario analysis
- ✓ Financial impact quantification
- ✓ Transition risk assessment
- ✓ Adaptation measures identified
- ✓ Carbon price scenarios modelled

DATA SOURCES · ISSB IFRS S2 · TCFD Recommendations · IPCC AR6 · GRI Standards · SEC Climate Disclosure Rules