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Climate, Environmental Degradation and Disaster Risk in Myanmar

a MIMU Analytical Brief

May 2022

MIMU Analytical Briefs shine a light on topical, emerging and under-explored issues relevant to humanitarian and development support in Myanmar based on analysis of available information.

This Brief includes a short narrative document along with methodology and dataset to enable others to take this analysis further.

This Analytical Brief focuses on the changing landscape of Myanmar in terms of climate, environmental degradation and disaster risk based on a review of recent research, hazard modelling and available data. It reviews the changing areas and populations at risk of exposure to natural disasters.

Summary

- Myanmar is one of the of the world's most affected countries in terms of natural disasters, and among the most vulnerable to new disasters in the years to come. In addition to significant loss of life, livelihoods, and property, natural disasters are estimated to cost up to 3% of Myanmar's annual GDP, and the longer-term impacts may be still greater.

- Changing climate and environmental degradation are influencing the frequency and severity of natural hazards in Myanmar, with predictions of more frequent and more severe floods, storms and droughts. Loss of natural ecosystems such as mangroves and forests, rising average annual temperatures, and more intense rainfall are all factors which could increase the impact of natural disasters on large numbers of Myanmar's population.

- Extreme weather events do not become disasters on their own - the level of impact is influenced by the vulnerability of the affected community. Densely populated districts with less infrastructure investment were found to be key vulnerability hotspots. Populous coastal areas in Rakhine State and Ayeyarwady and Yangon Regions were found to be at risk of a wider variety of destructive events than other areas.

- Activities aimed at disaster risk reduction, disaster preparedness and response in Myanmar should carefully consider current as well as projected disaster risks. Further research and data collection are needed to develop effective approaches that can reduce the impact of climate change and environmental degradation on disaster risk for communities. More can also be done to create a shared understanding of vulnerability and how best it can be measured given limitations in available data.

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Introduction

As a result of climate change, natural disasters are an increasing concern for people and governments around the world. Between 2000 and 2019, 11,000 extreme weather events caused the deaths of 475,000 people and losses of USD 3.54 trillion globally.[1] It is estimated that these costs will increase to up to USD 300 billion per year by 2030 and continue rising to USD 500 billion per year by 2050. Analyses from the United Nations[2], European Union[3], and others[4,5] have all ranked Myanmar as one of the countries most affected by natural disasters in recent years and most vulnerable to new disasters in the years to come.

Climate and disaster risk have had an important impact on Myanmar's development, as well as the vulnerability of its people. The 2018 Vulnerability Assessment by MIMU-HARP-Facility included Climate and Disaster Risk as one of three overlapping priority areas limiting equitable development and resilience in Myanmar, along with Conflict and Underinvestment/Underdevelopment. The Vulnerability Assessment created and validated a multi-purpose vulnerability index using data collected in Myanmar's countrywide 2014 Census. It also highlighted some of Myanmar's existing and future challenges around climate, environment, and disaster risk, especially in the Ayeyarwady Delta and Central Dry Zone.

This Analytical Brief builds on the MIMU-HARP-F study to explore the influence of climate change and environmental degradation on disaster risk in Myanmar. It uses data from the 2019 Intercensal Survey as the most recent nationally representative information, along with additional environmental and disaster analyses to highlight the connections between vulnerable populations, disappearing ecosystems, and natural hazards. This Brief focuses in particular on flooding, storms, droughts, and landslides as disasters that have a high impact on different areas of Myanmar and are heavily influenced by environmental changes. It is however limited by available data and further research on some aspects such as water-based ecosystems and the benefits that different ecosystems provide to nearby communities could usefully add to this in future.

Myanmar regularly suffers significant loss of life, livelihoods, and property from large and small disaster events. Examples include major events such as Cyclone Nargis in 2008 or the widespread flooding in 2015, as well as more localized hazards like landslides and forest fires. These events are estimated to cost Myanmar up to 3% of GDP annually, killing thousands of people and displacing millions more.[6] The death toll from Cyclone Nargis alone was estimated to be around 140,000 people and over 1.5 million people were displaced in the 2015 floods.

Research on disasters around the world has found the long-term consequences to be significantly larger than the short-term effects that are normally assessed and reported on.[7] Affected communities still don't return to their pre-disaster development trajectories 20 years after the event. This means, for example, that people in Sagaing Region and Mon and Kayin States are still behind where they would have been if not for the flooding from heavy monsoon rains in 2002. The effects of one extreme event can also cause longer-term disadvantages – waterborne diseases can be spread by droughts as well as floods for example – whereas floods often pull waste into the water system, droughts cause stagnation that reduces water quality.[8] According to the World Bank,[9] Myanmar's 2015 monsoon floods caused a 16% increase in inflation, a 12% decrease in exports, an increase in the trade deficit, and fluctuations in the exchange rate – changes which seriously affect the resilience of many of the country's people.

Myanmar is already regularly exposed to a variety of natural disasters due to its geography; climate change and environmental degradation are adding to these risks. Regular threats to different areas of the country include earthquakes, tsunamis, cyclones, floods, landslides, fires, and droughts. Scientists predict climate change will make storms and droughts more frequent and more severe; sea-level rise will pose new threats to coastal communities and shifting seasons and heat stress will create new challenges for agriculture.[10] Though it's difficult to attribute any individual event to climate change, Myanmar has recorded significant records in temperature and precipitation in recent years. The largest amount of rain in a single 24-hour period was recorded in Tanintharyi Region in 2009, then surpassed in Rakhine in 2011. The monthly rainfall for Chin State in July 2015 was 30% higher than any other month in the past 25 years; this amount of rainfall is considered to have a 0.1% chance of happening in a given year, meaning we would expect it once in one thousand years. The highest ever temperature in Myanmar was recorded as 47.2°C in May 2010.[11]

Disaster risk is often estimated as a combination of three factors - hazard, exposure, and vulnerability.[12] ***Hazards*** are natural or artificial events that pose a danger to an individual, community, organization, or society; ***Exposure*** refers to the number of people and assets that are endangered by the hazard; and ***Vulnerability*** is a combination of all the characteristics that determine how susceptible or resilient people, assets, and systems are to the impacts of hazards. The interplay between

[1] Eckstein, D., Künzel, V., and Schäfer, L. "Global Climate Risk Index 2021." January, 2021. Germanwatch e.V., Bonn, Germany.
[2] United Nations Office for Disaster Risk Reduction. "Global Assessment Report on Disaster Risk Reduction 2015." 2015. New York.
[3] Marin-Ferrer M., Vernacinni, L., and Poljansek, K. 2017. "INFORM Index for Risk Management: Concept and Methodology Report – Version 2017." 2017. Joint Research Centre, Luxembourg, European Union.
[4] Eckstein, D. et al. "Global Climate Risk Index 2021." January, 2021. Germanwatch e.V., Bonn, Germany.
[5] Regional Consultative Group (RCG) on Humanitarian Civil- Military Coordination for Asia and the Pacific. "Humanitarian Civil-Military Coordination in Emergencies: Towards a Predictable Model." 2017.
[6] United Nations Office for Disaster Risk Reduction. "Global Assessment Report on Disaster Risk Reduction 2015." 2015. New York: UNISDR.
[7] Hsiang S. M. & Jina A. S. "The Causal Effect of Environmental Catastrophe on Long-run Economic Growth: Evidence from 6,700 Cyclones." 2014. National Bureau of Economic Research. Cambridge, Massachusetts.
[8] Smith, K.R., Woodward, A., Lemke, B., Otto, M., Chang, C.J., Mance, A.A., Balmes, J. and Kjellstrom, T. "The last Summer Olympics? Climate change, health, and work outdoors." 2016. The Lancet.
[9] Drees-Gross, Alexandra L. et. al. "Myanmar economic monitor: staying the course on economic reforms." 2015. Myanmar economic monitor, World Bank Group. Washington, D.C.
[10] HARP-F and MIMU. "Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps." 2018.
[11] Center for Excellence in Disaster Management and Humanitarian Assistance. "Myanmar Disaster Management Reference Handbook." March, 2020.
[12] United Nations Office for Disaster Risk Reduction. "Understanding Disaster Risk." 2022. Accessed 1 Feb, 2022.

these 3 overlapping factors can be seen in Figure 1.[13] Based on this classification, the United Nations Office for Disaster Risk Reduction notes that "There is no such thing as a natural disaster, but disasters often follow natural hazards."

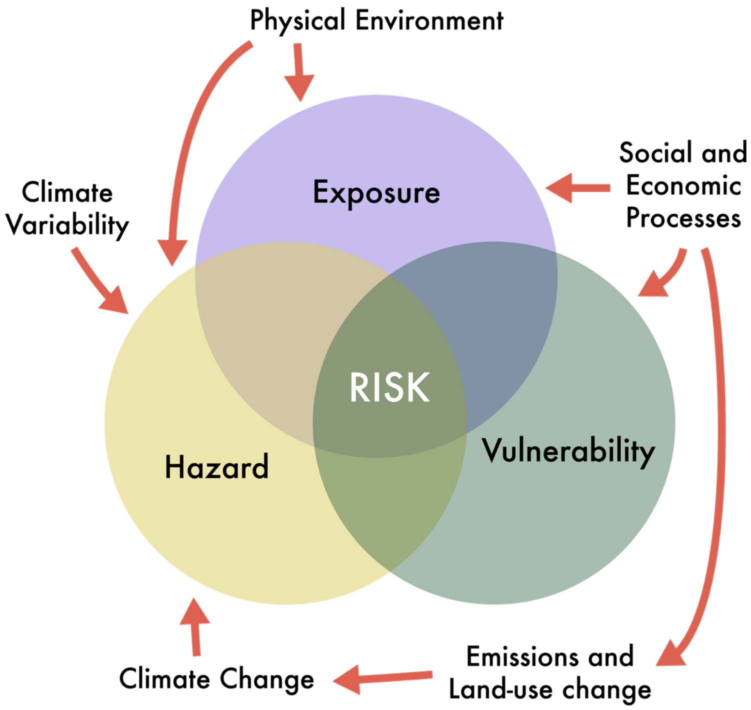

***Figure 1:** Factors contributing to Disaster Risk.*
(Adapted from WARNDIS Project Final Report)[14]

Natural ecosystems provide important benefits related to hazards and vulnerability. In particular they can help mitigate the effects of disasters and increase local communities' resilience and ability to recover from disasters. For instance, forests help the ground absorb and hold more water during heavy rainfall; this reduces flooding during the rainy season and increases the amount of groundwater available for drinking or irrigation during the dry season, making the community more adaptable to droughts and able to produce and store food for emergencies like future floods.[15] Natural ecosystems also provide numerous other direct and indirect benefits for improving resilience, including boosting income, water quality and air quality among others. All benefits that humans receive from the natural environment fall under the term 'Ecosystem Services.' Research on ecosystem services in Myanmar has noted their importance in climate resilience due to the ongoing relevance of areas providing the greatest amount of services under the range of climate conditions.[16]

The issues of natural disasters, climate change, and environmental degradation are deeply interconnected. Climate change increases the likelihood of certain disasters and endangers delicate ecosystems; losing these ecosystems contributes to climate change and makes the effects of these disasters more harmful; and larger and more frequent disasters damage ecosystems and further reduce their benefits. One area of Myanmar where these connections are most visible is the Ayeyarwady Delta. The Delta is considered very vulnerable to storm surges due to its geographic location, its large population and extensive cultivation of rice paddy.[17] Storm surges can flood agricultural areas with saltwater, severely impacting crops and endangering the food supply. As the Delta is responsible for about one third of Myanmar's rice production, this would affect not only local farmers but the rest of the country as well.

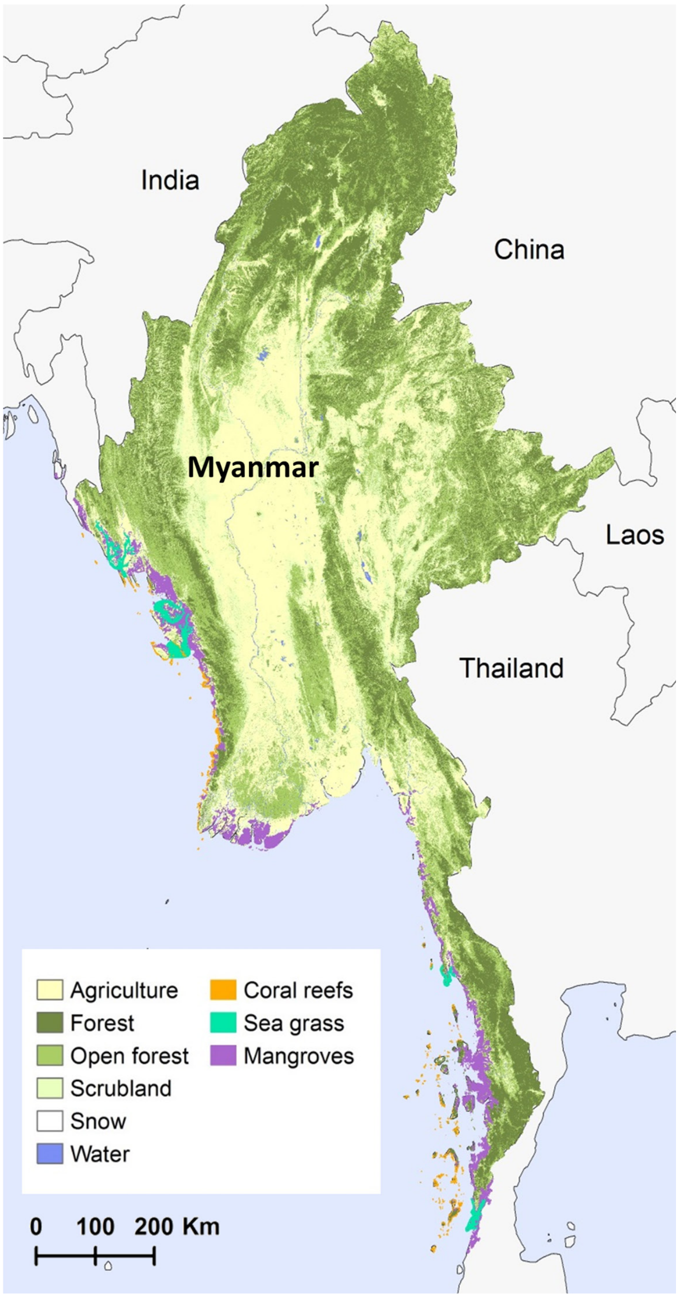

***Figure 2:** Myanmar's land cover and coastal habitats.*
(Source: Mandle, L. et al)[18]

[13] *Bruen, M. and Dzakpasu, M. "WARNDIS Project Final Report: A Review of Climate Change-related Hazards and Natural Disaster Vulnerabilities and of Agencies Involved in Warning and Disaster Management". 2018. Ireland.*
[14] *Ibid.*
[15] *Walz, Y., Janzen, S., Narvaez, L., Ortiz-Vargas, A., Woelki, J., Doswald, N., and Sebesvari, Z. "Disaster-related losses of ecosystems and their services. Why and how do losses matter for disaster risk reduction?" 2021. International Journal of Disaster Risk Reduction.*
[16] *Mandle, L., Wolny, S., Bhagabati, N., Helsingen, H., Hamel, P., Bartlett, R, et al. "Assessing ecosystem service provision under climate change to support conservation and development planning in Myanmar." 2017. https://doi.org/10.1371/journal.pone.0184951.*
[17] *Horton, R., De Mel, M., Peters, D., Lesk, C., Bartlett, R., Helsingen, H., Bader, D., Capizzi, P., Martin, S. and Rosenzweig, C "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.*
[18] *Mandle, L., et al. "Assessing ecosystem service provision under climate change to support conservation and development planning in Myanmar." 2017. https://doi.org/10.1371/journal.pone.0184951*

Vegetative ecosystems such as mangroves protect coastal communities from saltwater intrusion during storm surges. Mangroves play a particularly important protective role for these coastal communities; researchers have estimated that mangroves reduce the impacts of natural disasters in coastal areas in Myanmar by USD 165 million per year and reduce the number of people affected by storm surge flooding by 39%.[19] Beyond the value of flood control, the World Bank has estimated that mangrove and coral reef ecosystems provide around USD 5 billion per year in ecosystem services to coastal communities in Myanmar.

The ongoing rapid mangrove loss in the Delta will increase the population's vulnerability to unexpected events. Expansion of agriculture and shrimp farming in the Delta are causing rapid mangrove loss, making the area more vulnerable to storm surges and depriving residents of other benefits that support their ability to adapt to hazards. In addition, sea level rise from climate change will gradually push saltwater intrusion further inland during storms, forcing farmers and fishermen in the Delta to clear and occupy new land that is less affected and further disrupting the ecosystems that help with water management.

Myanmar's Changing Landscape

Climate Change

Average annual temperatures in Myanmar have been rising for several decades and are expected to continue to increase for several more at least. This trend is found throughout the world, and in Myanmar temperatures are expected to continue increasing steadily until at least 2040, although likely for much longer.[20] National daily average temperatures rose about 0.25°C per decade between 1981 and 2010, with daily maximum temperatures increasing by 0.4°C per decade.[21] Inland regions warmed slightly more, both on average and in maximum temperature, than coastal regions.

This trend is expected to continue, although the degree of warming will depend on global decarbonization successes or failures and varies by season and geographical region. As seen in Figure 3, which shows temperature projections based on optimistic and pessimistic scenarios developed by the Intergovernmental Panel on Climate Change (IPCC), Myanmar is expected to experience warming especially in the hot season (March to May) and during the coolest season (November to February). Even in the most optimistic scenario based on significant decreases in emissions in the near future, average temperatures in Myanmar are expected to have increased by at least one degree fifty years from now. As has already been happening, inland regions are expected to experience larger temperature changes than coastal regions, with the differences being more pronounced under the more pessimistic scenarios.

While possible changes in Myanmar's future rainfall are less clear, rainfall has become more intense and more likely to cause damage in the last 40 years.[22] Precipitation trends are more difficult to predict than temperature because the systems involved are more complex. Myanmar has seen an increase in total annual rainfall of 4.5% per decade from 1981-2010, with slightly larger increases on the coast than inland. With no statistically significant increase in the number of rainy days, this implies that individual rainfall events have become more intense. This is concerning because while consistent, moderate

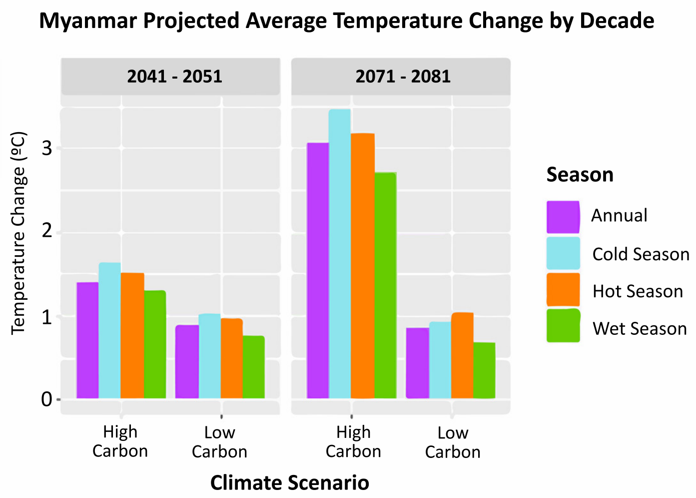

***Figure 3:** Projected average temperature change in Myanmar by season for 2041-2051 and 2071-2081 under high and low carbon climate change scenarios (Source: Climate Change Knowledge Portal)*

rainfall is often helpful to farmers, floods and other damage are likely to result from short, concentrated rainfall.

Much of Myanmar's coastline is made up of large, low-lying areas that will be significantly affected by anticipated sea-level increases. Most of these areas are found in Rakhine and Mon States, Ayeyarwady and Yangon Regions, and some areas of these states/regions risk being permanently under water with predicted sea level rises in the coming 10 years.[23] Areas which are higher may still be at increased risk of large coastal storms able to carry flooding much further inland, affecting many people who were previously unaffected by storm surges. The Ayeyarwady Delta presents an extreme example of how much change sea level rise could cause. Since 1870 the Ayeyarwady coastline is estimated to have remained remarkably stable, advancing only 0.34 km in the last century;[24] a sea-level increase

[19] World Bank Group. "Myanmar Country Environmental Analysis." 2019. Washington, D.C.
[20] World Bank Group. "Climate Change Knowledge Portal." Retrieved 28 Jan, 2022. https://climateknowledgeportal.worldbank.org/country/myanmar/vulnerability
[21] Horton, R., et al "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.
[22] Ibid.
[23] Based on predictions from Climate Central's Coastal Risk Screening Tool. Accessed 21/2/2022. https://coastal.climatecentral.org
[24] HARP-F and MIMU. "Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps." 2018.

of only 0.5 metres however could move the coastline by up to 10 km in some areas.[25] Looking forward, climate change is likely to expand the coastal area at risk of storm surges due to the combination of rising sea levels, heightened surges from more powerful storms and loss of protection from mangroves. While all three factors are important, analysis indicates that the greatest impact is expected from the loss of mangroves.[26]

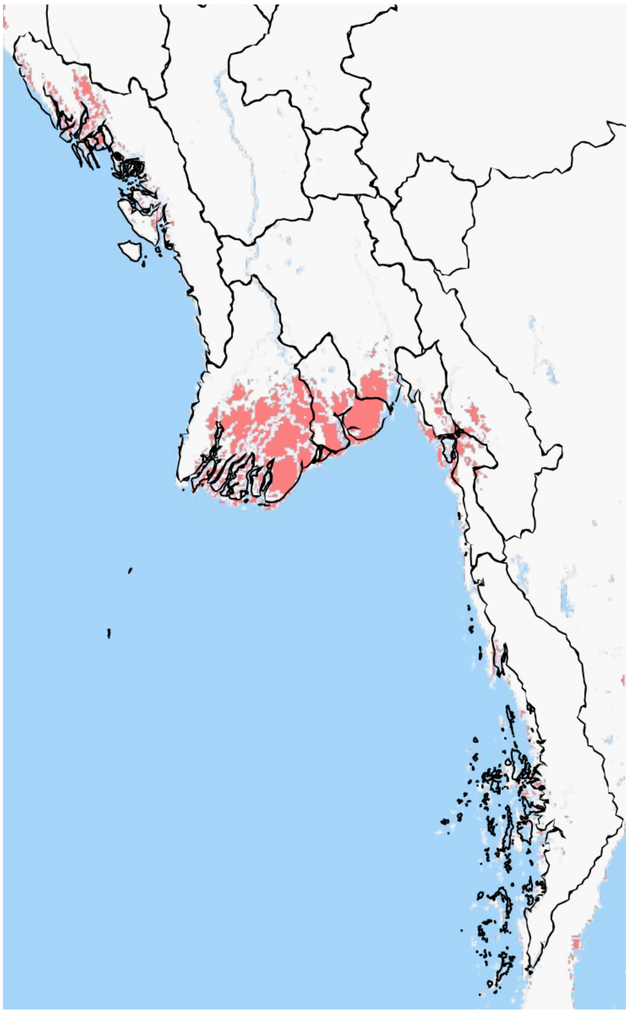

Figure 4: *Projected Sea level rise by 2050, based on the current trajectory of carbon emissions (Source: Climate Central, 2022)*

In addition to increasing the frequency and magnitude of natural hazards, climate change will increase the vulnerability of many people in Myanmar in other ways. Despite steps toward industrialisation of the economy, most people still live in rural areas and are involved in agriculture, 90% of which is rainfed.[27] Climate change will make weather patterns less predictable, and the number of plant diseases, pests and human pathogens are expected to spread more rapidly as a result of floods and droughts. These changes make unprepared communities less able to adapt to shocks like floods and storms, increasing the risks of severe outcomes from these hazards.

Deforestation

Myanmar has the most forest cover remaining among countries in Southeast Asia, but also one of the highest rates of deforestation.[28] Myanmar stands out for its remaining old-growth forests (up to 11% of total forest cover), its biodiversity, and the rate at which both are threatened through deforestation and biodiversity loss. Whereas 77% of the country's territory was covered by forest in 1948, this decreased from 60% in 1990 to 44% in 2015.[29] Although data collection on the ground has been inconsistent, satellite imagery indicates Myanmar's deforestation rate as between 1% and 2.5% from 2000 to 2020, making it one of the top ten countries globally for deforestation.[30]

Forest loss in Myanmar is not just a matter of complete forest removal, but also forest degradation where ecosystems are gradually compromised. Deforestation in Myanmar is often a process in which a forest is first degraded by selective tree removal for logging or fuel, and then eventually converted to plantation or agricultural land.[31] The main exceptions to this are forests that are cleared away for roads, dams or mines. Forests with valuable timber such as teak are at high risk of degradation, and degraded forests in areas that are suitable for high-value crops like oil palm are most likely to be converted entirely. Although agricultural land has been expanding in Myanmar, subsistence agriculture is not a substantial driver of deforestation compared to commercial operations.

From 2001 to 2020, Shan State lost the most forest cover of any area of Myanmar, followed by Kachin State and Sagaing Region.[32] In this period over 18,000 square kilometres of forest area were lost in Shan State, with Loilen, Lashio, Matman, and Tachileik Districts as particular hotspots. Kachin and Sagaing both lost over 5,000 square kilometres, particularly in Hkamti and Myitkyina Districts. Southern Myanmar is also increasingly affected: In Tanintharyi, 3,150 square kilometres of tree cover were lost in Mergui and Kawthoung Districts between 2001 and 2019, amounting to as much as 15% of the total tree cover.[33] The rate of deforestation, driven primarily by the expansion of commercial oil palm and rubber plantations, accelerated in 2020 and 2021. These rapid changes are undermining the exceptional biodiversity of this region, where new animal species were discovered as recently as 2019 and it is anticipated many more are still waiting to be identified.

Chin and Kayin States also saw significant deforestation and forest degradation over the past two decades.[34] Each lost over 4,000 square kilometres of forest cover, proportionally more than the losses in Kachin State. Other notable areas that saw large increases in forest loss between 2015 and 2020 were Bago and Taungoo Districts in eastern Bago Region and areas of Rakhine State, especially Thandwe District. Some analysis suggests that deforestation is slowing in some of these areas as the remaining forests are in less accessible places, but the current evidence for this is mixed.[35]

[25] *Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.*
[26] *Blankespoor, B, Dasgupta, S. and Lange, G. "Mangroves as Protection from Storm Surges in a Changing Climate." 2017. World Bank Group.*
[27] *Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.*
[28] *Kazsta, Z., Cushman, S., Saw Htun, Hla Naing, Burnham, D., Macdonald, D. "Simulating the impact of Belt and road initiative and other major developments in Myanmar on an ambassador felid, the clouded leopard, Neofelis nebulosa." 2020. Landscape Ecology.*
[29] *Food and Agriculture Organization of the United Nations. 2015. Global Forest Resources Assessment 2015. Italy.*
[30] *Zaw Naing Tun, Dargusch, P., McMoran, D., McAlpine, C., and Hill, G. "Patterns and Drivers of Deforestation and Forest Degradation in Myanmar." 2021. Sustainability.*
[31] *Zaw Naing Tun et al. "Patterns and Drivers of Deforestation and Forest Degradation in Myanmar." 2021. Sustainability.*
[32] *World Resources Institute. "Global Forest Watch." Accessed on 6 Mar, 2022.*
[33] *Erikson-Davis, M. "Deforestation surge threatens endangered species in Tanintharyi, Myanmar." March, 2021. Mongabay.*
[34] *World Resources Institute. "Global Forest Watch." Accessed on 6 Mar, 2022.*
[35] *Zaw Naing Tun et al. "Patterns and Drivers of Deforestation and Forest Degradation in Myanmar." 2021. Sustainability.*

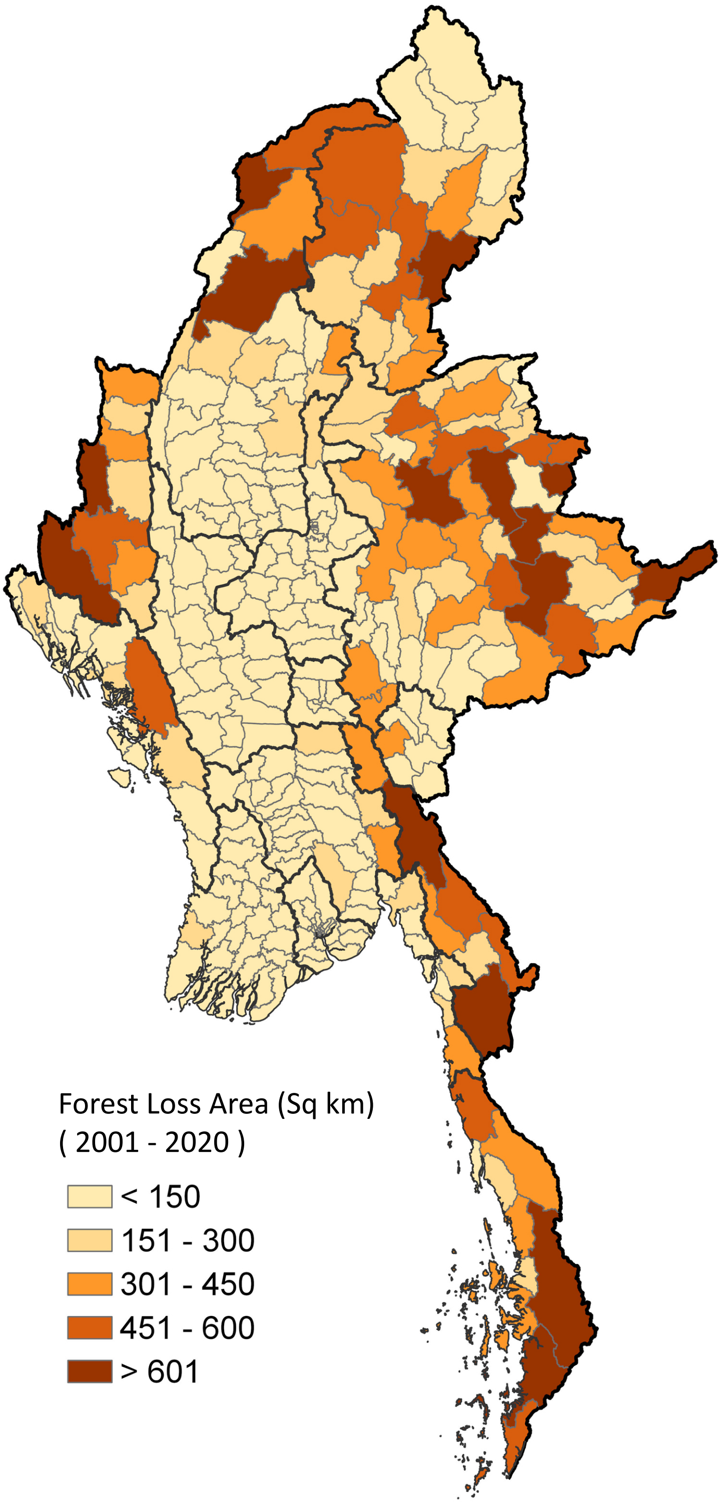

Figure 5: *Forest loss area in square kilometres from 2001 - 2020 (Source: Global Forest Watch)*

Forests provide important ecosystem services that can impact households down the length of a river basin. In addition to its impact on people living in the immediate area, deforestation affects water management further afield. Forests improve water quality by reducing sediment entering water through erosion, which can endanger both public health and transportation networks.[36] As previously mentioned, they increase the infiltration of rainwater into the ground, reducing flood hazards and recharging groundwater sources, which also helps maintain farms and ecosystems during extremely hot or dry weather.

Researchers from the Natural Capital Project examined how a variety of ecosystem services of forests in Myanmar affect vulnerable communities.[37] Forests are particularly valuable in preventing sediment from contaminating drinking water in Rakhine State where a large percentage of people there who do not have an improved source for drinking water, but also notable in sparsely populated Chin and Kachin States and northern Sagaing Region. The importance of forests in these areas is based on their value to households in densely populated areas downstream, as well as in the immediate vicinity of the forest. The forests that provide the most benefit in maintaining water flows for people reliant on surface water are not in the areas most at risk of drought such as Kayah and the Central Dry Zone, but in the areas nearby.

Mangroves provide many ecosystem services that may affect natural disaster risk. In addition to protecting coastal communities from natural hazards, they reduce coastal erosion, regulate water quality, provide a habitat for animals and food and fuel for people, help with climate change mitigation, and provide cultural and recreational benefits.[38] Mangroves also store a higher amount of carbon per equivalent area than terrestrial forests.[39] One study estimated that the cost of Myanmar's mangrove loss between 2000 and 2014 was almost USD 2.4 billion.[40] Survivors of cyclone Nargis noted that villages surrounded by mangroves had higher survival rates.[41] Many people recounted grabbing onto mangroves to avoid being swept away in the flooding and believed that the ocean water did not advance as far inland in areas with substantial mangrove vegetation.

The loss of mangroves is a major risk, and Myanmar has been losing mangroves even more rapidly than other types of forests for at least 25 years. Researchers differ on the exact rate of mangrove loss, but recent analysis based on more detailed satellite images suggests an average loss of 3.6 to 3.9% per year between 1996 and 2016. This loss is much greater than had previously been estimated.[42] Mangrove losses differed significantly by area, with Rakhine State losing the most total area at over 2,000 square kilometres. Bago and Yangon Regions lost almost all of their mangroves between 2007 and 2016, and Mon State's mangrove coverage decreased by 88% between 1996 and 2016.

[36] Mandle, L., Wolny S., Hamel, P., Helsingen, H., Bhagabati, N., and Dixon, A. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.

[37] Mandle, L., et al. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.

[38] Brander, L., Wagtendonk, A., Hussain, S., McVittie, A., Verburg, P., de Groot, R., and van der Ploeg, S. "Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application." 2012. Ecosystem Services.

[39] Herr, D. et al. 2011. Blue Carbon Policy Framework. IUCN and Conservation International.

[40] Estoque, R. et al. "Assessing environmental impacts and change in Myanmar's mangrove ecosystem service value due to deforestation (2000-2014)." 2018. Global Change Biology.

[41] United Nations Environment Programme. "Learning from Cyclone Nargis: Investing in the environment for livelihoods and disaster risk reduction." 2009.

[42] De Alban, J., Jamaludin, J., Wong de Wen, D., Maung Maung Than, and Webb, E. "Improved estimates of mangrove cover and change reveal catastrophic deforestation in Myanmar." 2019. Environmental Research Letters.

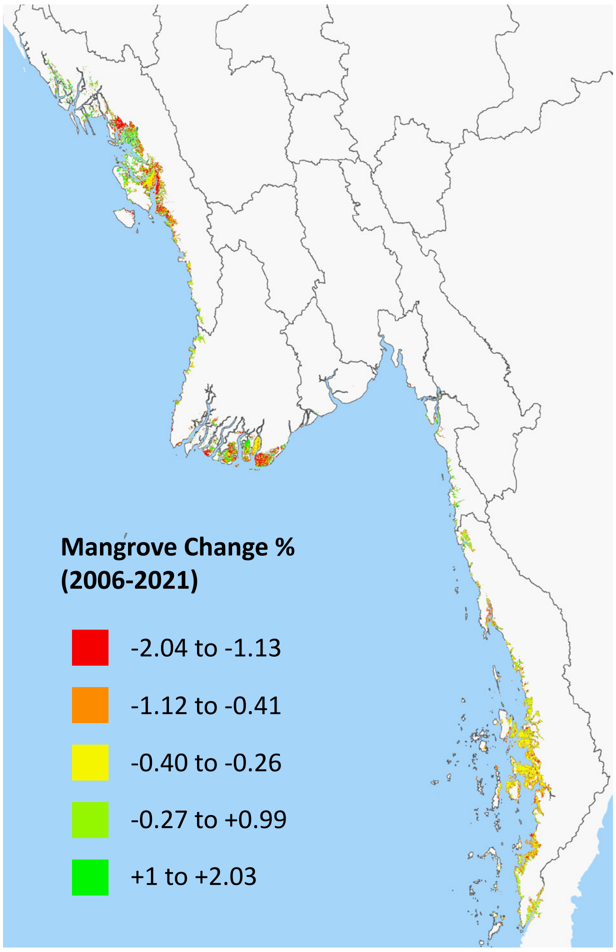

Figure 6: *Change in percentage of Myanmar's Mangrove cover from 2006 to 2021 (Courtesy of Andaman Capital Partners "Myanmar Blue Mangrove Project")*

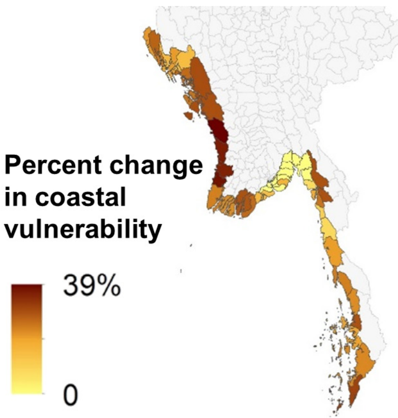

Figure 7: *Coastal townships' susceptibility to loss of ecosystem services from loss of natural vegetation under baseline climate conditions. (Source: Mandle, L. et al)*

Mangrove populations may have stabilized in some areas of the country, but Tanintharyi in particular is still at risk of further degradation. Mangrove loss is driven by multiple factors that vary by location –many mangroves in Mon State and Tanintharyi Region were converted to oil palm or rubber plantations, while most mangroves lost in Ayeyarwady are now rice paddy.[43] Shrimp farming, fuel wood harvesting, and urbanization have also been notable drivers of mangrove removal. Mangrove degradation may have slowed or reversed in some areas, especially Ayeyarwady, because of mangrove restoration projects and the fact that remaining mangrove areas are less viable for agricultural use.[44] However, at this point mangrove removal in these areas is driven by shrimp farmers, not rice farmers, so this possibility requires further investigation.

Water Resource Conservation and Management

Freshwater ecosystems have been expanding in Myanmar over the past 15 years. Freshwater ecosystems are natural or artificial ecosystems dominated by flowing or still water; these include reservoirs, lakes, rivers, canals, and some types of wetlands, including paddies and mangroves.[45] In Myanmar they have expanded from a baseline of around 5,900 square km in 2005 to around 6,500 square km in 2018, with a steady increase in coverage from 2005 to 2010 and relative stability up to the present.[46] It is not clear from the data why this is. Several likely contributors are agricultural expansion, as flooded rice paddy can sometimes be counted as surface water, mangroves being converted to shrimp farms or degrading enough to be counted as a water-based ecosystem, dam projects expanding the amount of surface area covered by water, and deforestation leading to increased surface water as less rain is able to sink into the soil.

Research on these ecosystems has noted significant threats to biodiversity and other important components of ecosystem health.[47] Many habitats in Myanmar have remained less degraded than in other countries in Southeast Asia, but this is changing rapidly. By 2012, 13% of all assessed freshwater species in the Indo-Burma biodiversity hotspot were threatened with extinction and experts expected that number to increase significantly.[48] While very limited on-site research has been done on rivers and other freshwater ecosystems in Myanmar, studies have found they are under significant pressure from human activity, namely poor waste management practices, agricultural runoff, side-effects of deforestation, and urbanization.

Myanmar's many existing and planned dams are anticipated to have large but unpredictable effects on Myanmar's water resources. Myanmar's significant water resources have made it an important component of China's Belt and Road Initiative, as well as other hydropower initiatives from India, Bangladesh, and Thailand.[49] The lack of field research on water resources in Myanmar poses serious constraints in assessing the potential impacts of these projects on ecosystems and communities.[50] Some may help with flood control and increase the navigability

[43] *De Alban, J., Jamaludin, J., Wong de Wen, D., Maung Maung Than, and Webb, E. "Improved estimates of mangrove cover and change reveal catastrophic deforestation in Myanmar." 2019. Environmental Research Letters.*

[44] *Zaw Naing Tun, Dargusch, P., McMoran, D., McAlpine, C., and Hill, G. "Patterns and Drivers of Deforestation and Forest Degradation in Myanmar." 2021. Sustainability.*

[45] *Millennium Ecosystem Assessment. "Ecosystems and Human Wellbeing: Wetlands and water synthesis." 2005. Washington, D.C.*

[46] *United Nations Environment Programme. "Freshwater Ecosystems Explorer." Accessed 8 Mar, 2022.*

[47] *Eriksen, T.E., Friberg, N., Brittain, J., Søli, G., Ballot, A., Årstein-Eriksen, E., Blakseth, T.A., and Braaten, HFV. "Ecological condition, biodiversity and major environmental challenges in a tropical river network in the Bago District in South-central Myanmar: First insights to the unknown." 2020. Limnologica.*

[48] *The Indo-Burma Biodiversity Hotspot includes all non-marine areas of Myanmar, Cambodia, Laos, Thailand, Vietnam, and parts of southern China*

[49] *Kazsta, Z., et al. "Simulating the impact of Belt and road initiative and other major developments in Myanmar on an ambassador felid, the clouded leopard, Neofelis nebulosa." 2020. Landscape Ecology.*

[50] *Taft, L. and Evers, M. "A Review of Current and Possible Future Human-Water Dynamics in Myanmar's River Basins." 2016. Hydrology and Earth System Sciences.*

of rivers, however the benefits may be compromised by increased deforestation in the construction area, changes to nearby water and land-based ecosystems, and potential significant impacts on downstream populations. For example, many farmers rely on silt from the rivers for arable land; dams will alter the siltation process in unpredictable ways.

Natural Hazards affecting Myanmar

Different areas of Myanmar regularly experience a variety of natural hazards, including earthquakes, floods, tsunamis, storms, droughts, landslides, avalanches, heat waves, and forest and urban fires. There are several methods of deciding which hazards to prioritize – the number of fatalities, the economic costs, the frequency of the hazard, and the Average Annual Loss (AAL) are common.[51] The AAL is the average cost per year over a longer period; this enables comparison of the impacts of smaller, frequent events with those that are rare but devastating. For example, Myanmar experiences regular flooding from rivers which can cost over USD 1 million in damage annually and result in hundreds of deaths. It is difficult to compare the relative damage of these frequent floods to Cyclone Nargis, which caused 140,000 deaths and over USD 4 billion in damage, except through a measure like AAL.

This analysis focuses on four types of natural hazards – floods, storms, drought and extreme heat, and landslides. All of these will be affected by climate change and human-caused environmental degradation and have been included in the top priority category in the 2015 Myanmar Risk Assessment Roadmap from the Asian Disaster Preparedness Center (ADPC), based on a combination of the methods described above and stakeholder concerns and priorities.[52] Flooding is by far the most frequent hazard in Myanmar, accounting for 51 percent of disasters between 1970 and 2015 that affected 100 or more people.[53] Storms, including cyclones and storm surge, account for 18 percent and, because of Nargis, are also responsible for most of the damage and loss of life caused by recent natural disasters. Drought and extreme heat can affect large parts of the country at once and are becoming significantly more likely because of climate change. These hazards will also increase the risk of other common hazards such as fires. Landslides made up 12% of disasters from 1970 to 2015, are much more likely in mountainous areas that are less at risk of storms and floods, and often impact the transportation system.[54]

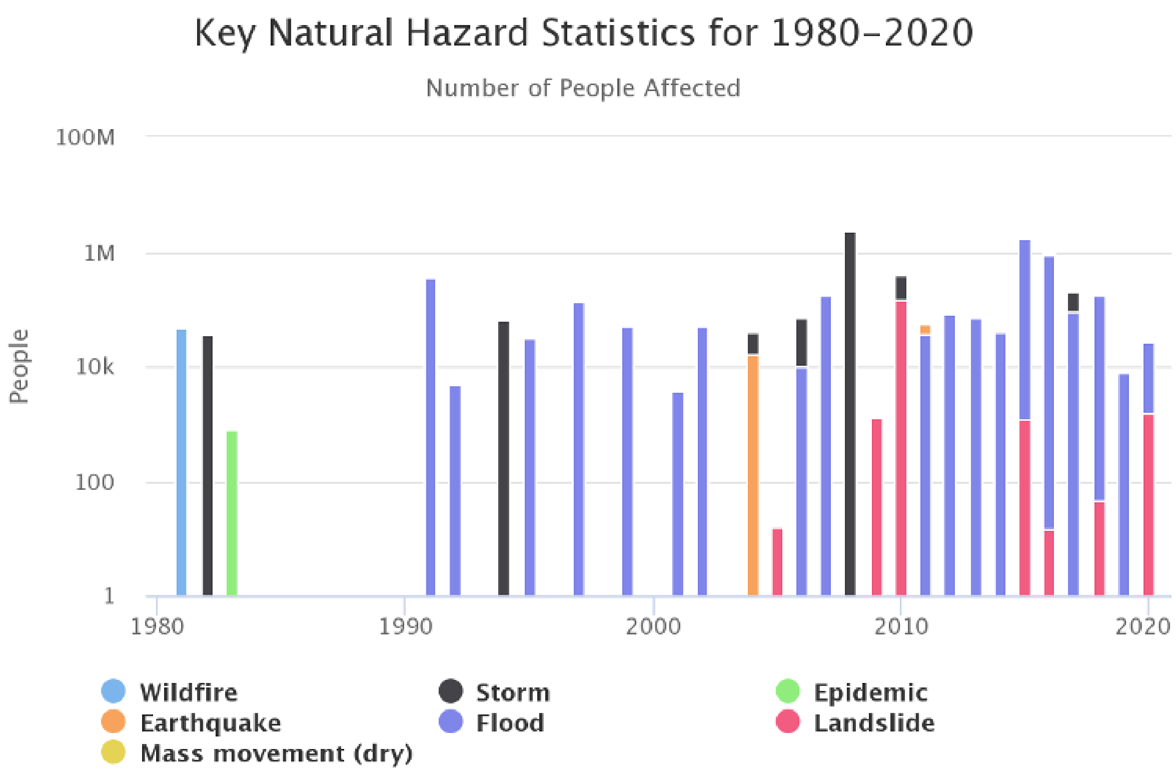

Figure 8: *Number of people affected by natural hazards by year from 1980 - 2020 in Myanmar. (Source: Climate Change Knowledge Portal)*

[51] *Asian Disaster Preparedness Center. "Risk Assessment Road Map, Myanmar." 2015.*
[52] *Ibid.*
[53] *Center for Excellence in Disaster Management and Humanitarian Assistance. "Myanmar Disaster Management Reference Handbook." 2020.*
[54] *Guha-Sapir, D., Below, R., and Hoyois, P. "EM-DAT: The CRED/OFDA International Disaster Database." Université Catholique de Louvain, Brussels, Belgium. www.emdat.be*

Floods – Myanmar's most frequent hazard

Flooding is the most frequent hazard in Myanmar, with the largest overall impact on people and property. Between 1970 and 2015, floods accounted for 51% of disasters affecting 100 or more people in Myanmar.[55] According to the Asian Disaster Preparedness Center, floods have the highest AAL of any hazard in Myanmar and three flood events between 2010 and 2020 each killed more than 100 people.[56] However, most research on the likelihood and impact of floods has focused on flooding in a specific township, state or region with few nationwide assessments on flood risk.[57] The national assessments that have been undertaken have not been comprehensive in that they focus on river and coastal flooding and likely underestimate the risks of flash floods and urban flooding. These assessments are based on satellite imagery and historical flood patterns due to the very limited data collection or tracking of surface water in Myanmar. Models that incorporate additional factors like land use, precipitation, and slopes would help to predict all categories of floods, providing a more accurate indication of flood risk around the country to strengthen preparedness and mitigation.

Riverine flooding, the most extensive flood hazard in Myanmar, occurs when rivers overflow their banks and water spreads through the surrounding areas. In Myanmar river flooding regularly occurs during the monsoon season, from June to October, and many communities have adapted to take advantage of these floods for depositing nutrients for agriculture. More extreme floods which exceed communities' capacity to cope occur around the country almost every year, though there is some evidence of their becoming more frequent in the last 10 to 15 years.[58]

Major flooding in 2015 affected almost every state and region, killed 125 people, and displaced over 1.5 million people.[59] Only Kayah and Tanintharyi were not affected. This protracted flood event caused over USD 1.5 billion in damage, affected 20.4 percent of Myanmar's rice cultivation area, and raised local food prices by up to 25 percent. In total over 17 million people were affected. While the flooding in 2015 was worse than usual, a typical year in Myanmar sees hundreds of thousands of people affected. Between 300,000 and 400,000 people were displaced by flooding every year from 2016 to 2019, and 10 to 100 people were killed.

The SERVIR-Mekong Historical Flood Analysis Tool (HFA) enables analysis of flooding over the past three decades.[60] There are several other tools for estimating the likelihood of flooding across areas of Myanmar, among them ThinkHazard! from the Global Facility for Disaster Risk Reduction and the World Bank,[61] the Global Estimated Risk Index for Flood Hazard developed by the United Nations Environment Programme,[62] and Global Flood Mortality Risks and Distribution by the Socioeconomic Data and Applications Center at Columbia University.[63] The SERVIR-Mekong HFA Tool is used in this analysis due to its use of more recent flood data up to 2018 and it's classification of historical floods based on parameters specific to Myanmar.[64] The tool designates each township as having low, medium, or high likelihood of annual flooding, based on detailed mapping of flood events from 1984 to 2018.

This tool indicates that flood probability is concentrated along Myanmar's coasts and Ayeyarwady River, as well as in Kayin State. Overall, an estimated 28 million people live in districts with a high risk of flood exposure in at least part of the district. Yangon and Ayeyarwady are the most populated areas at risk, followed by Bago and Mandalay Regions. By contrast, Shan, Chin, Kayah, and Kachin States have few residents with high danger of flooding as they are mostly mountainous. These areas do sometimes experience major flooding however, as for example in 2015 when every township in Chin state experienced floods while Matupi township has experienced some level of flooding in four years out of ten between 2010 and 2020.[65]

An alternative approach to flood risk assessment also confirmed Ayeyarwady, Bago, and Rakhine to be high risk areas. This analysis estimated the likely areas to be affected by a large flood event (a 100-year flood event, or a flood anticipated to happen once in 100 years).[66] Ayeyarwady and Bago stand out for the number of both urban and agricultural areas located in low-lying areas and Rakhine because of its exposure to storms from the Bay of Bengal. However, this method also found a high degree of risk for more of Kachin State, especially Waingmaw and Myitkyina Townships, and Tanintharyi Township in the south.

Deforestation and farmland expansion contribute to increased flood risk. Land use changes and natural resource management are important factors in flood hazard and vulnerability.[67] Replacing forests and freshwater ecosystems with farmland increases erosion and the amount of sediment that enters rivers during rainstorms, which can block waterways and contaminate drinking water. Forests also increase the amount of water that is absorbed by the ground or evaporates after heavy rainfall, reducing the flood risk for areas downstream.[68]

[55] Center for Excellence in Disaster Management and Humanitarian Assistance. "Myanmar Disaster Management Reference Handbook." 2020.
[56] Asian Disaster Preparedness Center. "Risk Assessment Road Map, Myanmar." 2015.
[57] Phongsapan, K., et al. "Operational Flood Risk Index Mapping for Disaster Risk Reduction Using Earth Observations and Cloud Computing Technologies: A Case Study on Myanmar." 2019. Frontiers in Environmental Science.
[58] World Bank Group. "Climate Change Knowledge Portal." Retrieved 28 Jan, 2022. https://climateknowledgeportal.worldbank.org/country/myanmar/vulnerability
[59] United Nations Office for Disaster Risk Reduction. "Disaster Risk Reduction in Myanmar: Status Report 2020." 2020. Bangkok, Thailand.
[60] Asian Disaster Preparedness Center. "Historical Flood Analysis Tool." 2022. https://servir.adpc.net/tools/historical-flood-analysis-tool
[61] https://thinkhazard.org/en/
[62] https://preview.grid.unep.ch/index.php?preview=data&events=floods&evcat=5&lang=eng
[63] https://sedac.ciesin.columbia.edu/data/collection/ndh/sets/browse
[64] Phongsapan, K. et al. "Operational Flood Risk Index Mapping for Disaster Risk Reduction Using Earth Observations and Cloud Computing Technologies: A Case Study on Myanmar." 2019. Frontiers in Environmental Science.
[65] Myanmar Information Management Unit. Townships affected by Flood and Cyclones dataset (2008-2021). 2022.
[66] Hnin Wuit Yee Kyaw and Dudley, A. "A risk assessment for major flooding in Myanmar incorporating hazard, exposure, and vulnerability." 2020. Unpublished manuscript. Map kindly provided by the authors for the purposes of this MIMU Analytical Brief.
[67] Taft, L. and Evers, M. "A Review of Current and Possible Future Human-Water Dynamics in Myanmar's River Basins." 2016. Hydrology and Earth System Sciences.
[68] Mandle, L., et al. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.

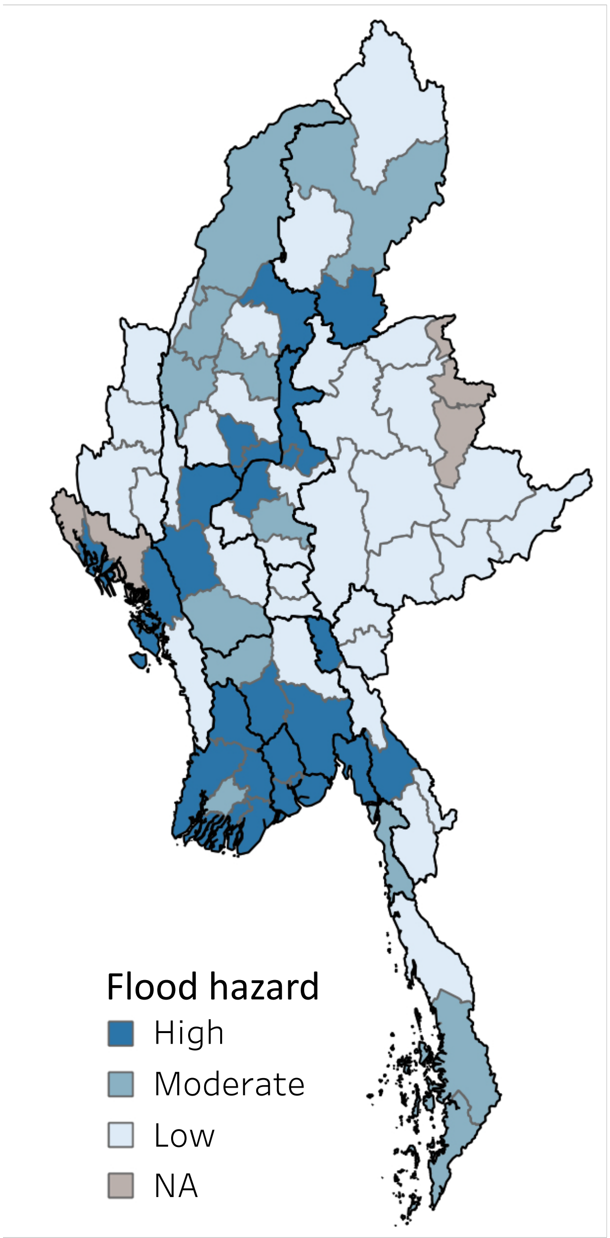

Figure 9: *Flood probability by district (Source: SERVIR-Mekong HFA Tool)*

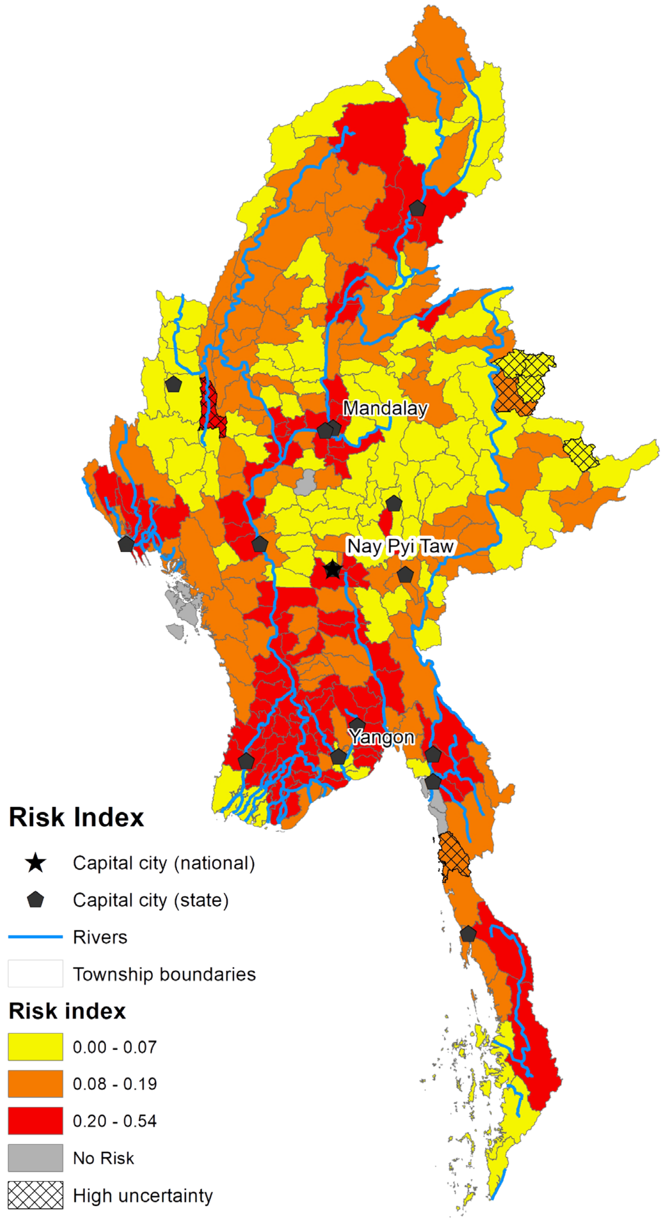

Figure 10: *Township flood risk in Myanmar based on an alternative risk assessment method developed by Hnin Wuit Yee Kyaw and Alexandra Dudley*

Climate change and environmental degradation are increasing flood risk in Myanmar, though not changing which areas are most at risk. While the effects of climate change on flood risk are not clear from the available historical data, projected increases in rainfall intensity will increase flood risk across the country in the future.[69] The effects of Myanmar's many new and proposed dams on flood risk are not yet clear – they could reduce flood probability, but they will also likely disrupt sediment flows and increase deforestation.[70] So far there has been very little assessment of the environmental impacts of dam projects in Myanmar.

Further analysis on flood risk in Myanmar is still needed. A lack of regular data collection on all aspects of water resource health and management prevents accurate assessment of how natural and artificial changes like large hydropower projects, pollution, and sedimentation are affecting flood probabilities.[71,72] Existing national studies have focused on riverine flooding, and more could be done to incorporate data around land use, impermeable surfaces, and slope to account for urban and flash flood events to make these tools more useful for predicting areas at risk.[73] Finally, flooding not only affects people directly through loss of livelihood, displacement and fatalities, but also has longer term effects on agriculture and infrastructure. More systematic management of data on flood impacts on these sectors would allow for more complete analysis of flood impacts nationwide.

[69] *Mandle, L., et al. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.*
[70] *Taft, L. and Evers, M. "A Review of Current and Possible Future Human-Water Dynamics in Myanmar's River Basins." 2016. Hydrology and Earth System Sciences.*
[71] *Hydro-Informatics Center. "Ayeyarwady State of the Basin Assessment (SOBA) 2017: Synthesis Report, Volume 1." 2017. Yangon, Myanmar.*
[72] *Taft, L. and Evers, M. "A Review of Current and Possible Future Human-Water Dynamics in Myanmar's River Basins." 2016. Hydrology and Earth System Sciences.*
[73] *Phongsapan, K. et al. "Operational Flood Risk Index Mapping for Disaster Risk Reduction Using Earth Observations and Cloud Computing Technologies: A Case Study on Myanmar." 2019. Frontiers in Environmental Science.*

Cyclones and Storms

Though less frequent than floods, cyclones in Myanmar tend to be significantly more dangerous as individual events. While storms, including cyclones and storm surge, accounted for 18 percent of disasters affecting 100 or more people between 1970 and 2015,[74] they are responsible for much of the damage and loss of life among recent natural disasters because of the major impact of cyclone Nargis. On 2 May 2008, Cyclone Nargis struck the Ayeyarwady Delta, affecting more than 50 townships, mainly in Ayeyarwady and Yangon Regions. The greatest damage was in Ayeyarwady Region, where a storm surge further compounded the effects of the cyclone. Significant damage was caused by wind speeds of up to 200 kilometres per hour, large waves that raised sea levels by three to four metres, and flooding that travelled far inland through irrigation channels.[75] The worst natural disaster in Myanmar's history, it killed around 140,000 people and seriously affected 2.4 million more.[76] Fishermen lost boats and equipment, 63 percent of rice fields were flooded with saltwater, and there was significant damage to infrastructure. In addition to the direct cost for humans, the storm damaged 43% of freshwater ponds, destroyed 38,000 hectares of mangroves, and damaged forest, wetland and coastal ecosystems.[77] This environmental damage affects the potential severity of future storms and the ability of local communities to respond.

Cyclones can cause major damage in Myanmar because of the vulnerability of coastal populations, especially in Rakhine and Ayeyarwady. Although damage from Cyclone Nargis is one of the main reasons for Myanmar's high ranking on many international lists of disaster vulnerability, Myanmar experiences significantly fewer cyclones than other countries considered to have high risk from disasters such as Bangladesh or the Philippines. While they occur less frequently than other hazards, the high potential for damage is of significant concern in areas where such storms are most likely to land. The tropical cyclones that affect Myanmar originate in the Bay of Bengal; of an average 10 cyclones per year only 6.4 percent reach Myanmar.[78] In the last 30 years cyclones in the Bay of Bengal have become more likely to reach hurricane-force windspeeds (sustained speed of over 120 kilometres per hour) and to reach Myanmar. Most of them have made landfall in Rakhine State on Myanmar's northwest coast; one of the reasons Cyclone Nargis may have been so deadly is that the Ayeyarwady Delta had not experienced such a large storm in recent memory and residents did not understand the level of danger.[79]

Ayeyarwady Region is an area of special concern as it not only has over six million people but is also responsible for around one third of Myanmar's rice production.[81] While Rakhine is hit by cyclones more often, it has half as many people and disruption in agriculture there would have a lesser effect on Myanmar's food supply. The impacts of coastal storms and flooding are affected by the density of population and infrastructure near the coast and the ability of coastal ecosystems to absorb high winds and storm surges.[82] It is important to note that population density can be accounted for in this analysis, but infrastructure is not.

In analysing the potential impact of storms and cyclones, we used data from the Global Risk Data Platform on the frequency of danger from high winds and storm surges. Although cyclones and other large storms are also likely to cause damage through landslides and flooding from heavy rains, modelling cyclones is such a complex task that priority was given to obtaining frequencies for wind and storm surge risk.

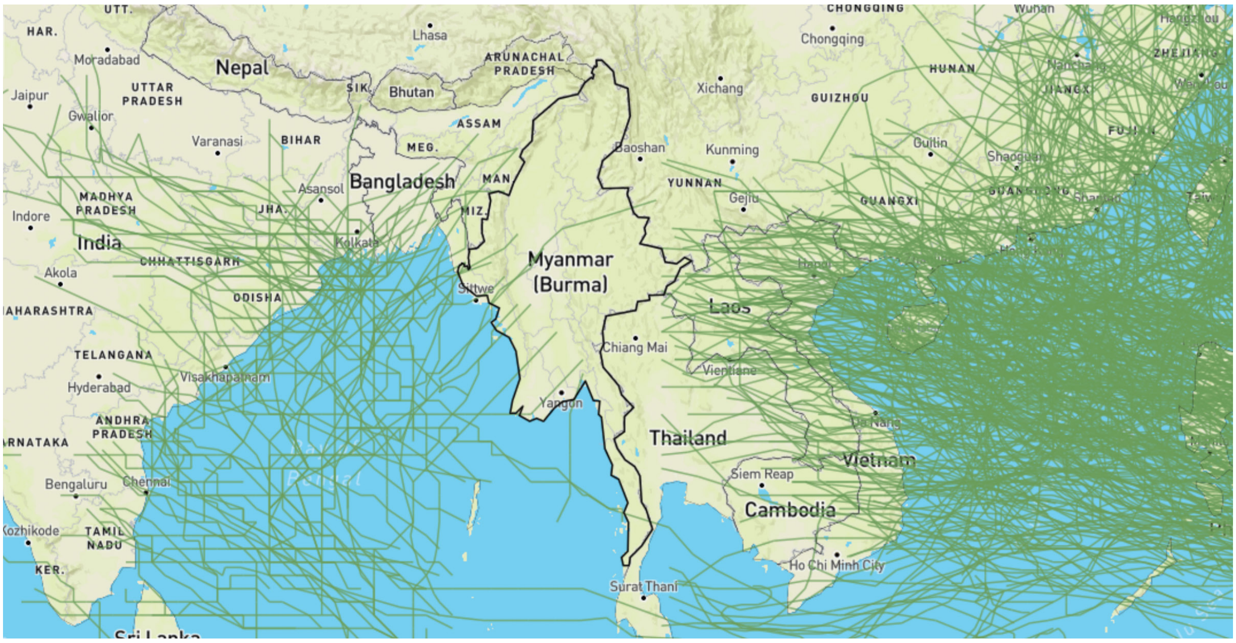

***Figure 11:** Cyclone tracks 1969-2009 (Source: Climate Change Knowledge Portal)[80]*

[74] Center for Excellence in Disaster Management and Humanitarian Assistance. "Myanmar Disaster Management Reference Handbook." 2020.
[75] United Nations Environment Programme. "Learning from Cyclone Nargis: Investing in the environment for livelihoods and disaster risk reduction." 2009.
[76] United Nations Conference on Trade and Development. "Vulnerability Profile of Myanmar." 2021.
[77] United Nations Environment Programme. "Learning from Cyclone Nargis: Investing in the environment for livelihoods and disaster risk reduction." 2009.
[78] Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.
[79] Ibid.
[80] https://climateknowledgeportal.worldbank.org/country/myanmar/vulnerability
[81] World Bank Group and Livelihoods and Food Security Fund. "Myanmar Rice and Pulses: Farm Production Economics and Value Chain Dynamics." 2019.
[82] Rao, M., et al. "Biodiversity conservation in a changing climate: A review of threats and implications for conservation planning in Myanmar." 2013. Ambio.

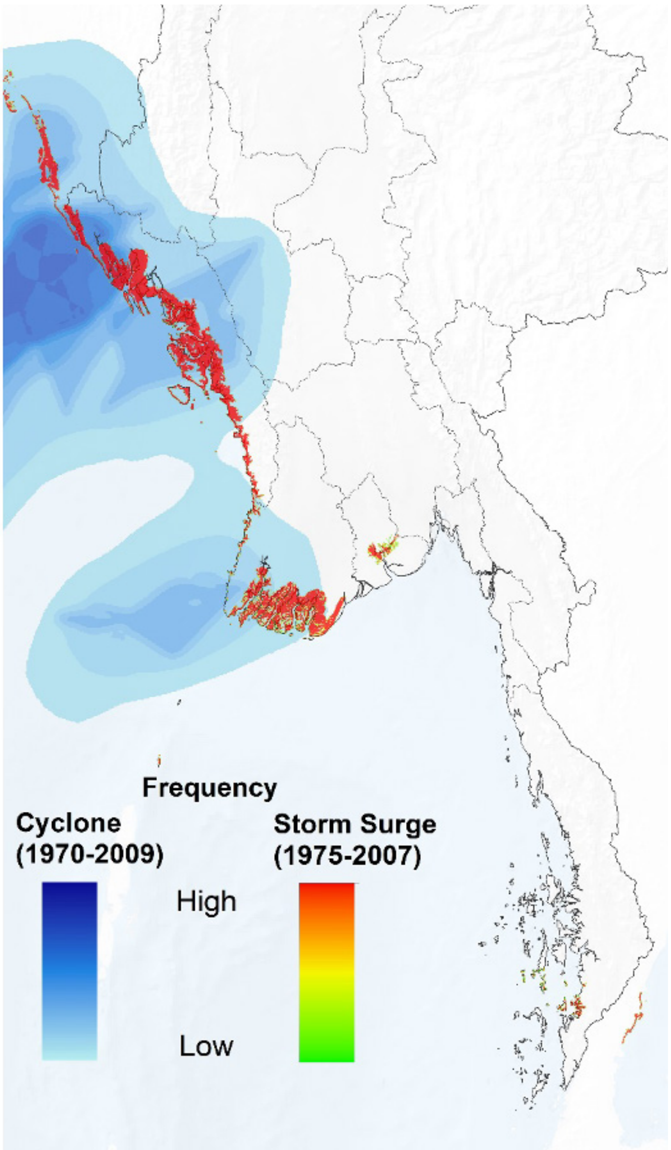

Figure 12: *Frequency of Cyclones (1970-2009) and Cyclone Surges (1975-2007) based on Saffir-Simpson category 5 and category 1 storms respectively. (Source: Global Risk Data Platform)*

Risk from cyclones is most heavily concentrated along the coast with some interesting differences between wind and storm surge risks. Almost 8.9 million people live in districts with a moderate to high likelihood of being affected by a cyclone, though the risks are low for most of these people. All five Rakhine State districts had high probability of wind damage and the highest storm surge likelihood of all districts. However, Matupi in southern Chin State and Minbu in southern Magway also had extremely high danger from storm winds. All four Yangon districts and Myeik and Kawthoung in Tanintharyi Region had a small probability of storm surge, but no danger from winds. Finally, while coastal Ayeyarwady districts had high risk from both wind and water damage, the inland districts of Hinthada and Maubin had no risk of storm surge and only minimal danger from wind. Residents of Rakhine have a significantly higher likelihood of being affected by a cyclone than residents of any other state or region.

These results provide a clear profile of storm risk and the particular vulnerability of Rakhine State. Despite the devastating impact of Cyclone Nargis in the Delta region, Rakhine State remains the most likely victim of future storms based on this analysis using available tools. Areas in Chin State and Magway region are also likely to experience some impacts from the high winds of these storms as they move further inland before losing power, with the risk decreasing the farther one is from the coast. Coastal sections of Ayeyarwady Region, which have almost one million vulnerable residents, also have a moderate to high probability of experiencing both impacts. However, the risk of wind damage further inland is lower than for districts inland from Rakhine State because of the lower likelihood of cyclones hitting the Ayeyarwady Delta. Similarly, Yangon and Tanintharyi have some danger of storm surge damage, as this could still be caused by a smaller scale storm, but it is unlikely that a cyclone with hurricane-force winds will reach this far east.

Some additional emphasis is placed on populous districts with low or moderate hazard danger when factoring in vulnerability and exposure. Sittwe District, which ranks high in both vulnerability and likelihood of being affected by a storm, remains the most at-risk district, but Pathein, Magway, Pakokku, Yangon (East), and Yangon (West) all become more concerning when their large populations are taken into account. However, hazard probability remains a more important factor for estimating storm risk than for estimating flood risk. Because floods are so common across large parts of the country, much more of the variation in risk comes from exposure and vulnerability for floods than for storms.

Climate change and environmental degradation will continue to increase risks from storms for coastal communities in Myanmar. Rapidly declining coastal habitats like mangroves, sea grass beds, and coral reefs protect coastlines from strong storms by reducing the strength of currents and stabilizing the soil.[83] Sea level rise will continue to push storm surges farther and farther inland, increasing the population, infrastructure, and agricultural areas affected.[84] While changes in the number of future cyclones are difficult to predict, research indicates that cyclonic wind speeds and precipitation will get more intense over the next several decades as ocean temperatures increase.

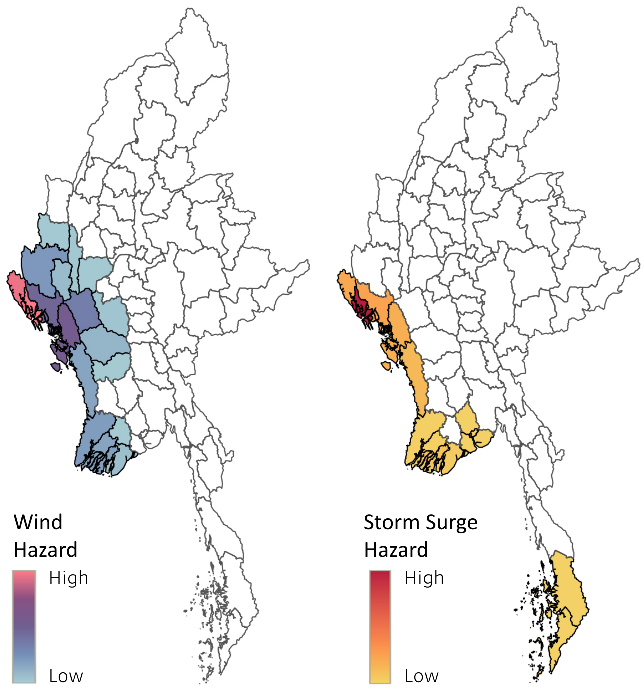

Figure 13: *Wind and Storm Surge Frequency by District (Source: Global Risk Data Platform)*

[83] *Mandle, L. et al. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.*
[84] *Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.*

Drought and Extreme Heat

Among the hazards reviewed in this analysis, drought is one of the most complex to analyse. Drought and extreme heat can affect large parts of the country at once and are becoming significantly more likely because of climate change. Unlike cyclones or landslides, droughts occur over long periods of time, and can be classified in different ways. Meteorological drought occurs when there is below-average rainfall in an area for a certain period of time – the exact amount and time period vary by region.[85] Agricultural drought occurs when there is so little moisture in the soil that it starts to have a negative effect on plants. Hydrological drought results from reduction in surface and underground water sources, usually after a longer period of meteorological or agricultural drought, or both. Finally, when agricultural or hydrological drought affect the local community through decreased crop yields, lack of water for household use or industry, and ecosystem stress, it is called socioeconomic drought.

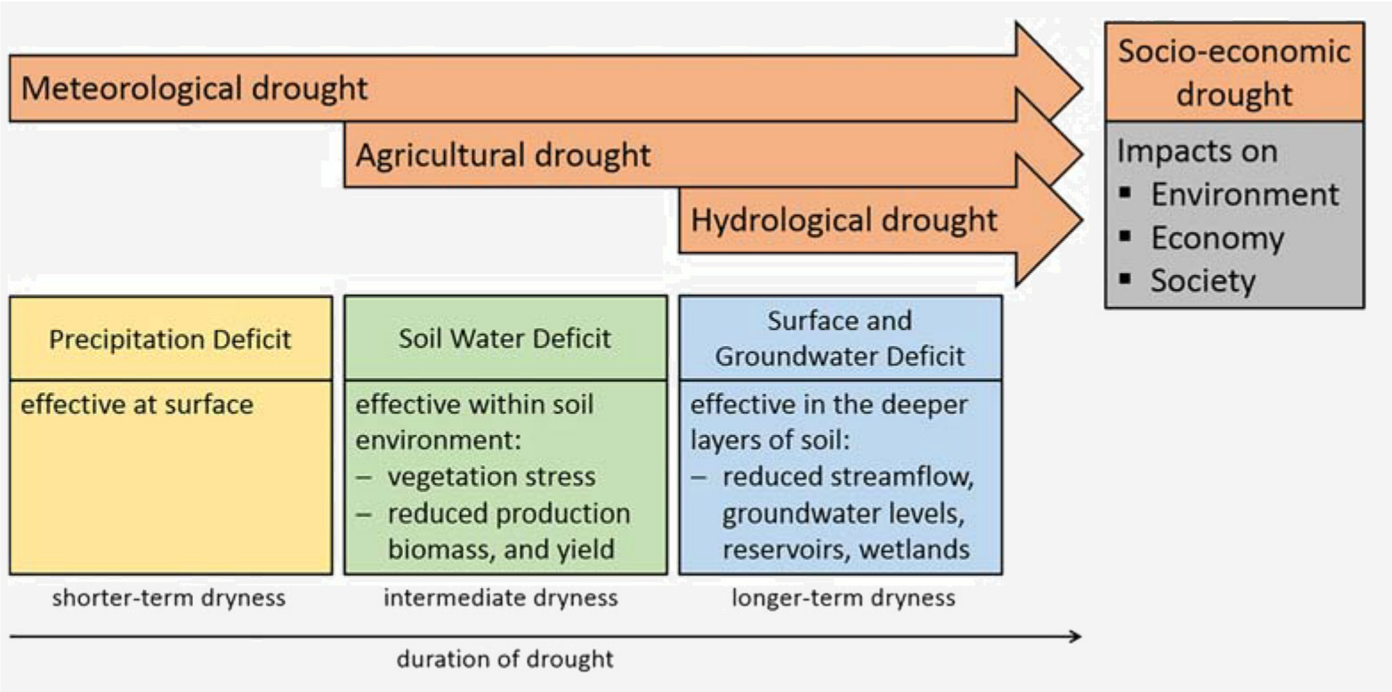

Figure 14: *Types of drought with their major triggers and impacts. (Source: Crocetti, L. et al.)*[86]

Meteorological droughts across Southeast Asia are often combined with above average temperatures, which increases the stress on plants and the likelihood of agricultural drought. This was observed in Myanmar in 2010.[87] That year saw record-breaking temperatures, with many areas averaging two to three degrees Celsius hotter than normal in the month of May. Although drought conditions were reported around the country, it was not associated with below average rainfall. The water shortage was most severe in Ayeyarwady, Yangon, Bago, Mandalay, and Sagaing Regions and Rakhine, Mon, and Shan States.[88] Even if an area is experiencing regular precipitation, it can still be vulnerable to other types of drought because of high heat, poor water resource management, and vulnerable populations and ecosystems. Seasonal shifts in precipitation are implicated in triggering droughts in many areas across the world in response to changing climate.[89]

Most drought analysis in Myanmar has focused on the Central Dry Zone, where droughts caused crop failures in 1997-1998, 2010, and 2014.[90] The Dry Zone, which includes parts of Mandalay, Magway, and Sagaing Regions, has almost 11 million people and extensive agriculture. Farmers in the area produce around 22 percent of Myanmar's rice paddy, 89 percent of its sesame, and significant amounts of pulses, seeds, and livestock. Most of the farms rely on rainfall and surface water; there is minimal pumped irrigation. During droughts many sources of surface water and wells can dry up, limiting water availability for agriculture, drinking and sanitation.

Southern Ayeyarwady and western Bago Regions also experience severe drought conditions frequently.[91] Labutta, Myaungmya, Pyapon, and Maubin are the Ayeyarwady districts with the most frequent drought, along with Thayawardy in Bago Region. These areas are very populated and have high numbers of vulnerable people.

[85] Ceglar, A. "Drought Indices." 2008. Drought Management Centre for Southeastern Europe.
[86] Crocetti, L., Forkel, M., Fischer, M. et al. "Earth Observation for agricultural drought monitoring in the Pannonian Basin (southeastern Europe): current state and future directions." 2020. Regional Environmental Change.
[87] Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.
[88] Minn Ko Ko Kyaw and Nilar Aye. "Mitigation Measures for Flood and Drought for Ayeyarwady Basin." 2018. American Scientific Research Journal for Engineering, Technology, and Sciences.
[89] Bruen, M. and Dzakpasu, M. "WARNDIS Project Final Report: A Review of Climate Change-related Hazards and Natural Disaster Vulnerabilities and of Agencies Involved in Warning and Disaster Management." 2018.Ireland.
[90] Taft, L. and Evers, M. "A Review of Current and Possible Future Human-Water Dynamics in Myanmar's River Basins." 2016. Hydrology and Earth System Sciences.
[91] Food and Agriculture Organization. "Agricultural Stress Index System (ASIS)." Accessed 2 March, 2022. http://www.fao.org/giews/earthobservation/

Vulnerable people in some of these drought-prone areas have already been affected by climate change. Residents who remember having access to nearby ponds year-round for water must now buy it or rely on wells, many of which are also running dry.[92] Most irrigation projects are large-scale and focused on large-scale farms, leaving smallholder farmers to mostly rely on inconsistent rainfall.[93] This is another illustration of how socioeconomic factors combine with natural hazards to create disasters.

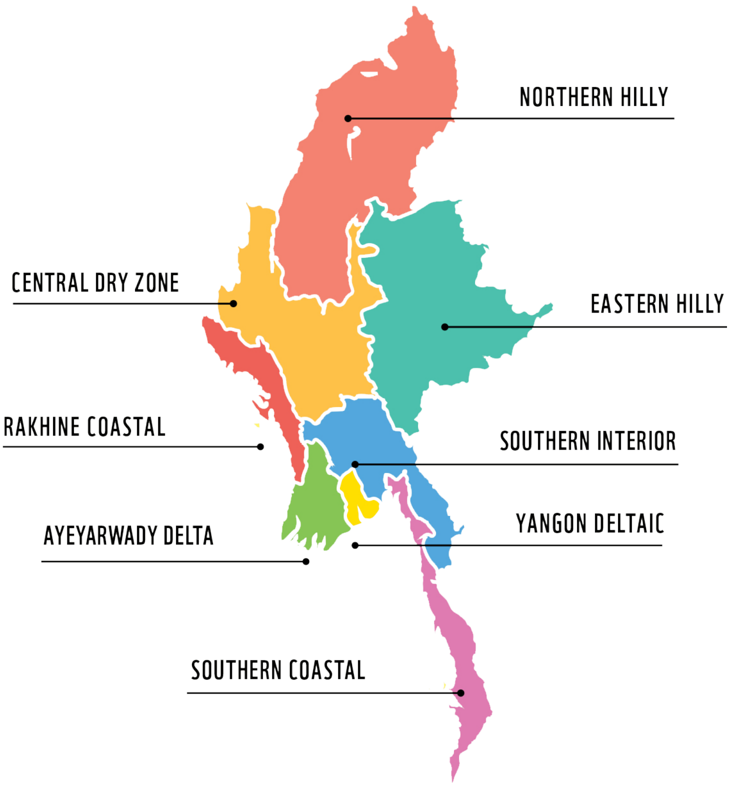

Figure 15: *The eight physiographic regions of Myanmar[94]*

Moderate droughts are likely to occur in Myanmar every 10-14 months, and severe droughts every two to three years.[95] An analysis by the UN Economic and Social Commission for Asia and the Pacific estimated the likelihood of meteorological drought across Southeast Asia: Myanmar has moderate probabilities of meteorological drought compared to other countries in Southeast Asia, where drought likelihood decreases with distance from the equator. In Myanmar they found that for both moderate and severe drought, the Ayeyarwady Delta, Central Dry Zone, and Northern and Eastern Hilly Regions (i.e. Kachin and Shan States) are more likely to experience drought than other areas.

Kayah and Shan states were found to have the highest risk of negative impacts in periods of severe drought in both 2015-16 and 2019-20.[96] When combining the severity of meteorological drought with social and agricultural factors, ESCAP found that Kayah and Shan States were the most affected, as they were drought hotspots in both periods and had large proportions of children suffering malnutrition, large numbers of impoverished households, and many families working as smallholder farmers on land exposed to drought. Nay Pyi Taw Union Territory and Rakhine State were considered vulnerable because of higher levels of malnutrition and dependence on agriculture, whereas Kayin, Mon, and Kachin States and Sagaing Region were all found to be vulnerable because of the amount of agricultural land affected by drought, or the higher percentage of agricultural land owned by smallholder farmers.

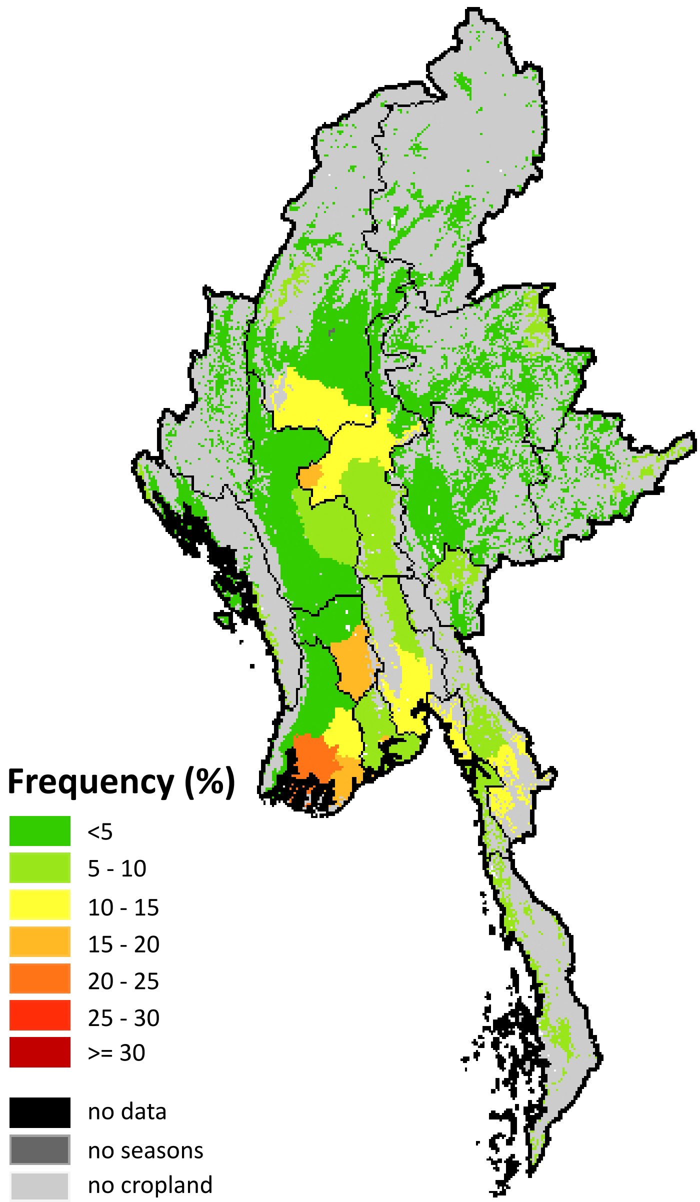

Figure 16: *Frequency of drought affecting more than 30% of cropland for main growing season from 1984 to 2020 (Source: FAO ASIS)*

Forests and other natural ecosystems can reduce the probability of all varieties of drought. Vegetation, including trees, increase the amount of rainwater that is absorbed into the ground, allowing it to be released slowly to maintain stream flows or plant health during the dry season.[97] It also increases the amount of water that evaporates, which can decrease the likelihood of meteorological drought. People living downstream from forests benefit from increased water availability during periods of little rainfall.

[92] *Daniel, R. "In rural Myanmar, more frequent and intense droughts are affecting local livelihoods." 2018. Stockholm Environment Institute.*
[93] *HARP-F and MIMU. "Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps." 2018.*
[94] *Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.*
[95] *United Nations Economic and Social Commission for Asia and the Pacific. "Ready for the Dry Years: Building resilience to drought in South-East Asia." 2021. Bangkok*
[96] *Ibid.*
[97] *Mandle, L., et al. "Natural connections: How natural capital supports Myanmar's people and economy." 2016. World Wildlife Fund-Myanmar.*

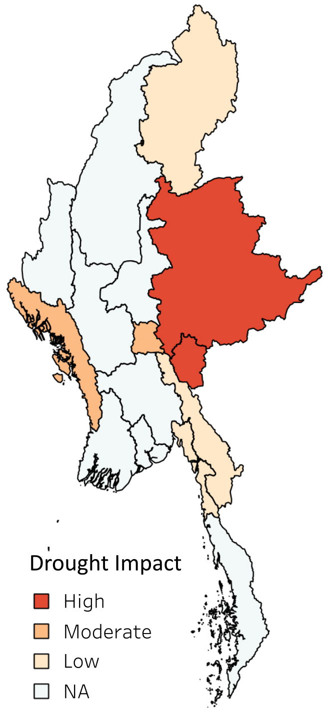

Figure 17: *Drought impact by State and Region for droughts in 2019/20. (Source: UNESCAP)*

Landslides

Landslides made up 12% of recorded natural disasters in Myanmar from 1970 to 2015 and are more likely to occur in mountainous areas. Landslides may also cause longer term impacts through damage to the transportation systems in affected areas. Landslide risk in Myanmar has been analysed less than the other hazards covered in this brief due to their localised nature among other factors. This is for several reasons: While storms, floods, and droughts all tend to affect large areas and broad sections of the population, landslides are limited to far smaller areas. The approach to measurement of impact also differs: EM-DAT, an international database of natural disasters used by many researchers for analysing risk, only records events with 10 or more fatalities, 100 or more people reported affected, a declared state of emergency or a call for international assistance.[98] These rules are more likely to exclude a landslide than a drought, for example, which is guaranteed to affect more than 100 people. Finally, landslides are often associated with other hazards, such as extreme precipitation or flooding, and assessing the impacts of landslides separate from these is difficult.

While most major flooding events in Myanmar have been accompanied by landslides, the damage from landslides is seldom described separately from the flooding.[99] The exception is landslides that are extremely deadly, such as one in Mon State in 2019 that killed 70 people.[100] While landslides pose a direct threat to human lives, they also have indirect impacts from the damage to infrastructure, especially road networks.[101] This causes extended periods of inaccessibility for some parts of the country, and can be especially problematic when interfering with relief efforts for other disasters like floods and storms. In addition, although individual landslide events have a limited area of impact, the frequency of landslides around the country means that thousands of people can be affected in a given year. The most extreme example is 2010, when an estimated 145,000 people in Myanmar were affected by landslides.[102]

Landslide risk is sometimes divided into the risk of landslides from precipitation and the risk from earthquakes. Although this analysis does not include earthquakes as a hazard of focus because they are not as affected by human activities, we analyse landslide risk based on both precipitation- and earthquake-induced landslides, as landslide risk is heavily influence by factors under human control such as deforestation, mining, and infrastructure design.

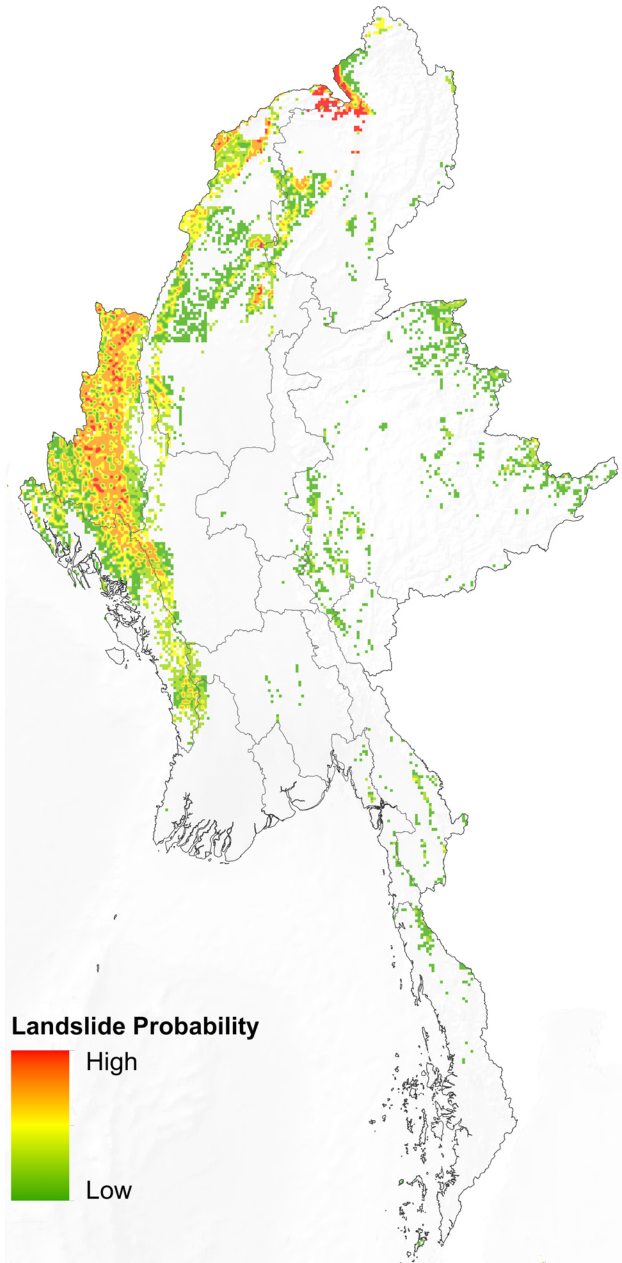

Figure 18: *Landslide probability in Myanmar (Source: Global Data Risk Platform)*

[98] *Asian Disaster Preparedness Center. "Risk Assessment Road Map, Myanmar." 2015.*

[99] *United Nations Office for the Coordination of Humanitarian Affairs. "Reliefweb." Accessed 17 Mar, 2022. https://reliefweb.int/disasters?advanced-search=%28C165%29_%28TY4728%29*

[100] *Center for Excellence in Disaster Management and Humanitarian Assistance. "Myanmar Disaster Management Reference Handbook." March, 2020.*

[101] *United Nations Children's Fund. "Myanmar Child-Centered Risk Assessment: Second Edition." 2017.*

[102] *World Bank Group. "Climate Change Knowledge Portal." Retrieved 28 Jan, 2022. https://climateknowledgeportal.worldbank.org/country/myanmar/vulnerability*

Western and northern Myanmar's hilly and mountainous areas are the most likely to experience landslides. The four districts in Chin State have the highest probability of landslide countrywide according to data from NASA's Socioeconomic Data and Applications Center. These are followed closely by Hkamti and Mawlaik Districts in Sagaing Region, and every district of Rakhine State with the exception of Sittwe. It should be noted that even areas with low risk of landslides can suffer severe damage. Thaton District in Mon State, where the deadly 2019 landslide occurred, has a low probability.

Deforestation and mining are both major drivers of landslide risk in Myanmar. Mines in northern Myanmar regularly have deadly landslides, often killing more than one hundred people per year.[103] Deforestation is another main cause, as vegetation on slopes helps to absorb water and keep the soil in place.

Exposure and Vulnerability

Extreme weather events do not become disasters on their own; the level of impact is influenced by the vulnerability of the affected community. This involves various complex interactions between environmental and human variables such as land use practices, water management, and the ability of local government to respond to emergencies.[104] Methods for assessing vulnerability vary based on location, the hazards being considered, and data availability. While holistic indexes are becoming more common, many methods are still focused on physical infrastructure over socio-economic factors.[105]

This analysis considers vulnerability using the MIMU-HARP-F Vulnerability Index as one of several measures of vulnerability used to consider disaster risk in Myanmar. Others have been developed for the UNICEF Child-Centred Risk Assessment,[106] the European Commission's Index for Risk Management (INFORM),[107] and by independent researchers.[108] The indicators vary in these indexes with some using a larger number of indicators, including for example public infrastructure measures such as road density or government capacity indicators such as proximity to emergency response warehouses. They generally find similar patterns of vulnerability across the country, with medium to high vulnerability in most of Rakhine, Kachin, Shan, and Kayin States, and medium vulnerability in parts of the Ayeyarwady Delta and Central Dry Zone. However, it is notable that when measuring disaster risk, the methods for calculating and combining vulnerability and exposure can have a significant effect on the areas considered most and least at risk.[109]

Indicator	Data Limitations
Female (15 and over) literacy rate Child dependency ratio Percent of households with safe sanitation Percent of households with an improved drinking water source Percent of households with a roof and walls of high-quality materials Percent of the population (10 and over) working as unpaid family workers Percent of households with access to electricity	Data collected with sampling methodology for households but not institutions. Data provided at district level. Gaps in enumeration including self-administered zones, Maungdaw and Mrauk-U Districts in Rakhine State, or Hopang and Matman Districts in Shan State.
Percent of population (25 and over) with a middle school education Percent of population (10 and over) with an ID card	These two indicators were not included in the 2019 ICS so taken from the 2014 Population and Housing Census which covered households and institutions. Data was provided at township level. Gaps in enumeration included parts of Rakhine, Kachin and Kayin States (est. 2.34% of the population).
Conflict Index	Reflects incidents of clashes/battles, conflict fatalities, displacement and violence against civilians over the period 2019-2021. Underestimates internally displaced persons who are not located in formally recognized camps

Sources used for the indicator 2019 Intercensal Survey | 2014 Census | ACLED (2019-2021)

Figure 19: *MIMU-HARP-F Vulnerability Index Indicators and sources used for this analysis (Source: MIMU)*

[103] Fishbein, E. and Aung Myat Lamung. "How A Beloved Gemstone Became A Symbol Of Environmental Tragedy In Myanmar." 2020. National Public Radio
[104] Horton, R., et al. "Assessing Climate Risk in Myanmar: Technical Report." 2017. World Wildlife Fund. New York.
[105] United Nations Office for Disaster Risk Reduction. "Understanding Disaster Risk." 2022. Accessed 1 Feb, 2022.
[106] United Nations Children's Fund. "Myanmar Child-Centered Risk Assessment: Second Edition." 2017.
[107] Marin-Ferrer M., Vernacinni, L., and Poljansek, K. "INFORM Index for Risk Management: Concept and Methodology Report – Version 2017." 2017. Joint Research Centre, Luxembourg, European Union.
[108] Hnin Wuit Yee Kyaw and Dudley, A. "A risk assessment for major flooding in Myanmar incorporating hazard, exposure, and vulnerability." 2020. Unpublished
[109] Ibid.

For the purposes of this analysis, levels of vulnerability are estimated at district-level based on under-development as of late 2019, and conflict incidents over the period 2019-2021. The MIMU-HARP-F Vulnerability Index was developed based on a statistical modelling of the situation across townships, countrywide, and estimates vulnerability using ten measures of human development along with a four-part conflict index. This Vulnerability Index is applied at district level so as to use the more recent 2019 ICS data for some measures of human development (i.e. socioeconomic and demographic variables such as housing amenities, education, and the child dependency ratio). The measure of conflict is based on incidents over the period 2019 to 2021 as recorded in the Armed Conflict Location & Event Data Project (ACLED) and reflects incidents of clashes/battles, conflict fatalities, displacement and violence against civilians recorded over the period.[110]

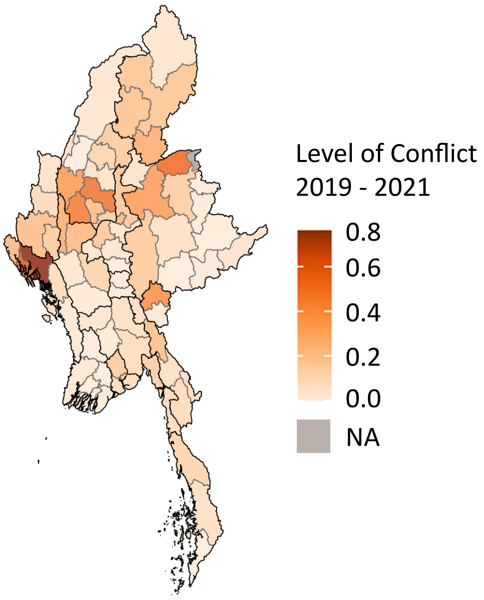

***Figure 20:** Level of conflict by District, 2019-2021, using the MIMU-HARP-F Conflict Index.*

While this approach allows comparison of possible affected populations, the levels of vulnerability are under-estimated, particularly in areas with high conflict or displacement. This under-estimation is due to various limitations and gaps in data availability. Data from the 2014 Census is used for two indicators which were not collected in the ICS (percent of population with no ID card and percent with above middle school education), thus assuming no significant developments in these metrics over the 2014-2019 period. The 2014 Census is also used for district level population projections as the most comprehensive estimates given the 2019 ICS focused on households and did not include institutions. Gaps in enumeration affect both the 2014 Census (particularly Rakhine) and the 2019 ICS (not enumerated in any of the self-administered zones, Maungdaw and Mrauk-U Districts in Rakhine State, or Hopang and Matman Districts in Shan State).

The conflict component of the index reflects incidents of clashes/battles, conflict fatalities, displacement and violence against civilians for the period 2019-2021 as recorded by ACLED. This is an approximation allowing conflict in the 2019-2021 period to be factored into the wider vulnerability index. Displacement and changes in infrastructure since February 2021 are not included in the other indicators or total district population estimate, and underestimates internally displaced persons who are not located in formally recognized camps. The result of these limitations is an under-estimation of vulnerability in locations which have large IDP populations or have experienced significant, recent conflict and displacement during the period 2019-2021, such as Kale in Sagaing Region or Loikaw in Kayah State.

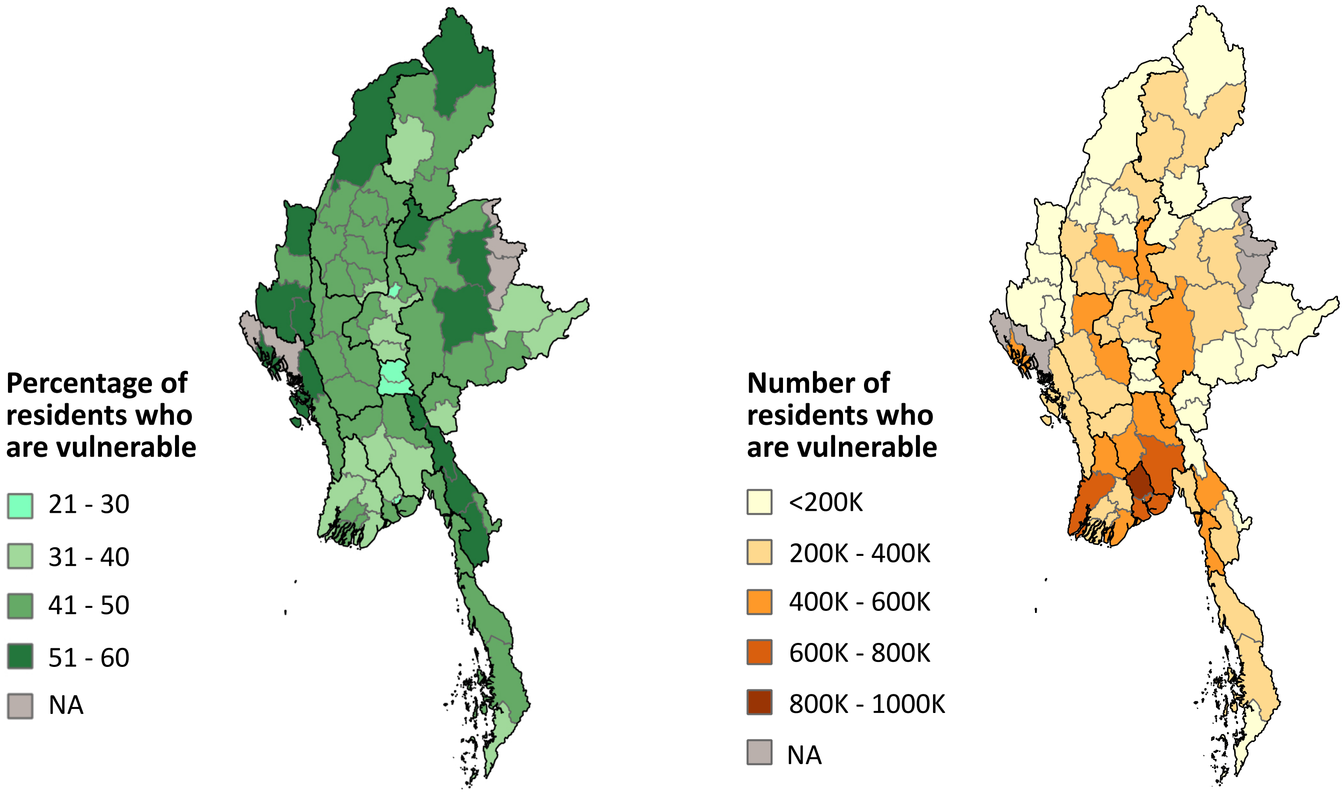

***Figure 21:** Estimated percentage and number of vulnerable population by District in 2021 using the MIMU-HARP-F Vulnerability Index.*

[110] The Armed Conflict Location & Events Database (ACLED) is a non-profit global initiative gathering disaggregated data on conflict-related incidents from a wide variety of sources. The events considered in this analysis are drawn from the ACLED dataset as accessed on 25 January, 2022.

In the absence of more recent countrywide data, this analysis assumes the living standards of late 2019 continued to 2021. While this allows comparison of people who may be vulnerable in areas exposed to natural hazards across districts, this approach clearly under-estimates the major impact of the COVID-19 pandemic and other factors in 2020-2021 on Myanmar's population. It estimates 21.2 million people to be vulnerable in terms of non-conflict indicators in 2019, and/or direct exposure to conflict from 2019 to 2021.[111] Districts with the highest percentage of vulnerable people are primarily in more remote areas, as a key component of vulnerability is lack of access to infrastructure and basic services. The most vulnerable districts – where 55-60% of the population is considered vulnerable – are found around the edges of the country in Chin (Falam, Matupi and Mindat), Kayin (Hpapun), Rakhine (Sittwe) and Shan (Loilen) and Sagaing (Hkamti).

When adding in exposure, the most prominent districts tend to be those with a large population centre and relatively poor education and electricity access. Districts with the highest number of vulnerable people tend to be in populated Regions, particularly Yangon North followed by Yangon South, Bago district, Yangon East and Pathein district in Ayeyarwady. Yangon (North) is a notable outlier whose large number of vulnerable people seems entirely based on its population size, as opposed to a combination of population and poor development indicators. Also notable is that areas in the Upper Delta and Central Dry Zone such as Hinthada, Thayarwady, and Magway are in the medium-high groupings on both maps.

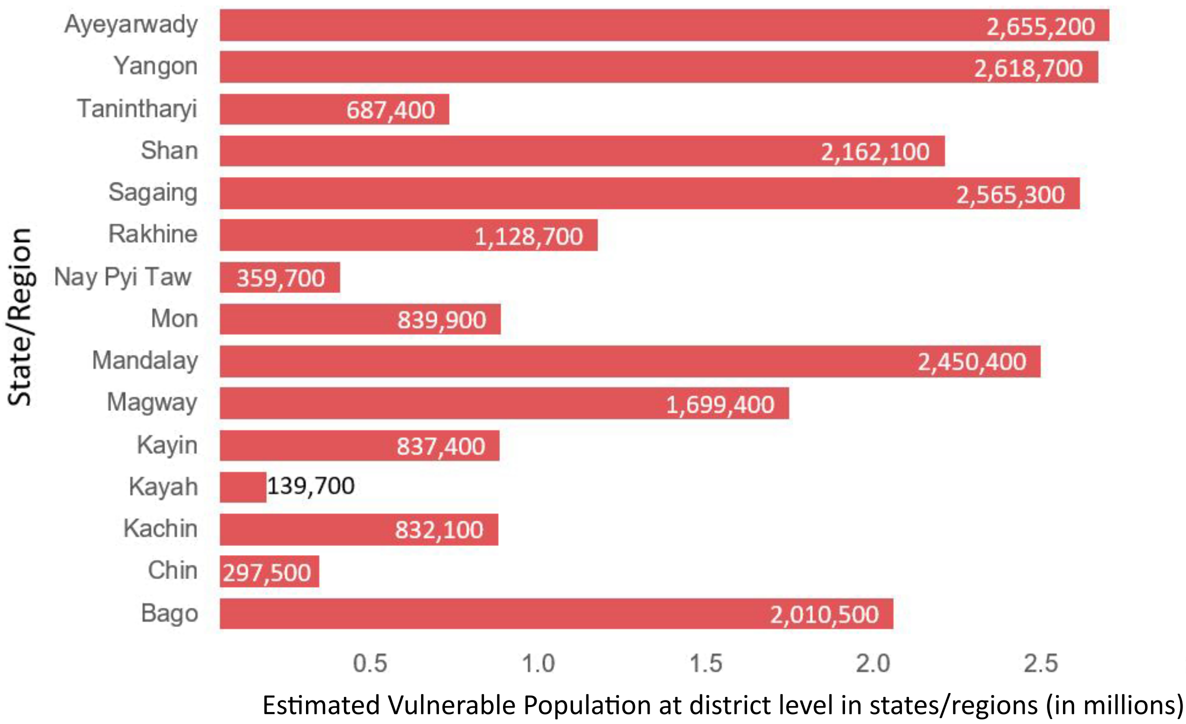

Figure 22: *Estimated vulnerable population by State/Region 2021 (Source: MIMU-HARP-F Vulnerability index)*

There are several notable differences between these patterns of vulnerability and exposure and other analyses that were done previously, for example the MIMU-HARP Vulnerability Assessment[112] and UNICEF's Child-Centered Risk Assessment,[113] reflecting the situation as of 2016 and 2017 respectively. The percentage of vulnerable people appears higher in northern Chin State and much of Sagaing Region now because of the increase in conflict in 2021. The vulnerability of districts in Rakhine and northern and eastern Shan States appears lower relative to other districts; however, this is the result of the high number of conflict incidents in other parts of the country in 2021 and does not necessarily reflect an improvement to the still very low living standards in some of these areas. Finally, because this analysis uses districts while previous analysis was at the township level, Yangon's exposure stands out more. While most Yangon townships are not outliers in terms of number of inhabitants, Yangon districts are significantly more populous than almost all other districts in Myanmar and as a result the number of vulnerable people is also much larger.

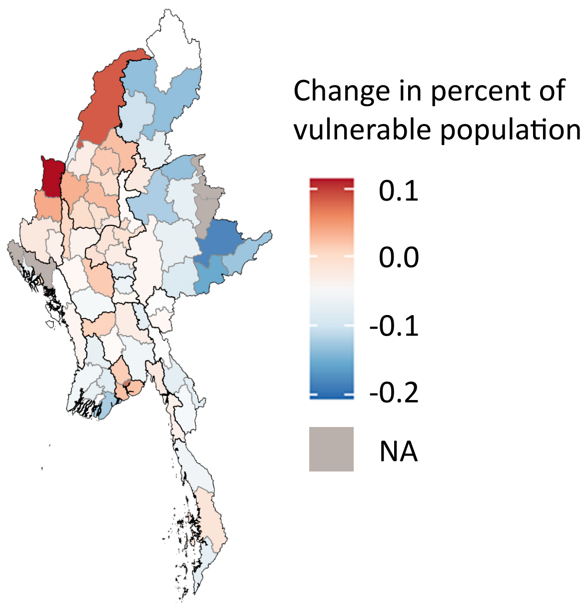

Figure 23: *Change in the percent of the population considered vulnerable by district between 2016 and 2021 estimates (Source: MIMU-HARP-F Vulnerability Index)*

[111] Using countrywide population estimates for 2021 based on the 2014 census projections (55.1 million population).
[112] United Nations Children's Fund. "Myanmar Child-Centered Risk Assessment: Second Edition." 2017.
[113] HARP-F and MIMU. "Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps." 2018.

On average, districts saw significant improvements in most measures since this index was last calculated, but this was offset by a large increase in conflict in 2021. Measures related to infrastructure improved and there was a decrease in the number of unpaid family workers per household between 2014 and 2019, but these improvements were offset by the large increase in conflict in 2021. The average percent of households per district with access to safe sanitation, drinking water, and electricity, all improved by between 25 and 88%, while the female literacy rate and child dependency ratio improved only slightly over this five-year period. Unfortunately, conflict level increased by 67% between measures of conflict used in the previous vulnerability assessment (2015-2016) and in the period 2019-2021. This needs to be considered alongside the significant improvements in access to amenities for many households in the 2014-2019 period which would have lowered the overall estimation of vulnerable population prior to the shocks of 2020 and 2021.

Exposure and vulnerability to Natural Hazards

For the purposes of this analysis, the MIMU-HARP-F vulnerability measure with data from the period 2019-2021 has been used alongside the modelling of areas likely to be impacted in order to estimate vulnerable population who may be exposed to different types of natural hazards. It should be noted that these are very approximate estimates for the reasons already described, and that they likely under-estimate vulnerability; however they do enable a comparison of areas which may be impacted by particular hazards.

Vulnerability to Floods: Based on the flood probability designations from the SERVIR-Mekong Historical Flood Analysis Tool, an estimated 28 million people live in districts with a high risk of flood exposure in at least part of the district.[114] This includes at least 10.8 million people who would be vulnerable based on the vulnerability tool used in this analysis. Over two million vulnerable people live in high flood probability areas in Yangon and Ayeyarwady Regions, and more than a million live in Bago and Mandalay Regions. A further 3.2 million vulnerable people live in areas with moderate risk of flooding.

Vulnerability to Cyclones: Cyclone risk is most heavily concentrated along the coast though there are differences in risks by area. Almost 8.9 million people live in districts which have a moderate to high likelihood of being affected by a cyclone, though the risks are low for most of these people. About 4 million vulnerable people in Rakhine, Chin, Magway, and Ayeyarwady could be considered to have medium or high risk, with residents of Rakhine having a significantly higher likelihood of being affected by a cyclone than those in any other state or region. All five Rakhine State districts had high probability of wind damage and the highest storm surge likelihood of all districts – the combined estimated vulnerable population of the three districts for which vulnerability could be estimated is 1.1 million people. Other areas with extremely high danger from storm winds are Matupi in southern Chin State (99,000 vulnerable people) and Minbu in southern Magway (289,000 vulnerable people). As noted, districts in Yangon and Myeik and Kawthoung in Tanintharyi Region had a small probability of storm surge and low danger from winds, however in the unlikely event that a storm surge were to hit Yangon it could affect up to 2.6 million vulnerable people, compared to around 455,000 in Myeik and Kawthoung. Finally, while coastal Ayeyarwady districts had high risk from both wind and water damage, the inland districts of Hinthada and Maubin had no risk of storm surge and only minimal danger from wind.

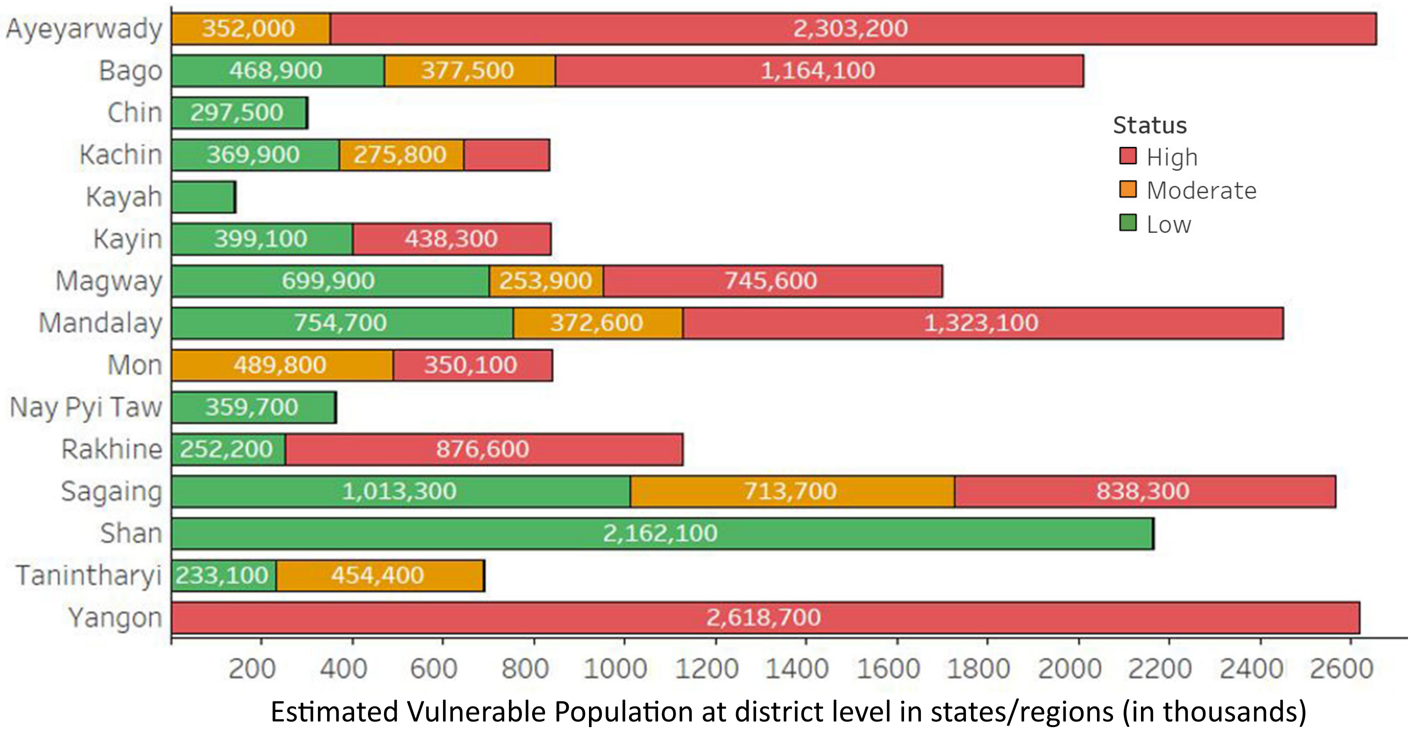

***Figure 24:** Estimated number of vulnerable people per State/Region by district flood probability based on flooding from 1984-2018 (Source: MIMU/HARP-F Vulnerability Index and SERVIR-Mekong Historical Flood Analysis Tool)*

[114] *These calculations are based on 2014 Census projections of 55.29 million population in Myanmar in 2021.*

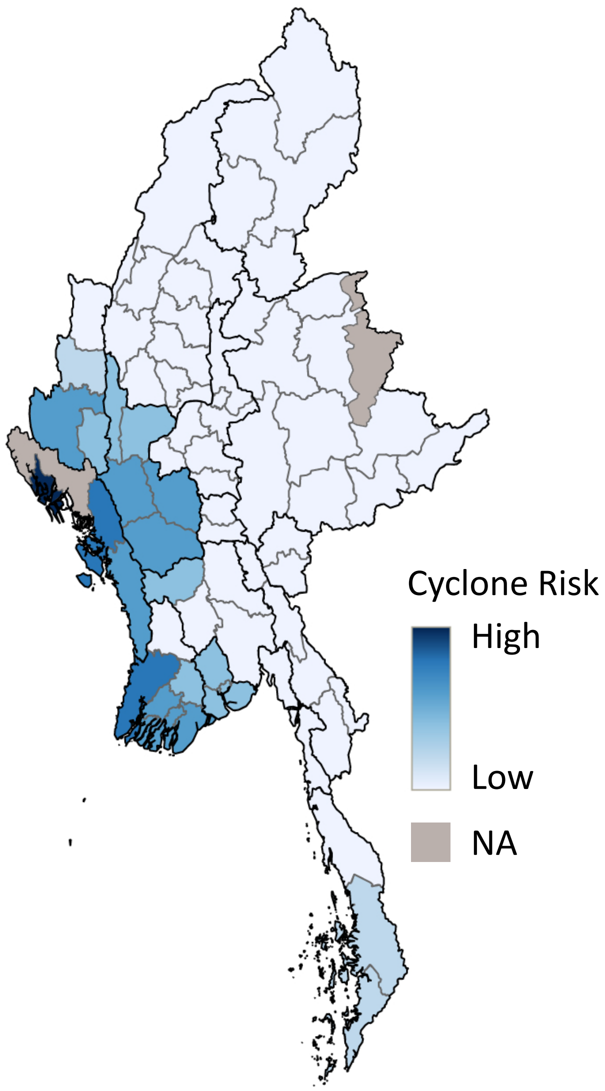

Figure 25: *Cyclone risk based on storm surge and wind hazard and the estimated vulnerable population by district (Source: MIMU-HARP-F Vulnerability Index and Global Risk Data Platform)*

Vulnerability to Drought and Extreme heat: There are an estimated 4,570,000 vulnerable people in the Central Dry Zone, which is regularly exposed to the impacts of drought. Shwebo, Magway, and Pakokku stand out as districts at risk of drought with the highest number of vulnerable people – between 400,000 and 600,000 each. Kanbalu, Shwebo, Magway, and Yinmarbin have the highest vulnerability scores with 46 to 47% of their populations considered vulnerable. As noted, vulnerable people in some of these drought-prone areas have already been affected by climate change. Southern Ayeyarwady and western Bago Regions also frequently experience severe drought conditions. The Ayeyarwady districts with the most frequent drought – Labutta, Myaungmya, Pyapon, and Maubin – have a combined vulnerable population of over 1.4 million people, while Thayawardy in Bago Region has almost 500,000 vulnerable people.

Vulnerability to Landslides: Myanmar's western and northern hilly and mountainous areas are the most likely to experience landslides, with the highest probability in four districts in Chin State and Hkamti in Sagaing Region as per modelling by NASA's Socioeconomic Data and Applications Center. Over 5 million people in Myanmar live in districts with high risk of landslides, however the localised nature of this hazard means that affected areas will be relatively limited. The localised risk of landslides also makes it difficult to predict potential vulnerability. When factoring in vulnerability and exposure however, as many as 473,000 people would be considered vulnerable in the five most frequently impacted districts (Chin State and Hkamti District). Kyaukpyu and Sittwe in Rakhine State (378,000 and 491,000 vulnerable people, respectively) and Taunggyi in Shan State (529,000 vulnerable people) stand out as individual districts with large, vulnerable populations and moderate landslide risk.

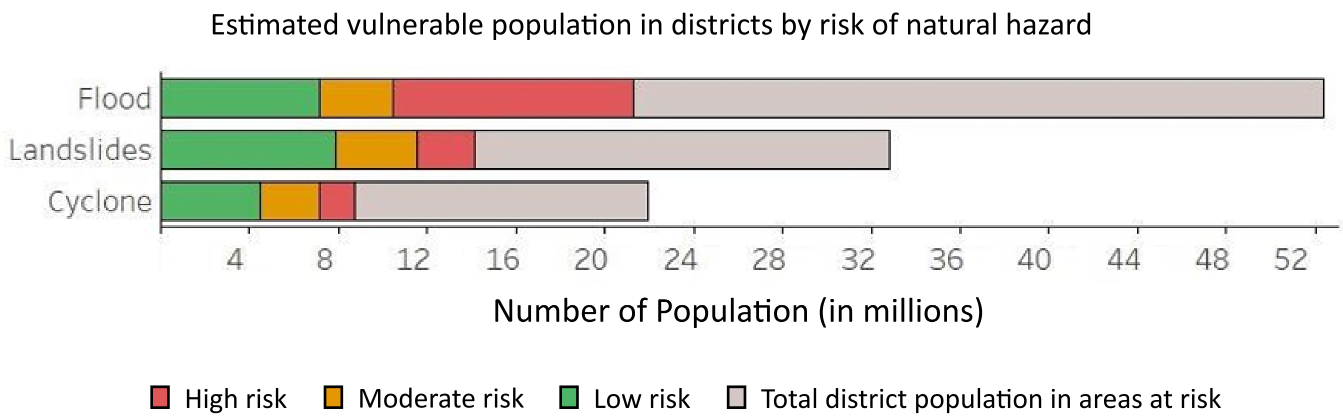

Figure 26: *Estimated overall and vulnerable population at risk of common natural hazards in Myanmar.*[115]
(Source: MIMU-HARP-F Vulnerability Index, SERVIR-Mekong Historical Flood Analysis Tool, Global Risk Data Platform, SEDAC)

[115] *These calculations are based on 2014 Census projections of 55.29 million population in Myanmar in 2021.*

Conclusion

Myanmar is ranked as one of the world's most affected countries in terms of natural disasters, and among the most vulnerable to new disasters in the years to come. In addition to significant loss of life, livelihoods, and property, natural disasters are estimated to cost up to 3% of Myanmar's annual GDP, and the longer-term impacts may be still greater. Climate change and environmental degradation are adding to these risks with predictions of more frequent and more severe floods, storms and droughts as well as the risk of rising sea-levels.

Natural ecosystems such as mangroves and forests play an important role in mitigating the effects of various hazards, however Myanmar's landscape is changing; rising average annual temperatures, more intense rainfall and environmental degradation are all factors which could seriously impact some of the most populated regions of the country and increase the impact of natural disasters. Satellite imagery indicates Myanmar to be one of the top ten countries globally for deforestation, with mangroves – an important protective ecosystem in coastal areas, being lost even more rapidly than other types of forests.

Changing climate and environmental degradation are influencing the frequency and severity of natural hazards in Myanmar. Extreme flooding which can exceed communities' capacity to cope has been more frequent over the past decade. An estimated 28 million people live in districts which have a high risk of flood exposure in at least part of the district area, mainly along Myanmar's coasts, the Ayeyarwady River and in Kayin State. Cyclones and major storms are expected to become more intense as ocean temperatures increase, with residents of Rakhine State anticipated to have a higher likelihood of being affected. Drought is another natural hazard that is becoming significantly more likely as a result of climate change; the Ayeyarwady Delta, Central Dry Zone, and Northern and Eastern Hilly Regions are more likely to experience drought than other areas, whereas Kayah and Shan States had the highest risk of negative impacts in recent periods of severe drought.

Extreme weather events do not become disasters on their own - the level of impact is influenced by the vulnerability of the affected community. This involves complex interactions between environmental and human variables, and this analysis found densely populated districts with less infrastructure investment to be key vulnerability hotspots. Populous coastal areas in Rakhine State and Ayeyarwady and Yangon Regions were found to be at risk of a wider variety of destructive events than other areas.

Activities aimed at reducing disaster risk in Myanmar should carefully consider current as well as projected disaster risks. Further research and data collection are needed to develop effective approaches that can reduce the impact of climate change and environmental degradation on disaster risk for communities. There is a need for consistent data collection on the ground to complement the satellite information used to develop current models estimating the impact of natural disasters and areas at risk. In addition, while vulnerability indexes that have been used for this and other analyses often have similar findings, they would benefit from further validation and fine-tuning.

The Myanmar Information Management Unit / MIMU is a service of the United Nations provided by United Nations Development Programme (UNDP) working together with the UN Resident and Humanitarian Coordinator. It supports the information management needs, analysis and decision-making of the humanitarian, development and peace-focused actors across Myanmar.

For further information on the data and methodology used in preparation of this Analytical Brief, as well as other relevant products to support information and analysis (dataset), please see https://themimu.info/environmental-analysis

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