# Climate risk assessment: Black tiger shrimp, Mekong Delta, Vietnam

Monterey Bay Aquarium

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# Disclaimers

The *Climate risk assessment: Black tiger shrimp, Mekong Delta, Vietnam* has been prepared for informational purposes only. It presents a point-in-time analysis based on the climate data, scientific literature, and stakeholder input available at the time of writing. Climate projections carry inherent uncertainty, and the findings should be read as indicative of relative risk rather than as predictions of conditions at any specific site or in any specific year. The assessment is not intended to substitute for site-specific technical, environmental, or regulatory evaluation, and it does not override legislation, internal policies, or procedures. All users should seek independent advice before taking action. We have made every effort to verify sources, facts, and figures. Monterey Bay Aquarium and the authors shall not be responsible to any party for the use or interpretation of the information contained within this assessment. The designations presented in this publication do not imply the expression of any opinion whatsoever on the part of Monterey Bay Aquarium concerning the legal status of any country, territory, city, or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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# Overview

To protect ocean health and meet global seafood demand, Monterey Bay Aquarium works with farmers, communities, industry, scientists, and governments to tackle environmental, social, and economic challenges. Monterey Bay Aquarium supports small-scale aquaculture farmers and fishers, promotes international sustainability standards, and builds social resilience. With climate impacts like warming, rainfall shifts, flooding, extreme weather, and sea level rise threatening seafood production and coastal communities, Monterey Bay Aquarium created a climate risk assessment framework to:

1. **Assess risk** by examining the hazards, exposure, vulnerabilities, and responses across aquaculture production, communities, and supply chains.
2. **Determine priority actions, investments, and innovations** required to enhance climate resilience and support climate adaptation.
3. **Guide stakeholder engagement**, fostering collaboration with experts, stakeholders, farmers, and policymakers to implement adaptation and resilience actions.

This summary presents an application of the climate risk assessment for extensive black tiger shrimp farming in the Mekong Delta, Vietnam, in 2025–2026.


**Map 1.** An ideal habitat for farmed prawns, Vietnam's Southern Mekong Delta is the primary global hub supplying black tiger shrimp to Japan, China, Europe, and the U.S. Photo: Monterey Bay Aquarium.

# Climate risk assessment framework

Climate risk reflects the interaction of hazard, exposure, vulnerability, and response, which determine the likelihood and severity of impacts. Building on the frameworks of the Intergovernmental Panel on Climate Change[1] and the Food and Agriculture Organization (FAO)[2], our assessment framework combines climate data, socioeconomic and governance factors, environmental conditions, and local responses to evaluate the risk to aquaculture production.

- **Hazards:** Potential occurrence of a natural or human-induced physical event or impact that may cause loss to infrastructure, livelihoods, services, and/or ecosystems.
- **Exposure:** Historical and projected exposure of species, habitats, farmers, communities, and supply chain hazards.
- **Climate Risk:** Interaction of hazards, exposure, vulnerability, and impact severity, considering interdependent hazards, cascading effects, adaptive capacity, and uncertainty.
- **Vulnerability:**
  *Sensitivity:* Susceptibility to losses from climate impacts based on intrinsic and contextual factors and local perceptions.
  *Adaptive capacity:* Ability to respond or recover from climate impacts based on environmental, governance, and socioeconomic factors.
- **Response:** Actions and investments to reduce sensitivity and build capacity for adaptation and resilience of farms, communities, and the overall production system.

The overlapping nature of the risk factors in the assessment framework is illustrated in Figure 1.


**Figure 1.** The climate risk assessment framework.

# Approach and scope

The climate risk assessment combines a review of existing research, climate data, and impact analysis using two climate scenarios: Representative Concentration Pathway (RCP) 4.5, reflecting a likely warming trajectory, and RCP 8.5, used as a high-risk stress test to explore potential worst-case impacts and support long-term planning, based on observed 21st century conditions.[3] We analyzed hazards and exposure in the Mekong Delta region, downscaling to the provincial and district levels. Vulnerability and risk were assessed using climate data, studies, surveys, and local perceptions on the impacts of climate change on production, communities, and supply chains. The assessment also incorporated input from 11 aquaculture and climate experts in Vietnam.[4]

## Black tiger shrimp in the Mekong Delta, Vietnam

Vietnam produces more than one-third of the world's black tiger shrimp (*Penaeus monodon*) and contributed to 8 percent of United States shrimp imports in 2022.[5] About 90 percent of ponds and 80 percent of output originate from the Mekong Delta, mainly by small-scale farmers.[6] These farmers often struggle to demonstrate environmental sustainability via eco-certification or rating schemes. Black tiger shrimp is mainly farmed in low-density, extensive systems.

**Mangrove–shrimp integrated farming**
Integrates shrimp cultivation with mangrove forests in large ponds with no feeding and minimal intervention. Farmers often stock mud crab as a secondary species. This system can offer environmental and economic benefits: mangroves buffer storms, lessen erosion, store carbon, support biodiversity, and promote resilient livelihoods.

**Rice–shrimp farming**
A long-practice system that alternates between wet season rice cultivation and dry season shrimp farming. The system balances freshwater and brackish water to ensure food security and diversify income on land in the delta affected by salinity. Expanding brackish water zones is offering short-term opportunities to convert rice land to shrimp.

Since 2019, Monterey Bay Aquarium has been collaborating with Vietnamese shrimp industry leaders and buyers in key markets to invest in efforts that address barriers to sustainable black tiger shrimp production and build community resilience in the Mekong Delta. In Cà Mau province, we are working collectively to achieve a green rating (Best Choice) for 20,000 small-scale farms, with 4,174 farm sites having already achieved it as of December 2025.[7]

# Climate hazards and exposure

Vietnam is among the countries most exposed to climate change impacts, with the Mekong Delta particularly at risk due to its low elevation, long coastline, and unique geography. The region faces several significant, interconnected hazards, including rising average temperatures and longer heatwaves, variable annual and seasonal rainfall, increased rain-induced flooding, more frequent and intense droughts, salinity intrusion, and the combined impact of land subsidence and sea level rise.

**Effective sea level rise**

- Effective sea level rise, which incorporates land subsidence and coastal erosion, poses a significant threat.[8]
- Without action, projections under high-emission scenarios indicate that 43 percent of Cà Mau province could be underwater by 2030 and 75 percent by 2050.[9]

**Change in precipitation and flooding**

- Annual precipitation has increased with considerable variability from season to season and year to year.
- The Mekong Delta is highly vulnerable to riverine, flash, and coastal flooding. Extreme rainfall is expected to increase by up to 10 percent by 2050, raising flood risk.[10]

**Salinity intrusion**

- Saltwater is advancing 30–50 km inland under normal conditions and extending up to 150 km inland in the Mekong Delta during drought conditions, surpassing projections for 2050.[11]
- By the 2050s, lower river flows and increased likelihood of more frequent and longer droughts will exacerbate intrusion, especially during extreme events.

**Drought and water availability**

- Recurring droughts, particularly during El Niño years, combined with reduced river flows and groundwater extraction, have led to persistent freshwater shortages, elevated salinity, and sediment loss.[12]
- Mangrove–shrimp farms may have less exposure to freshwater droughts than inland rice–shrimp systems.

**Increasing temperatures and heatwaves**

- Over the past 40 years, temperatures in Cà Mau province have increased by 0.32°C each decade, the highest temperature rise in the delta.[13]
- Projections indicate further increases of 1.74°C to 4.18°C by the end of the century, intensifying heatwaves and rising air and water temperatures.[14]

**Extreme weather**

- Typhoons and storm surges, once rare along the southern delta coast, are becoming more frequent and intense, increasing risks to shrimp production regions.[15]

**Photo 1.** Small-scale shrimp farmer working on his boat in Vietnam. Photo: Monterey Bay Aquarium.

# Climate vulnerability

Black tiger shrimp are highly sensitive to changes in temperature and salinity; heat stress and unpredictable rainfall degrade pond conditions and increase the risk of disease. Small-scale farmers often lack access to credit, insurance, timely weather data, and water-saving technologies. Extreme weather events, such as storm surges and droughts, combined with production losses, exacerbate poverty and hinder adaptation. Since over 95 percent of production is concentrated in the Mekong Delta, Vietnam's black tiger shrimp sector is highly vulnerable.

## Species and production

Black tiger shrimp farming in the Delta is moderately to highly vulnerable to climate change, although integrated systems, which account for most production, offer some adaptive capacity. Air temperatures are projected to surpass the black tiger shrimp's maximum thermal tolerance of 33–34°C for extended periods, with pond temperatures likely exceeding this during peak heat, resulting in higher mortality rates, slower growth, increased disease risk, and restrictions on farming in certain areas and seasons.[16] Nonetheless, the relationship between surface temperatures and the differing effects of rapid versus gradual changes in pond water temperature on shrimp growth and disease remains underexplored, both globally and locally in the Mekong Delta.[17] Unpredictable rainfall alters pond pH and salinity, while droughts worsen water scarcity. Rising sea levels and land subsidence further aggravate these challenges by flooding low-lying zones and damaging infrastructure.

## Environment and ecosystem

Mangrove–shrimp and rice–shrimp farming systems can enhance environmental and socioeconomic resilience by delivering ecological benefits and diverse income streams. Between 2010 and 2020, Vietnam's mangrove restoration efforts added approximately 5,400 hectares each year, providing ecosystem services that help communities withstand typhoons.[18] However, in parts of the Mekong Delta, weak enforcement and poor land-use planning led to continued mangrove loss, competition for water resources, and pollution. Unfed black tiger shrimp systems have minimal impact on effluent quality but can be in proximity to intensive shrimp farms, increasing the risk of pathogen exposure for extensive farmers.[19]

## Community and livelihoods

Rural communities in the Mekong Delta, particularly in Cà Mau (population 1.23 million), are highly vulnerable due to their heavy reliance on shrimp farming. While households diversify by engaging in crab farming, harvesting mangroves, and small-scale trade, shrimp remains their primary source of income.[20] Farmers report yield declines due to heavy rains and heatwaves, while storm surges increasingly damage infrastructure and reduce income. Farmers often adapt by adjusting their cropping schedules, monitoring salinity levels, and experimenting with biological treatments. However, they are hindered by restricted access to credit, insurance, and tailored climate services, which are necessary for large-scale adaptation efforts.

# Industry and supply chains

Vietnam's black tiger shrimp industry relies heavily on production in the Mekong Delta, which accounts for over 95 percent of the country's output. The reliance on wild-caught broodstock (70 percent) raises sustainability concerns due to limited data and poor traceability, although efforts are underway to address these issues.[21] The *National Adaptation Plan and Resolution 120* strengthen the industry's ability to adapt, but progress is hampered by insufficient funding and fragmentation.[22] Governance shortcomings, inadequate land-use planning, and limited access to real-time data further undermine the resilience of small-scale shrimp farmers.

**Photo 2.** Vietnam is the world's largest producer of giant tiger prawns. Photo: Trieu Tuan/Shutterstock.

# Climate risk

Black tiger shrimp farming in the Mekong Delta, especially in Cà Mau, faces increasing climate-related threats. Both gradual and sudden hazards are becoming more frequent and overlapping, making coastal communities highly vulnerable.

**Critical compounding risks: Very high exposure and vulnerability**

**Sea level rise** is one of the most severe long-term threats to shrimp farming in the Mekong Delta. Without urgent adaptation, up to 75 percent of Cà Mau could be inundated by 2050, with land subsiding up to 6 cm per year and sediment flows declining due to upstream dams.[23] Coastal erosion and storms are damaging ponds and infrastructure while frequent surges are amplifying production losses. Most small-scale shrimp farmers lack early warning systems, insurance, and social protection, leaving them unable to recover or relocate—impacts that not only threaten vulnerable farmers, but also ripple through the supply chain.

**Shifts in precipitation and flooding** add to these risks. Annual rainfall is increasing, with projections of a 10 to 20 percent increase and greater variability. These changes lead to pond failures, disease outbreaks, and production instability. Between 2035 and 2044, severe flooding could affect 3 to 10 million people throughout Vietnam, with damages in the Mekong Delta alone exceeding $2.1 billion by 2050.[24]

**Salinity intrusion** from sea level rise, longer dry seasons, and reduced freshwater flows is disrupting rice–shrimp systems, which depend on precise freshwater-saline cycles. In the short-term, increased salinity levels offer opportunities for rice farmers to switch to rice–shrimp systems, but in the long-term increased climate variability and salinity levels may make these systems difficult to manage. Black tiger shrimp tolerate moderate salinity (growing best at roughly 10–25 ppt); extreme and fluctuating levels increase disease risk with sharp salinity drops following heavy rain causing osmotic shock and increasing mortality when not managed promptly. In Cà Mau, salinity in the dry season has risen by nearly 0.5 ppt per year, and existing hard infrastructure like sluice gates and natural mangrove buffers are often inadequate to address the increasing salinity, and most farmers lack the localized forecasts or financing needed to upgrade their water management systems.[25]

### Gradual onset risks: High exposure and high/moderate vulnerability

**Droughts** are becoming more severe and frequent. The 2016 drought damaged 158,000 hectares of aquaculture and deprived 12,000 households of drinking water.[26] Inland rice–shrimp systems are especially vulnerable, with freshwater flows reduced by upstream dams and over-extraction. While some farmers adjust schedules and use basic retention methods, infrastructure gaps and uneven adoption of water-saving technologies persist.

**Rising temperatures and heatwaves** pose a high exposure risk for shrimp farmers and communities under high-emission scenarios, with a projected 4.18°C increase in average annual temperatures and up to 40 percent of days exceeding extreme temperature thresholds by 2100.[27] Black tiger shrimp are sensitive to temperatures above 32°C, which can affect feeding and immune systems and increase disease risk. Rising temperatures lead to algae blooms and oxygen loss, particularly in shallow ponds with poor water exchange.

### Potential significant risks: High exposure but uncertain vulnerability

**Extreme weather**, including more frequent and severe storms, is threatening shrimp farms and infrastructure in provinces like Cà Mau and Kiên Giang. Storms can damage shrimp farms and disrupt fishing, including the black tiger broodstock fishery. Rainfall during cyclones is projected to rise by up to 20 percent, raising flood risks.[28] Vietnam has a national disaster management system, but local response is hampered by outdated plans, aging infrastructure, and limited recovery funding. Most shrimp farmers lack insurance and safety nets, leaving them highly vulnerable to losses from extreme weather.

# Adaptation and resilience priorities

Building resilience requires a holistic perspective that connects environmental health, farming practices, community well-being, and institutional support. Climate risk and resilience differ markedly by production system, so adaptation priorities should be matched to each. For the extensive and rice–shrimp systems assessed here, experts prioritize managing salinity intrusion and sea level rise, followed by extreme weather, like rainfall, flooding, and drought.

## Reduce sensitivity to climate impacts

- **Strengthen infrastructure and ecosystems:** Restore mangroves, build dikes, expand water-saving technologies, and finance farm upgrades (e.g., deeper ponds, shade cover).
- **Improve farm practices:** Test, support, and promote the integration of climate-adaptive practices and technologies to reduce the impact of heatwaves, salinity intrusion, and changes in rainfall.
- **Adopt inclusive water management:** Develop reservoirs and irrigation plans with communities and governments that balance aquaculture and agriculture needs.

## Increase capacity to adapt

- **Advance climate information services:** Expand local forecasting and early warning systems; engage and strengthen farmer support organizations and networks; increase farmer knowledge and access to technology to monitor and adapt to changing pond conditions; and integrate local hazard mapping and adaptation demonstrations into disaster responses and climate plans.
- **Support community resilience:** Enable local actors to assess risks, set priorities, and design adaptation plans; provide training in climate-smart aquaculture and disaster management.
- **Strengthen governance:** Improve coordination across sectors, include farmers in planning, and integrate long-term climate scenarios into policy.
- **Mobilize finance and insurance:** Build readiness for climate finance and develop tools like parametric insurance and payments for mangrove ecosystem services.

## Tailor priorities to the farming system

- **Mangrove–shrimp (extensive):** Restore and protect mangrove cover, explore integration of seaweed into ponds, test approaches to increase the survival rate of post-larvae and juveniles, and adjust stocking timing to seasonal salinity and temperature.
- **Rice–shrimp (extensive):** Improve water control and storage, secure freshwater during the dry season, use localized salinity forecasts, and adjust the rice–shrimp calendar as salinity intrusions shift.

# Next steps

Building on this assessment, Monterey Bay Aquarium will initially focus on working with partners to demonstrate climate-adaptive practices in extensive systems, including mangrove–shrimp and rice–shrimp systems. This work will strengthen water management to buffer against salinity, rainfall, and temperature swings, help farms adopt appropriate technologies and adaptive practices, and promote the role of mangroves in coastal protection and increase climate resilience in integrated shrimp systems.

**To learn more or engage in future work, contact Timothy Moore, Senior Fellow, at tmoore@mbayaq.org.**

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