IDENTIFYING VULNERABLE COMMUNITIES AND SAFE ISLANDS IN THE MALDIVES

OVERVIEW

By combining AI-based population analysis and climate projections, Microsoft's AI for Good Lab and IOM Maldives identified populations at risk from sea level rise, finding roughly 9,000 people (4% of population outside the capital) who may be in vulnerable areas by 2050.

Five specific islands were identified as "safe" with minimal sea level rise risk, supporting IOM's efforts to propose relocation sites for vulnerable communities.

This data-driven approach to disaster risk reduction (DRR) provides a valuable tool for policy development, long-term relocation strategies, and enhancing the Maldives' National Adaptation Plan (NAP).

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BACKGROUND AND CONTEXT

The Maldives is an archipelago of 1,192 coral islands grouped into 26 atolls in the Indian Ocean, administratively governed as 20 atolls. Renowned for its rich biodiversity, including vibrant coral reefs, seagrass beds, and mangroves, the Maldives is also one of the countries most vulnerable to the impacts of climate change.

With a population of 515,000 (Census 2022), the Maldives is a middle-income economy heavily reliant on tourism, fisheries, and construction. One-third of the population consists of migrants, mainly from Bangladesh, India, and Sri Lanka, along with increasing numbers from the Philippines, Indonesia, and Thailand. It's estimated that more than 65,000 migrants are irregular, contributing to informal sectors.

While the tourism industry drives economic growth, income inequality and regional disparities persist, with smaller islands facing limited access to services. Climate change further exacerbates socioeconomic vulnerabilities, threatening livelihoods, infrastructure, and the well-being of both local and migrant communities.

As the Earth warms, the sea level is projected to rise by anywhere from 0.3 to 1.0 meters.[1] The majority of the Maldives lies below 1 meter above sea level, meaning that rising sea levels pose a significant threat to the country's future, which hinges on balancing economic growth, political stability, and sustainable environmental adaptation.

To help the country prepare for this impending threat, Microsoft's AI for Good lab has partnered with the Maldives team of the International Organization for Migration (IOM), the leading organization within the United Nations promoting safe, orderly, and regular migration for the benefit of all. In this partnership, we have identified specific locations on islands where people and buildings may be at climate disaster risk of sea level rise and increased coastal flooding.

However, not all islands on the Maldives have the same risks due to sea level rise. In addition to quantifying populations at risk of sea level rise, we are also able to identify "safe islands" – islands that may have lower risk of sea level rise in the future and therefore could be good candidates for well-planned relocations of vulnerable communities.

IMPLICATIONS FOR POLICY AND PLANNING

This island risk assessment could serve as a valuable tool for policy development, future planning, and sustainable development efforts in the Maldives. Identifying safer islands with minimal sea level rise risk can support long-term relocation strategies and infrastructure planning. Additionally, this data can be aligned into the Early Warning for ALL (EW4ALL) framework and the National Adaptation Plan (NAP) to enhance disaster preparedness and climate resilience. However, given the reliance on forward-looking climate projections, it is essential to periodically update the model to reflect evolving climate conditions and newly available data for more informed decision-making.

This analysis of safe islands in the Maldives is an example of a data-driven approach to disaster risk reduction (DRR). DRR aims to reduce the negative impacts of hazards through systematic efforts to analyze and manage causal factors of disasters. This includes reducing exposure to hazards, lessening the vulnerability of people and property, wise management of land and the environment, and improving preparedness for adverse events.

In the context of climate change and its associated impacts, such as sea level rise, DRR is crucial for the survival and well-being of vulnerable communities. Proactive relocation of communities to safer areas, like the "safe islands" identified in this document, is a key DRR strategy. This approach minimizes exposure to hazards like coastal flooding and reduces the vulnerability of people and infrastructure to the impacts of sea level rise. By identifying and relocating to safe islands, the Maldives is taking concrete steps towards ensuring the long-term resilience and sustainability of its communities in the face of climate change.

To achieve these policy goals and implement effective DRR strategies, we developed a novel approach combining climate projections with AI-based population density analysis. The following section details our methodology.

[1] 2018: mpacts of 1.5°C Global Warming on Natural and Human Systems

COMBINING CLIMATE PROJECTIONS WITH AI-BASED POPULATION DENSITY

To provide the data-driven insights necessary for effective policy planning and DRR strategies, we developed a methodology that combines climate projections with AI-based population density analysis.

We identified areas with sea level rise using the Deltares Sea Level Rise and Coastal Flooding database.[2] This dataset uses climate projections to forecast coastal inundations due to sea level rise and storm surges in the year 2050, based on the current climate trajectory.

We combine this data with population hotspot data from an AI model developed by the AI for Good lab.[3] The model predictions allow us to generate a high resolution (roughly 40 meter resolution), temporal dataset, meaning it allows us to track where people are at the level of individual buildings over time. We convert this dataset to population counts by normalizing the data to the 2022 Maldives census.[4]

By combining and comparing these two datasets, we can identify vulnerable communities, specifically, people who are living in areas that may be affected by sea level rise by 2050.

We can also do the opposite to identify "safe islands", or islands with minimal sea level rise risk. Note that because the sea level rise model we are using relies on forward-looking climate projections, the results should be interpreted with caution. While we believe the model to be generally accurate, areas currently identified as "safe" could be subject to change as climate conditions change or as new data becomes available.

Identifying Vulnerable Communities

One area with a significant amount of people at risk is Addu City in the south of the Maldives. Figure 1 shows the sea level rise and population hotspots for three time stamps: 2018, 2020, and 2023. Over 5,000 people, or 30% of all people in Addu City, live in at-risk areas. This is one of the areas in the Maldives with the largest concentration of vulnerable populations.

Within the capital city of Male and especially Hulhumale, there is a significant population marked as at-risk. However, Hulhumale is a reclaimed island that was developed in response to sea level rise threats. With elevation over 2 meters above sea level, the island is relatively protected from the effects of climate change. Our sea level rise risk projections have a key limitation: they do not account for such engineered protections. This means our data overstates the risk to Hulhumale's population. Given these artificial flood defenses, we exclude Hulhumale's residents from our climate disaster risk calculations.

Figure 1: *People at sea level rise risk in Addu City. There is significant overlap between the population map and the projections of sea level rise (red), meaning there are population in Addu City at risk. We estimate over 5,000 people, or roughly 30% of the population in this area, is at risk of sea level rise.*

[2] Planetary computer and Deltares global data (ai4edatasetspublicassets.blob.core.windows.net)

[3] Ferres, Juan M. Lavista, and William B. Weeks. Mapping Population Movement Using Satellite Imagery, in AI for good: applications in sustainability, humanitarian action, and health. John Wiley & Sons, 2024, Ch. 30.

[4] https://census.gov.mv/2022/

In total, we find that outside of the capital city and neighboring islands, nearly 9,000 people are in at-risk areas, or about 4% of this population. We note that this may underestimate the number of people at risk of climate-induced effects, since there is considerable pluvial (rain-driven) flooding on many islands, which is not captured in our data. The full results for individual islands of interest and the country as a whole are in Table 1 in the Appendix.

Identifying Safer Islands

The IOM Maldives team had several candidate islands to evaluate for sea level rise risk as potential "safe islands" that could be used to relocate vulnerable communities to.

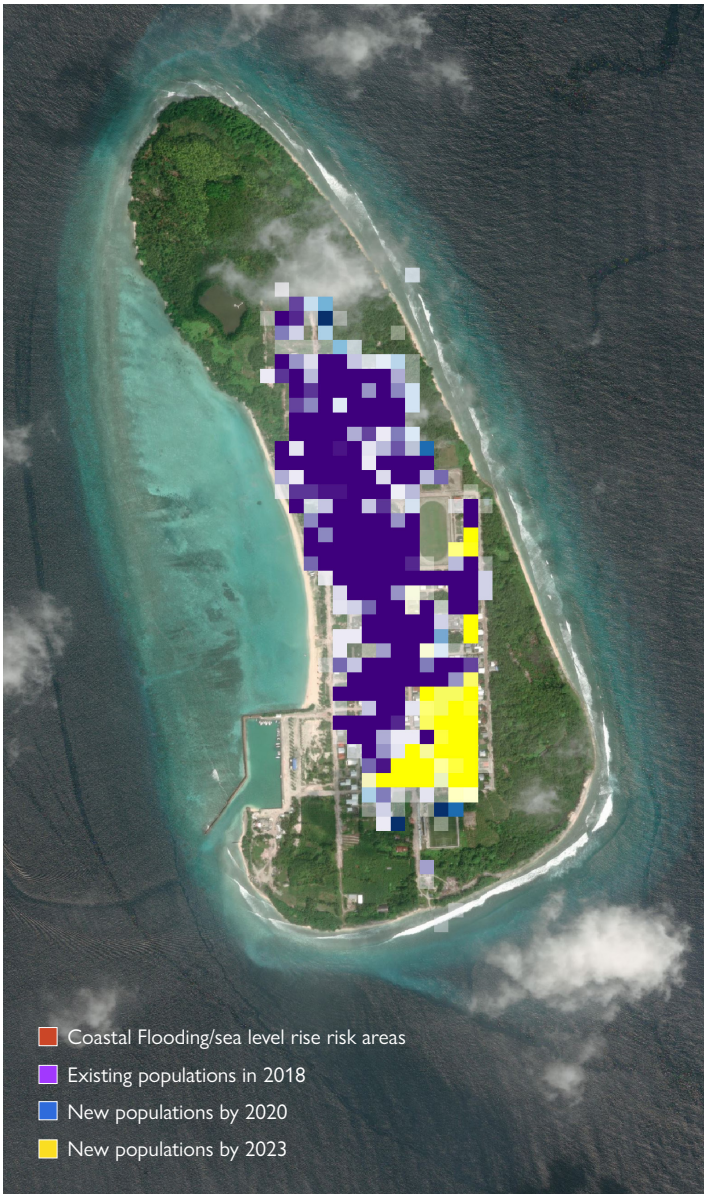

Figure 2: *People at risk in Sh. Milandhoo, a potentially safe island. The lack of the red, sea-level rise layer indicates that this island is projected to be safe from sea-level rise.*

Figure 2 shows the population and sea level rise risk for Sh. Milandhoo. This is one example of an island with minimal risk of sea level rise and coastal inundation. There is currently no projected risk for the island, as evidenced by the lack of the red sea level rise and coastal flooding layer that is visible in Figure 1.

IDENTIFYING SAFE ISLANDS

By repeating this type of analysis for key islands in the Maldives, we were able to confirm the following islands as "safe islands", meaning that the risk associated with sea level rise is lower than for other islands. In fact, for each of these islands we see at most two pixels at risk of sea level rise (roughly 1.6 hectares), meaning the vast majority of the land of each of these islands is projected to be safe from sea level rise and coastal inundation.

- Sh. Funadhoo
- Sh. Milandhoo
- R. Hulhudhufaaru
- D. Kudahuvadhoo
- K. Thulusdhoo

These islands were selected as part of a pilot program as potential relocation sites, and this work helped in confirming these islands as good candidate sites.

In addition to these five islands, we were also able to identify additional potentially safe islands from this preliminary work. Furthermore, we were able to confirm that the islands suspected of having higher climate disaster risk of sea level rise and flooding risk do in fact appear as higher risk in the Deltares projections.

The identification and confirmation of safe islands in the Maldives, as detailed in this report, represent a significant step towards effective disaster preparedness and risk reduction (DRR). These islands offer a tangible solution for relocating vulnerable populations and creating resilient communities that can withstand future sea level rise and coastal flooding events. The pilot program focusing on these "safe islands" can serve as a model for other Small Island Developing States (SIDS) facing similar threats. The scalability of this approach, as highlighted in the document, underscores its potential to contribute to global efforts in addressing climate change and its impact on vulnerable populations.

CONCLUSIONS AND NEXT STEPS

Microsoft's AI for Good lab and the IOM Maldives team collaborated to identify islands with and without climate disaster risk of sea level rise and coastal flooding by 2050. This has helped the IOM team propose potential "safe islands" as potential planned relocation sites that people at risk on other islands in the Maldives could be moved to.

While the current work focused on a subset of islands as part of a pilot program, this approach could scale to all of the Maldives and to any of the Small Island Developing State (SIDS) across the world. Many sea level rise analyses project material increase in sea levels by 2050, with some areas potentially affected by 2030. This leaves these vulnerable communities in a precarious situation, and this type of work can help quickly identify which areas may be at higher or lower risk.

APPENDIX

Table 1. Population, population at climate disaster risk, and percent of population at risk for the Maldives as a whole and islands of intereset identified by the IOM Maldives team. Note that regions with a star (Hulhumale and the Country as a whole) have artificially larger population of risk. This is because the sea level rise layer does not account for the manmade defenses against sea level rise present on the island of Hulhumale

	Population			Population at Risk			% of Population at Risk		
	2018	2020	2023	2018	2020	2023	2018	2020	2023
Addu City	16,581	16,809	15,659	5,506	5,441	5,050	33%	32%	32%
Dhidhoo	2,383	2,503	2,553	90	95	116	4%	4%	5%
Feydhoo	1,205	1,274	1,399	560	582	623	46%	46%	45%
Funadhoo	1,377	1,608	1,876	0	0	0	0%	0%	0%
Fuvahmulah	9,676	10,519	9,177	93	90	0	1%	1%	0%
Hanimadhoo	4,335	3,925	4,116	0	0	0	0%	0%	0%
Hitadhoo	13,628	13,740	12,302	5,345	5,272	4,859	39%	38%	39%
Hulhudhufaaru	1,350	1,483	1,679	0	0	0	0%	0%	0%
*Hulhumale	73,129	83,586	84,474	*57,483	*58,852	*55,969	*79%	*70%	*66%
Kudahuvadhoo	4,766	4,791	5,008	0	0	0	0%	0%	0%
Kuludhuffushi	7,460	7,741	8,052	0	0	0	0%	0%	0%
Male_City	99,993	66,430	94,846	706	682	682	1%	1%	1%
Maradhoo	3,017	3,130	3,406	194	200	221	6%	6%	6%
Milandhoo	1,486	1,489	1,739	0	0	0	0%	0%	0%
Naifaru	2,815	3,039	3,404	0	0	0	0%	0%	0%
Noomara	446	458	416	0	0	0	0%	0%	0%
Rinbudhoo	27	26	26	0	0	0	0%	0%	0%
Thinadhoo	3,816	4,501	4,714	258	287	290	7%	6%	6%
Thulusdhoo	6,328	7,442	7,285	21	16	0	0%	0%	0%
Vaanee	12	9	98	0	0	0	0%	0%	0%
Villingili	7,512	8,029	8,158	0	0	4	0%	0%	0%
*Country	412,443	413,023	438,588	*67,761	*70,326	*66,255	*16%	*17%	*15%
Country (excluding Male and Hululmale)	226,667	247,748	244,794	9,039	9,229	8,880	4%	4%	4%


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