Myanmar Information Management Unit

Climate, Environmental Degradation and Disaster Risk in Myanmar

Methodology guide - May 2022

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Introduction

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. The main census/surveys used are:

Areas at risk

- Floods - SERVIR-Mekong Historical Flood Analysis Tool
- Cyclones - Global Risk Data Platform
- Drought – Various data sources (meteorological, agricultural, etc.)
- Landslides - NASA Socioeconomic Data and Applications Center (SEDAC)

Potentially exposed population

- 2021 projections from 2014 Housing & Population Census

Vulnerability

- MIMU-HARP-F Vulnerability Index
- 2014 Population and Housing Census
- 2019 Intercensal Survey
- ACLED (conflict events)
- UN Sources (displacement)

All results presented are from the main national level surveys/census.

The software used for this Analytical Brief are:

- R and Excel for the Data Analysis and
- R and Tableau for the Data Visualisations.

I. Vulnerability Index

Vulnerability scores were calculated at the district level using the MIMU-HARP-F Vulnerability Index developed in 2016. Data for comparing between the original vulnerability assessment in 2016 and this analytical brief can be found on the 2016-21 Vulnerability and 2016-21 Change tabs. The index is calculated as an average of the following indicators:

Indicator	Source
Female (15 and over) literacy rate	2019 Intercensal Survey
Child dependency ratio	2019 Intercensal Survey
Percent of population (25 and over) with a middle school education	2014 Census
Percent of population (10 and over) with an ID card	2014 Census
Percent of households with safe sanitation	2019 Intercensal Survey
Percent of households with an improved drinking water source	2019 Intercensal Survey
Percent of households with a roof and walls of high-quality materials	2019 Intercensal Survey
Percent of the population (10 and over) working as unpaid family workers	2019 Intercensal Survey
Percent of households with access to electricity	2019 Intercensal Survey
Conflict index	ACLED (2019-2021)

Data was primarily taken from the 2019 Intercensal Survey (ICS) and the Armed Conflict Location and Event Data Project for 2019-2021. When the Index was developed it was calculated at the township level using data from the 2014 Census; however, calculations were done at the district level for this brief because the ICS data is not available at the township level. The percent of the population with a middle school education was collected for the ICS but was not made available at the district level and the percent of the population with an ID card was not collected at all, so this analysis used data from the 2014 Census for those indicators. This is discussed further in the Vulnerability Limitations section.

Some indicators were modified slightly from the original index based on differences between the 2014 Census and the 2019 Intercensal Survey:

- No households were listed as having earth rooves in the 2014 Census, but several were listed that way in the 2019 ICS. These were counted as low-quality roofing materials, in alignment with the materials for walls (very few households used these materials, so it did not have a significant effect on the percentages).
- The varieties of sanitation systems recorded were slightly different; designations of "improved sanitation" were based on categories from ICS Union Report.[1]
- Similarly, there was variation in the categories of drinking water facilities recorded. Discussion of what constitutes "improved drinking water" and how the indicator has changed over time can be found in the MIMU Drinking Water brief methodology.[2]
- Some townships changed districts between 2016 and 2021. For example, Matupi and Paletwa Township in Mindat District in Chin State were moved into the newly formed Matupi District in 2017. To keep comparisons consistent when comparing against the MIMU-HARP-F Vulnerability Assessment, the 2016 district vulnerability scores were determined by aggregating the 2016 township-level data based on the 2021 district assignments.

In addition, there were some minor modifications to the Conflict Index. Details on how the conflict index was developed can be found in the methodology annex of the MIMU-HARP-F Vulnerability Assessment.[3] For this analysis, data on internally displaced people was based on the UN sources.

The conflict index is calculated by creating percentages for four indicators based on the maximum value for each indicator: Displaced population, Number of events of violence against civilians, Number of battles, and Number of fatalities as a result of conflict. These percentages are then averaged to create a conflict index ('Conflict Index B'), the multiplicative inverse of Conflict Index B is calculated, and then a final percentage is calculated for each district by dividing the inverse of Index B by the highest inverse value ('Conflict Index C'). Conflict Index C is then used for calculating the district vulnerability score.

The steps in calculating the conflict index for a district i can be seen in the equations below, where a is the number of displaced people in the district, b is the number of incidents of violence against civilians, c is the number of battles, and d is the number of fatalities as a result of conflict.

$$Conflict\ Index\ B = \left(\frac{a_i}{\max(a)} + \frac{b_i}{\max(b)} + \frac{c_i}{\max(c)} + \frac{d_i}{\max(d)}\right)/4$$

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[1] Department of Population, Ministry of Labour, Immigration and Population. "2019 Intercensal Survey: Union Report." December, 2020. The report in English can be accessed here: https://myanmar.unfpa.org/sites/default/files/pub-pdf/inter-censal_survey_union_report_english.pdf

[2] MIMU. "Changing Sources of Drinking Water in Myanmar (2014-2019): Methodology guide." February, 2021. The report in English can be accessed here: http://www.themimu.info/sites/themimu.info/files/documents/Methodology_Guide_Analytical_Brief_Drinking_Water_09Feb2021_ENG.pdf

[3] HARP-F and MIMU. "Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps." 2018. The report in English can be accessed here: https://themimu.info/vulnerability-in-myanmar

$$Conflict\ Index\ B\ Inverse = 1/\begin{Bmatrix} 110\ if\ Index\ B = 0 \\ 100\ if\ Index\ B > 0\ and < .1 \\ else\ \frac{1}{Index\ B} \end{Bmatrix}$$

$$Conflict\ Index\ C = \frac{Index\ B\ Inverse_i}{\max\ (Index\ B\ Inverse)}$$

In the original version of the vulnerability index, districts with 0% in Conflict Index B were assigned an inverse value of 620, and districts with 0.5% were assigned 615. This served to emphasize the difference between districts with any conflict in 2015-2016 and districts with no conflict at all, as conflict incidents were concentrated in a few parts of the country. As almost all districts had some conflict incidents in 2019-2021, and there were several districts between 0 and 1% in Conflict Index B, this was adjusted so that districts with 0% in Conflict Index B were given an inverse value of 110, and districts between 0 and 1% were given an inverse value of 100. This reorients the final index slightly to better show the relative differences between districts with varying levels of conflict.

I.A. Vulnerability Limitations

The vulnerability index was developed as a general tool for assessing vulnerability to a wide range of hazards. The estimates are generally in line with other general vulnerability estimates for Myanmar. One of the major limitations of the conflict index is the lack of data on displacement in Myanmar. Displacement data from UN sources for this period includes people in officially designated camps and is thus missing people in some areas affected by conflict in 2021 (e.g . Sagaing Region). An attempt was made to estimate this data based on the ACLED dataset, but this was not feasible as ACLED includes only general displacement figures.

Despite these limitations, the displacement data was included because it does give valuable information about vulnerability in districts with established IDP camps, especially in Rakhine, Kachin, and Kayin States. If this data were left out, vulnerability in these areas would likely be underestimated relative to areas with high levels of recent conflict. In this way, the index does represent both districts with a high number of conflict events and some districts where many conflict-affected people have fled to. We should therefore note that vulnerability will be underestimated in some districts with recent displacement that has not been reported by UN sources.

The 2019 Intercensal Survey was collected as a sample of households, and thus does not include information about people living in monasteries, schools, displacement camps, or other institutional residences. District population was taken from the population projections based on the 2014 Census. These projections were validated against the 2019 ICS data and found to be accurate but cannot account for recent factors like conflict that influence where people are located.

Two of the indicators used in the vulnerability index were not available from the 2019 ICS data – percent of the population with a middle school education was not reported at the district level and percent of the population with an ID card was not collected. Data from the 2014 Census was used for these two indicators instead. The middle school completion rate is highly correlated with the female literacy rate, which saw minimal change from 2014 to 2019, so the lack of 2019 data likely has a limited effect on the vulnerability scores. As this indicator includes all people over the age of 25, the population considered will not change very much in a five-year period, so unless there was a major push for adult education up to the middle school level, one would expect it to change slowly.

Unfortunately, the percent of the population with an ID card was not correlated with any other indicators, so the change in this indicator since 2014 is impossible to estimate. Based on literature review and expert consultation it seems unlikely that this has changed a significant amount, any improvements were almost certainly much smaller than those seen for other indicators such as access to electricity.

Finally, four districts were not enumerated in the 2019 ICS because of ongoing conflict – Mrauk-U and Maungdaw in Rakhine State and Hopang and Matman in Shan State. As such they have been assigned a vulnerability score of NA in this analysis. However, based on their human development indicators from the 2014 Census and the fact that they were too conflict-affected for data collection in 2019, it is likely that a high proportion of the residents in these districts can be considered vulnerable.

II. Natural hazard calculations and limitations

II.A. Floods

The SERVIR-Mekong Historical Flood Analysis (HFA) Tool assigns a flood probability of High, Moderate, or Low to every township in Myanmar, based on flood data from 1984-2018.[4] To convert this into a district-level indicator the census population projection for 2021 was used to determine the number of people per district in townships with High, Moderate, and Low probability of flooding. The probability with the most people was assigned as the value for the entire district. As flood risk is geographically correlated, in almost all districts one risk level was clearly dominant. Because flood probability was presented in this dataset as a categorical variable, it was not possible to combine it with the vulnerability and exposure estimates from the vulnerability index to estimate the district-level flood risk.

The district-level flood probability calculations can be found on the Historical Flood Probability tab of the Climate, Environmental Degradation and Disaster Risk in Myanmar dataset.

II.B. Cyclones

Cyclone data was obtained from the Global Risk Data Platform, which divides cyclone hazard into Wind and Storm Surge hazard. The wind frequency is calculated based on historical data from 1970-2009 for Saffir-Simpson Category 5 cyclones, and the storm surge frequency is calculated based on data from 1975 to 2007 for Saffir-Simpson Category 1 cyclones. Both hazards are available as raster datasets;[5] the method for transforming this data into a categorical variable of cyclone risk based on administrative boundaries was adapted from the methodology for the SERVIR-Mekong HFA Tool.[6]

For each individual hazard type, the pixel values representing the hazard frequency were summed for each district and then divided by the district area. As the pixel values for the two hazards were on different scales, the district-level values were converted to percentages by dividing by the largest district value for each hazard type (the same as the envelope method for the Conflict Index). These two percentages were then summed for the district-level hazard score, which was then multiplied by the estimated vulnerable population to estimate cyclone risk. Districts were assigned a cyclone risk ranking between 1 and 6 based on data exploration, with 6 corresponding to negligible cyclone risk.

The following equation describes the calculation of cyclone risk for an individual district j, where w is the wind hazard value for an individual pixel, n is the number of pixels per district, A is the area of the district, W is the district cyclone wind hazard, S is the district cyclone storm surge hazard, and P is the number of vulnerable people in the district.

$$W_j = \frac{\sum_{i=1}^{n} w_i n_i}{A_j}$$

$$S_j = \frac{\sum_{i=1}^{n} w_i n_i}{A_j}$$

$$Cyclone\ risk = \left(\frac{S_j}{\max(S)} + \frac{W_j}{\max(W)}\right) \times P_j$$

[4] The original township-level data adapted for this brief can be found at https://servir.adpc.net/tools/historical-flood-analysis-tool.
[5] Cyclone data can be accessed at: https://preview.grid.unep.ch/index.php?preview=data&events=cyclones&lang=eng
[6] Phongsapan, K., Chishtie, F., Poortinga, A., Bhandari, B., Meechaiya, C., Kunlamai, T., Khun San Aung, Saah, D., Anderson, E., Markert, K., Markert, A., and Towashiraporn, P. "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.

The summed raster data is labeled as "Wind Frequency" and "Storm Surge Frequency" on the Cyclone Risk tab of the Climate, Environmental Degradation and Disaster Risk in Myanmar dataset; the columns represent the intermediate values as presented in the above equations. For the final "Cyclone Risk Ranking," 1 corresponds to the highest cyclone risk, and 6 represents the lowest possible cyclone risk.

- The focus on storm surges and wind damage means that the relationship between landslides, floods, and storms is not investigated in this analysis, a gap that requires more dedicated research in the future.
- The time boundaries of the dataset mean that cyclones that did notable damage in Myanmar in 2010, 2016, and 2017 were not included in the analysis.
- The models used for cyclone risk estimates are based on global satellite datasets, and do not incorporate field research on important factors such as water dynamics and protective vegetation such as mangroves. This is a consistent problem for natural hazard analysis in Myanmar, as there is very little countrywide data on water resources.

II.C. Drought

Of the hazards analyzed in this brief, drought is the most complex to identify because of the different varieties (meteorological, agricultural, etc.) and because it occurs over a longer time period. Past research on drought in Myanmar has mostly focused on specific areas, especially the Central Dry Zone, or has analyzed the effects of specific drought events. Most data sources focus on meteorological drought as it is the easiest to classify, but also provides the least insight into the conditions for people and ecosystems. For instance, agricultural drought conditions were widespread across Myanmar in 2010 because of extreme heat in May, but there was no meteorological drought because the country still experienced average rainfall that month.[7]

Countrywide data on drought probability is extremely limited; some data sources do not provide granular enough data to be useful at the subnational level,[8] some are categorized by outdated administrative boundaries,[9] and some are not available in formats that can be manipulated for additional data analysis.[10] As with other data on natural hazards in Myanmar, countrywide data is heavily reliant on remote sensing and there has been little validation with on-the-ground research.

Based on these difficulties, this brief does not include a formal, district-level estimate of drought risk. Instead, it highlights parts of Myanmar that other research has identified as having a high frequency of agricultural or meteorological drought and connects that research to estimates of vulnerable people based on the Vulnerability Index.

II.D. Landslides

Landslide data was obtained from the NASA Socioeconomic Data and Applications Center hosted at Columbia University, which provides global raster data of landslide hazard.[11] Landslide probability is estimated based on a model from the Norwegian Geotechnical Institute and incorporates slope, soil moisture, precipitation, and other factors that affect landslide likelihood. Landslide probability is reported as a ranking from 2 to 10, with values below 5 representing negligible landslide risk.

To calculate landslide risk in Myanmar this brief used a similar methodology as for cyclones. Pixel values were aggregated for a district by summation, divided by the district area, and then multiplied by the district vulnerable

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[7] Worldwide Fund for Nature. "Assessing Climate Risk in Myanmar: Technical Report." March, 2017.
[8] World Bank Group. "Climate Change Knowledge Portal." Accessed 28 Jan, 2022.
https://climateknowledgeportal.worldbank.org/country/myanmar/vulnerability.
[9] Global Facility for Disaster Risk Reduction. "ThinkHazard!." June, 2020. Accessed 23 February, 2022.
https://thinkhazard.org/en/. ThinkHazard! provides categorical data at the district level, but district boundaries are based on FAO's GAUL dataset from 2015 which is now out of date. In addition, it is missing or mislabels some districts that did exist in 2015, such as Mrauk-U.
[10] Food and Agriculture Organization. "Agricultural Stress Index System (ASIS)." Accessed 2 March, 2022.
http://www.fao.org/giews/earthobservation/. Raster data is only available from this service in the WMS format, which does not allow data to be extracted for additional analysis, such as combining it with vulnerability and exposure to estimate risk.
[11] Landslide data can be accessed at: https://sedac.ciesin.columbia.edu/data/set/ndh-landslide-hazard-distribution

population. Districts were then assigned a ranking for landslide risk from 1-10 based on data exploration, with 1 corresponding to no detectable landslide risk and 10 representing the highest landslide risk in the country. This ranking is found on the Landslide Risk tab of the Climate, Environmental Degradation and Disaster Risk in Myanmar dataset in the risk_level column.

The equation below describes the calculation of landslide risk for an individual district j, where l is the landslide probability ranking for an individual pixel, n is the number of pixels per district, A is the area of the district, and P is the number of vulnerable people in the district.

$$L_j = \frac{\sum_{i=1}^{n} l_i n_i}{A_j} \times P_j$$

Although landslides are a more localized hazard than the others included in this analysis, there is still value in estimating landslide risk at the district level. Landslides often affect transportation networks and other infrastructure that can have spillover effects on a larger area and repairing landslide damage often requires resources from beyond the immediate location of the landslide as well.

One weakness of the dataset is that it was developed in 2005, based on satellite data from 2000. While some areas have not changed significantly in that time, parts of Myanmar have seen significant deforestation and construction of roads, dams, and mines, all of which can increase landslide risk. Many of the deadliest landslides in Myanmar occur at mining sites, where poor regulation and management practices lead to landslides even without excess precipitation or earthquakes.[12] Although it is possible to estimate landslide risk from satellite data, that level of detail is not feasible for a global dataset. Therefore, additional research estimating landslide risks specifically in Myanmar could be very beneficial for disaster risk preparedness.

III. Climate Change and Environmental Degradation

Data on temperature change projections for Myanmar referenced in this brief were obtained from the World Bank's Climate Change Knowledge Portal. Temperature projections from the SSP1 – RCP1.9[13] pathway from the Intergovernmental Panel on Climate Change's sixth report were referred to as the "optimistic" or "low carbon" scenario in the brief, and SSP5 – RCP8.5[14] was referred to as the "pessimistic" or "high carbon" scenario.

The dataset includes the expected change in average temperature per month by decade, based on a reference period from 1995 to 2014. For this brief, expected seasonal temperature change was calculated as the average change for the months typically associated with each of Myanmar's three seasons: The hot season is March to May, the wet season is June to October, and the cold season is November to February.

Projections of sea-level rise and annual flooding for 2050 were taken from Climate Central's Coastal Risk Screening Tool. The settings selected were: the IPCC 2021 report as the projection data source, areas protected by ridges were not shown as threatened, luck was set as "medium" and projections were based on the current carbon emissions pathway.[15]

Forest loss data was obtained from the University of Maryland Global Land Analysis and Discovery Lab in partnership with Global Forest Watch. Total forest loss from 2001 to 2020 was calculated by summation of all townships in a district for all years. For example, the forest loss in district i which contains n townships would be calculated as:

$$District_i\ forest\ loss = Township_1 2001\ Loss + \ Township_1 2002\ Loss \ldots Township_n 2020\ Loss$$

Depending on the quality of forest management practices in different parts of the country, this may overestimate forest loss in some areas where forests were harvested, replanted, and harvested again within the time period covered by the

[12] Lin, Y.N., Park, E., Wang, Y., Quek, Y.P., Lim, J., Alcantara, E., Loc, H.H. "The 2020 Hpakant Jade Mine Disaster, Myanmar: A multi-sensor investigation for slope failure." 2021. ISPRS Journal of Photogrammetry and Remote Sensing.
[13] Shared Socioeconomic Pathway 1 – Representative Concentration Pathway 1.9, from the World Climate Research Programme's Coupled Model Intercomparison Project.
[14] Share Socioeconomic Pathway 5 – Representative Concentration Pathway 8.5
[15] Additional details on the variability of sea-level projections and the limitations of this tool can be found in the Details and Limitations section of any map produced at https://coastal.climatecentral.org/

data. This also does not calculate forest loss as a percentage of original forest area or the amount of forest coverage remaining in 2020, both valuable components of assessing deforestation and the most important remaining areas for conservation.

The maps on ecosystem services from forests included in the brief were taken from analysis done by the Natural Capital Project at Stanford University using their Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) Tool. These maps represent the location of forests providing different ecosystem services to people in Myanmar, with darker blue representing more valuable forests. They do not necessarily represent the locations of the communities benefiting from these services, as forests can play an important role in managing water availability or quality for a large watershed.[16]

The United Nations Environment Programme provides data on freshwater ecosystems from 1984 to 2019 through their Freshwater Ecosystems Explorer.[17] Unfortunately, this data is again tied to the outdated GAUL administrative boundaries, and cannot be used below the State and Region level in Myanmar. In addition, these subnational data do not align with the summary information in the Sustainable Development Goals 6 portal,[18] even though both are supposed to represent Sustainable Development Indicator 6.6.1: Spatial extent of water-related ecosystems over time. Therefore, this brief only includes data at the national level for this indicator.

[16] For additional details on the InVEST Tool and methodology for producing these maps, see 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. PLoS ONE.

[17] Data from the Freshwater Ecosystems Explorer can be accessed at: https://www.sdg661.app/map

[18] Sustainable Development Goal 6 data for Myanmar can be found at: https://sdg6data.org/country-or-area/Myanmar