An integrated approach to evaluate population exposure to inland and coastal flooding

SUMMARY

This study endeavors to provide a comprehensive retrospective analysis of the global population's risk to flooding, how it has changed over time, how it changes regionally and how it is expected to change in the future. It combines recently published global population data with the most advanced views of global flood hazards to assess the impacts of the peril from both inland and coastal sources. The analysis assesses the implications of defenses and looks at different return periods to assess the implications of the peril at different probabilities of occurrence. For the present, the study finds that 2.3 billion people are at risk from more than 10 centimeters inland flooding at the 100-year return period, 240 million from coastal flooding respectively. It also finds that the proportion of population exposed to more than 10 centimeters of flood risk has consistently grown across the period analyzed (1975-2030), currently standing at 29%, or about 3-in-10 people globally. Those numbers are expected to grow based upon projected future populations.

Introduction

Flooding is a pervasive and recurrent natural hazard that has far-reaching consequences for both human communities and the environment. The past two decades have witnessed a significant increase in the frequency and intensity of flooding events globally, attributing to a complex interplay of climate change, urbanization, and land-use practices. As flooding continues to pose a growing threat, understanding the populations most vulnerable to its effects is paramount for effective disaster management and mitigation efforts. This study aims to provide a comprehensive retrospective analysis of the populations at risk of flooding over the past 40 years, drawing insights from existing data while also contributing to the expanding body of knowledge on this critical issue.

The rising incidence of flooding events worldwide underscores the urgency of assessing the demographic, geographic, and socioeconomic characteristics of communities exposed to flood risks. The populations vulnerability to flood risk is influenced by a host of factors, including physical location, infrastructure resilience, socioeconomic status, and climate variability. Recognizing these complexities, a robust understanding of the dynamics surrounding flood risk can inform targeted policy interventions and community-focused resilience strategies.

Several studies have laid the groundwork for understanding populations at risk of flooding. From a climate change point of view, research by the World Bank, such as its 2014 report "Turn Down the Heat: Confronting the New Climate Normal," has examined the global consequences of climate change, emphasizing how extreme weather events, including floods, disproportionately affect the most vulnerable populations, exacerbating social inequalities [1]. From a demographic point of view, Jun Rentschler and other researchers published an analysis in 2022 in Nature Communications revealing that a significant proportion of the world's population currently faces exposure to floods that are statistically expected to occur once every century [2]. The study further highlights that a substantial majority of this group resides in countries classified as having low-to-middle income levels. In a 2023 study, the same researchers demonstrated that human settlements have expanded continuously into present-day flood zones since 1985 [3], which implies that many countries amplify their exposure to floods instead of adapting. The authors further suggest that while there is clear evidence that climate change increases the probability of extreme disaster events, it has proven politically expedient to invoke climate change as an external force that places disasters beyond local authorities' influence.

This study, conducted by Insurance Solutions from Moody's, combines population data from the European Commission's Joint Research Center [5] with flood hazard data from the Global Flood Data and Maps product Moody's RMS recently released. The goal is to assess how population growth has affected global exposure to flooding, how growth into areas at risk of flooding varies among countries, the impact of flood defenses on reducing flood risk, and how the impact of flood risk is expected to change based upon future

Data

The findings presented in this research are derived through a methodical synthesis of two globally comprehensive datasets. The first relates to flood hazards and the second to population demographics.

1

GLOBAL FLOOD DATA

In 2023, Moody's RMS released Version 2 of the Global Flood Data and Maps [4]. This dataset encompasses multiple layers of information, capturing the severity of both inland (fluvial and pluvial) and coastal flooding on a global scale. The data provides views of flood risk for eight different return periods from 10 - 1,000 years to understand flood risk at both high and low probabilities of occurrence. Furthermore, for each return period, the data provides expected flood depth information at 10-meter resolution, ensuring a high-resolution and detailed view of location-level flood impacts. Importantly, the dataset includes both defended and undefended views of risk for both inland and coastal flood risks. A flood defense is defined as a standard of protection (SoP), which represents, in terms of return period, the probability of the maximum event the defense can withstand. The Moody's RMS Global Flood Data and Maps reflects flood risk as it stands today, as it is derived on present-day climate and current mitigation strategies. It does not incorporate any potential changes due to factors like climate change or socioeconomic shifts.

Fluvial flooding is defined as the flooding triggered by excessive discharge in major rivers, and therefore it occurs mainly in river floodplains. Pluvial flooding is the flooding that occurs due to excessive precipitation or excessive discharge in minor rivers and streams and can occur anywhere. Coastal flooding is defined as flooding induced by storm surges (wind driven) and tides (non-wind driven). Return period is defined as the inverse of the probability of occurrence, for instance a 100-year return period represents a 1% chance in any given year.

2

GLOBAL POPULATION DATA

In 2023, the European Commission's Joint Research Center released an updated version of its Global Human Settlement Layer [5]. This data presents a breakdown of population measured in terms of number of people per grid cell with a resolution of 100 meters by 100 meters. This is based on population figures spanning from 1975-2020, taken at intervals of five years, and includes projections for 2025 and 2030, all of which are derived from NASAs fourth version of the Gridded Population of the World data set, the CIESIN GPWv4.11 dataset [6]. These estimates and projections have been broken down from larger census or administrative units to individual grid cells. This disaggregation process is guided by factors such as the distribution, density, and classification of built-up areas as represented in the Global Human Settlement Layer for each corresponding period.

Methodology

The Global Flood Data and Global Population Data are available at different resolutions — 10 meters and 100 meters, respectively. For this reason, the population at risk of flooding is calculated first by downscaling the 100-meter population data to 10-meters, assuming a uniform population distribution within each cell, and then counting the population within the 10-meter cells that are overlapped by the flood data.

The analysis conducted in this paper is primarily carried out at the global and the regional level, but for certain instances it delves into a more detailed examination at the national level. For the analysis throughout this paper, the world's countries are categorized into six regions for ease of reference. However, the composition of these regions doesn't strictly adhere to continental boundaries. For instance, Russia, despite its transcontinental status, falls within the Europe & North Asia-designated region. The regions are North America, Latin America, Europe & North Asia, Africa, South Asia & Middle East, and Oceania. Figure 1 provides a visual representation of these regions' geographical territories in a world map.

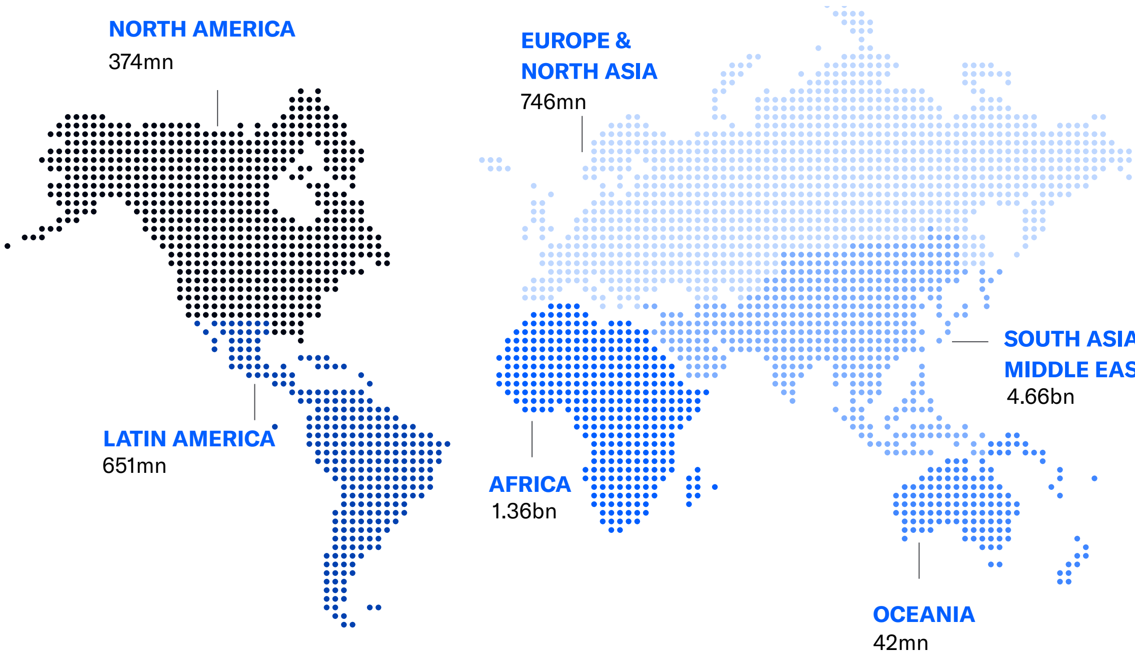


Figure 1 *Geographical territories world map with respective total population by region. Total global population in 2020 was 7.84billion.*

Present-day picture

Moody's estimates that approximately 2.4 billion individuals live in locations that are exposed to inland (fluvial and pluvial) flood risk, at the 100-year defended return period, representing just over 31% of the global population. For nearly 2.3 billion of those individuals, that risk is greater than 10 centimeters and represents about 29% of the world's population.

Concurrently, approximately 260-million people are exposed to non-zero risk from coastal flooding at the same return period and over 70% of those individuals live in just 5 countries. Furthermore, for about 240 million of those individuals, that risk is again greater than 10 centimeters representing just over 3% of the world's population.

With an increased flood depth of over 50 centimeters based on the same once-in-a-century frequency, the affected population is estimated to be approximately 655 million for inland flooding and 200 million for coastal floods.

For comparison, a separate study conducted in 2022 utilizing a different dataset found that around 1.81 billion people, or 23% of the global population, are vulnerable to floods that occur once in 100 years and have a depth exceeding 15 centimeters [2]. In a similar study, Nature Communications published research by Laura Devitt and others in 2023 revealing that 1.4 billion people worldwide are exposed to river flooding that happens once every 100 years [7].

Given that these investigations employ varying hazard and demographic data and operate under distinct assumptions, it's inevitable that the outcomes display a degree of variability. Nonetheless, the overarching narrative persists: A significant portion of the population is impacted by some form of flood risk. Moreover, as the following analysis will show, this trend is projected to continue its upward trajectory into the future.

The Moody's analysis results at the sub-global scale reveal a stark disparity in flood risk across regions, with some being much less exposed than the global average, while others are far more exposed. Perhaps unsurprisingly, South Asia stands out as the most flood-prone region, with almost 40% of its inhabitants susceptible to non-zero inland flooding at the 100-year return period level. South Asia also tops the list when it comes to coastal flooding, with just over 5% of its population at risk at the same return period. Conversely, when it comes to inland flooding, Oceania is the least exposed region with just under 17% of its population at risk. While from a coastal perspective, Europe with North Asia has the smallest proportion of population at risk with a scant 0.27% facing potential coastal flood threats. The other continents' flood risk exposure falls between that of South Asia and Oceania. However, as illustrated in Figure 2, there is a pronounced contrast between South Asia and the rest of the world in terms of population exposed to non-zero hazard for both inland and coastal flood risk.

Moody's estimates that today approximately 2.7 billion individuals live in locations that are at risk of inland or coastal flooding at the 100-year defended return period. That is more than 1 out of 3 people globally.

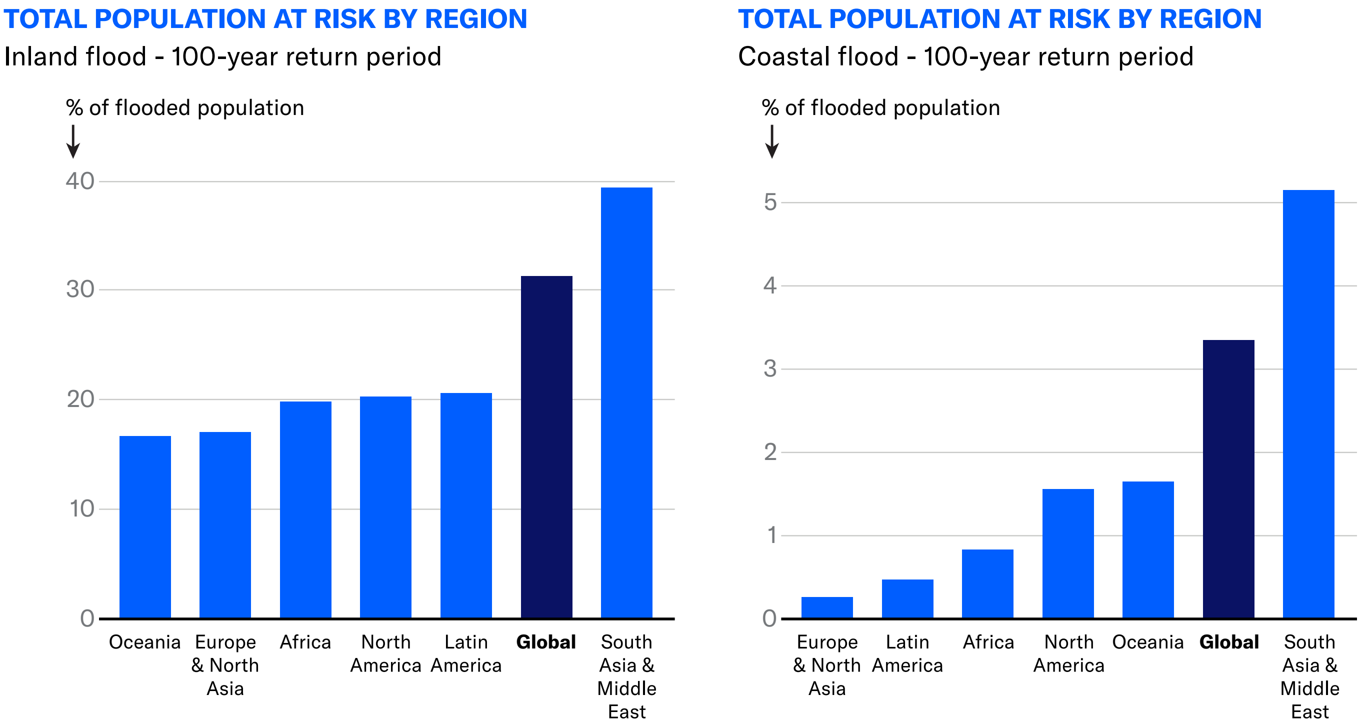
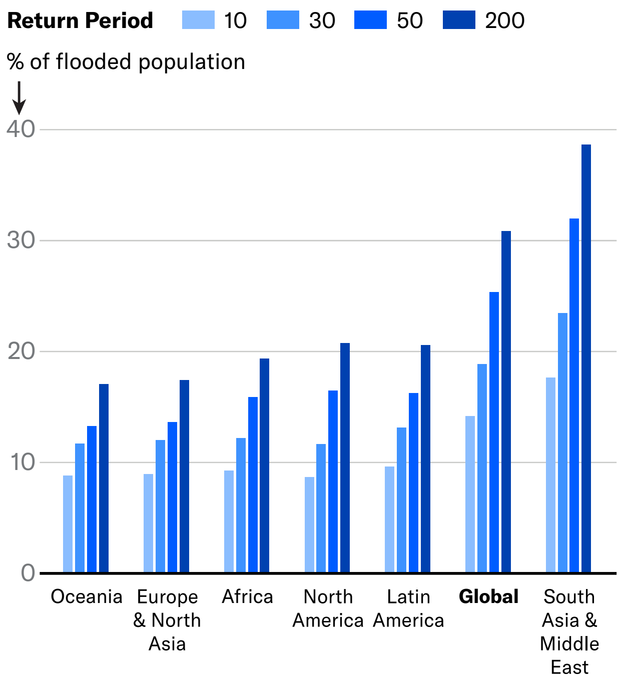


Figure 2 *Population at risk as a percentage of total population for different regions. Based on 2020 population and 100-year defended return period. Inland flood (left) and coastal flood (right).*

Digging deeper into the percentage of the population at risk of flooding, Figure 3 demonstrates the percentage of population at risk of flooding across four return periods, including the 10, 30, 50 and 200-year. In this analysis, a similar result is observed to that presented in figure 2. For inland flooding, the plot shows a gradual increase in the percentage of population at risk for increasing return periods. The only notable exceptions are Europe and Oceania, where the percentage of flooded population does not change much from the 30-year to 50-year return period. Several factors could explain this difference, including the unique distribution of population in flood plains or the distinct topographies that might restrict floodplain extension in these regions. Another plausible explanation is the presence of flood defenses. If a significant part of the population is shielded from up to a 50-year fluvial flood event, the difference in flood-affected population between the 30- and 50-year return periods would be minimal, with pluvial flooding being the main contributor. There is a similar pattern in Europe regarding coastal flood exposure.

TOTAL POPULATION AT RISK BY REGION AND RETURN PERIOD

Inland flood



TOTAL POPULATION AT RISK BY REGION AND RETURN PERIOD

Coastal flood

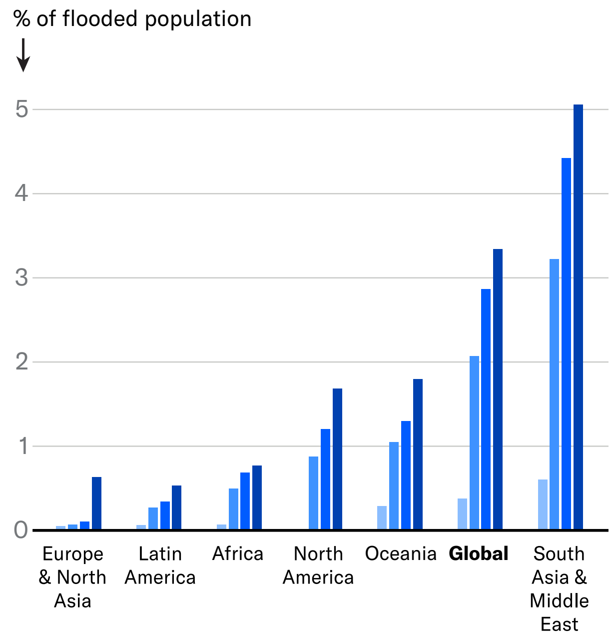


Figure 3 *Population at risk as a percentage of total population for different regions and return periods based on 2020 population. Inland flood (left) and coastal flood (right).*

Here, the population percentage remains nearly unchanged up to the 50-year return period scenario but sees a sharp increase at the 200-year return period scenario. Similarly, North America's population exposed to 10-year coastal flood events is remarkably low (0.01%). This should however not be confused with property at risk, where in some regions the population exposed to frequent coastal flooding is low but the proportion of high value homes being affected leads to more headline news.

Table 1 offers a comprehensive overview of the global population that is vulnerable to flooding across various return periods, considering the presence of defenses. Interestingly, when considering a 1,000-year return period, the population exposed to inland flooding increases by approximately 1.1 billion compared with the 100-year. At this extreme return period over 4-in-10 of the world's population are considered at risk of inland flooding. Considering the same extreme for coastal flooding the exposed population increases by approximately 160-million and puts an additional over 1-in-20 at risk . This represents an increase of approximately 35% and 65% for inland and coastal flood risk, respectively. However, when looking at the population exposed to the more frequent flooding, we can observe a large gap between the population exposed to flooding at a 10-year return period and the population exposed at a 30-year return period for both inland and coastal flooding. For inland flooding the population at risk of flooding at the 30-year return period is almost four times higher than the 10-year, and this figure is even more extreme for coastal with over a hundred-fold increase between the two return periods. This disparity can be largely attributed to the varying levels of defenses against floods, with protections designed for a 10-year recurrence being more widespread than those for higher recurrence intervals.

RETURN PERIOD	POPULATION AT RISK (MILLIONS) Inland	PERCENT OF POPULATION Inland	POPULATION AT RISK (MILLIONS) Coastal	PERCENT OF POPULATION Coastal
10	394.1	5.0	1.2	0.0
30	1,407.2	18.0	152.6	1.9
50	1,995.6	25.5	221.8	2.8
100	2,277.8	29.1	239.0	3.1
200	2,564.4	32.7	262.8	3.4
250	2,781.1	35.5	362.5	4.6
500	3,075.4	39.2	386.5	4.9
1000	3,381.0	43.1	400.8	5.1

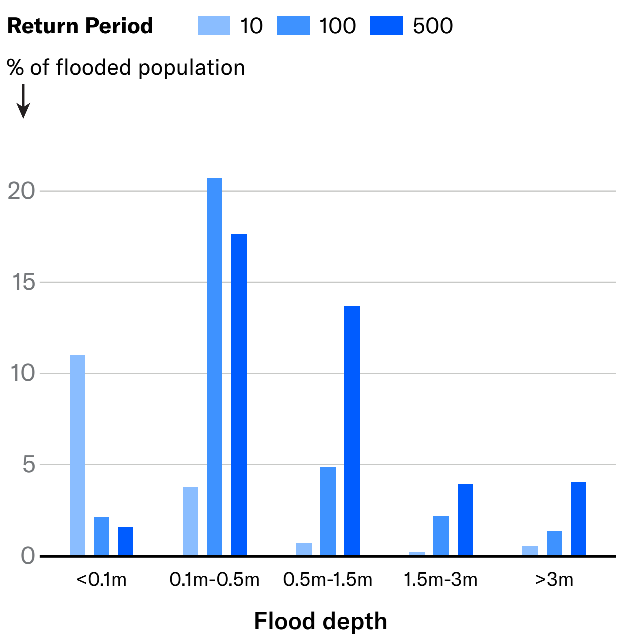
***Table 1** Global population at risk of inland and coastal flooding greater than 10cm. Providing absolute population at risk as well as at-risk population as a percentage of total population. Based on a defended scenario.*

In addition to absolute counts, Moody's also analyzed the severity of the flood hazard that populations are exposed to. Figure 4 illustrates the percentage of flooded population for various hazard bands, return periods, and inland and coastal flooding alike. As can be observed by the figure, out of the 29.1% of the global population exposed to more than 10cm of inland flooding, about 70% of those (21%) are exposed to between 10 and 50cm.

As expected, the severity of flood risk varies with return period. For instance, at a 10-year return period, populations are primarily affected by low flood depths, typically below 0.5 meters. However, for longer return periods, flood depths between 0.1 meters and 1.5 meters become more prevalent. This trend holds for both inland and coastal flooding, but the hazard levels are generally higher for coastal flooding.

TOTAL POPULATION AT RISK BY FLOOD DEPTH AND RETURN PERIOD

Inland flood



TOTAL POPULATION AT RISK BY FLOOD DEPTH AND RETURN PERIOD

Coastal flood

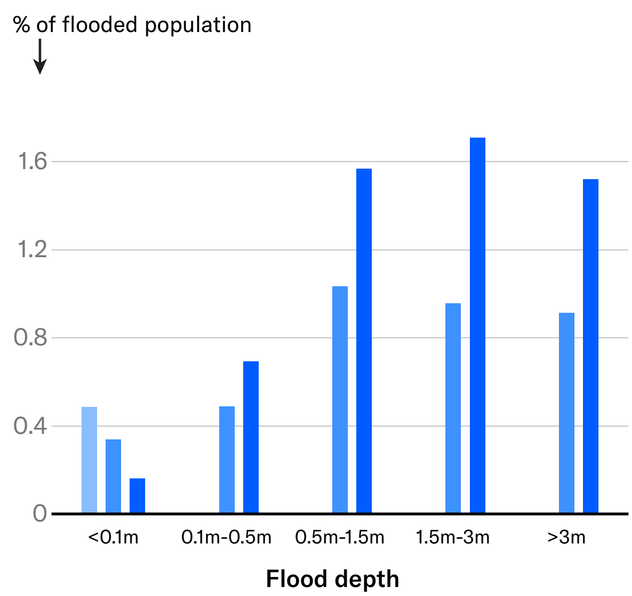


***Figure 4** Population at risk as a percentage of total population for different return periods and different hazard bands. Defended view based on 2020 population. Inland flood (a) and coastal flood (b).*

Delving into a national-level analysis, Tables 2 shows the five countries with the highest exposure to inland flooding both in terms of absolute population at risk, and as a percentage of the total country population. Table 3 provides the same analysis but for coastal flooding.

While it is unsurprising to see that the five countries with the largest number of people exposed to flooding are among the highest populated Asian countries, it is interesting to observe that the top two countries with the highest percentage of population exposed to inland flooding are in fact Suriname and Guyana, both in Latin America. This is due to a combination of the risk that flooding poses to these countries alongside the density of population distribution. Indeed, Suriname has one of the highest concentrations of population within its capital. Based on the 2012 census, almost half of Suriname's population is living in Paramaribo, the country's capital, and, when looking at the 100-year map, the entire city is exposed to inland floods. For this reason, the country reaches a staggering level of 92% of population exposed to inland flooding. Similar considerations can be drawn for Guyana where most of the population resides in high-risk coastal zones. Additionally, Guyana is the only country in the top-five list of countries with the highest percentage of flooded population for both inland and coastal flooding.

RANK	COUNTRY	CONTINENT	POPULATION AT RISK (MILLIONS) Inland	POPULATION AT RISK (%) Inland
1	India	Asia	622.1	44
2	China	Asia	453.2	32
3	Pakistan	Asia	136.8	61
4	Bangladesh	Asia	121.4	73
5	Indonesia	Asia	104.3	38
1	Suriname	South America	0.6	92
2	Guyana	South America	0.6	77
3	Bangladesh	Asia	121.4	73
4	Pakistan	Asia	136.8	61
5	Cambodia	Asia	9.9	61

Table 2 *Five countries with the highest number of people at risk of inland flooding (top table) and five countries with the highest number of people at risk of inland flooding as a percentage of the total country population (bottom table). Based on a 100-year return period, defended scenario.*

RANK	COUNTRY	CONTINENT	POPULATION AT RISK (MILLIONS) Coastal	POPULATION AT RISK (%) Coastal
1	Bangladesh	Asia	59.70	36
2	China	Asia	52.93	4
3	India	Asia	47.92	3
4	Vietnam	Asia	23.80	25
5	Philippines	Asia	14.82	13
1	Tuvalu	Oceania	0.008	76
2	Guyana	South America	0.42	53
3	Kiribati	Oceania	0.05	40
4	Maldives	Asia	0.20	39
5	Myanmar	Asia	12.85	24

Table 3 *Five countries with the highest number of people at risk of coastal flooding (top table) and five countries with the highest number of people at risk of coastal flooding as a percentage of the total country population (bottom table). Based on a 100-year return period, defended scenario.*

At the 100 year return period 25% of the global population exposed to inland floods is protected by flood defenses, 36% for coastal floods respectively.

Impact of defenses

Moody's RMS Global Flood Data and Maps delivers a robust perspective on defended flood risk. This perspective relies on the calibration of inland and coastal flood defenses, specifically in areas encompassed by Moody's RMS flood models.

For regions not covered by these models, Moody's RMS employs its proprietary defense model to ensure comprehensive global coverage.

PERCENTAGE OF DEFENDED POPULATION AT RISK BY RETURN PERIOD
Inland flood

PERCENTAGE OF DEFENDED POPULATION AT RISK BY RETURN PERIOD
Coastal flood

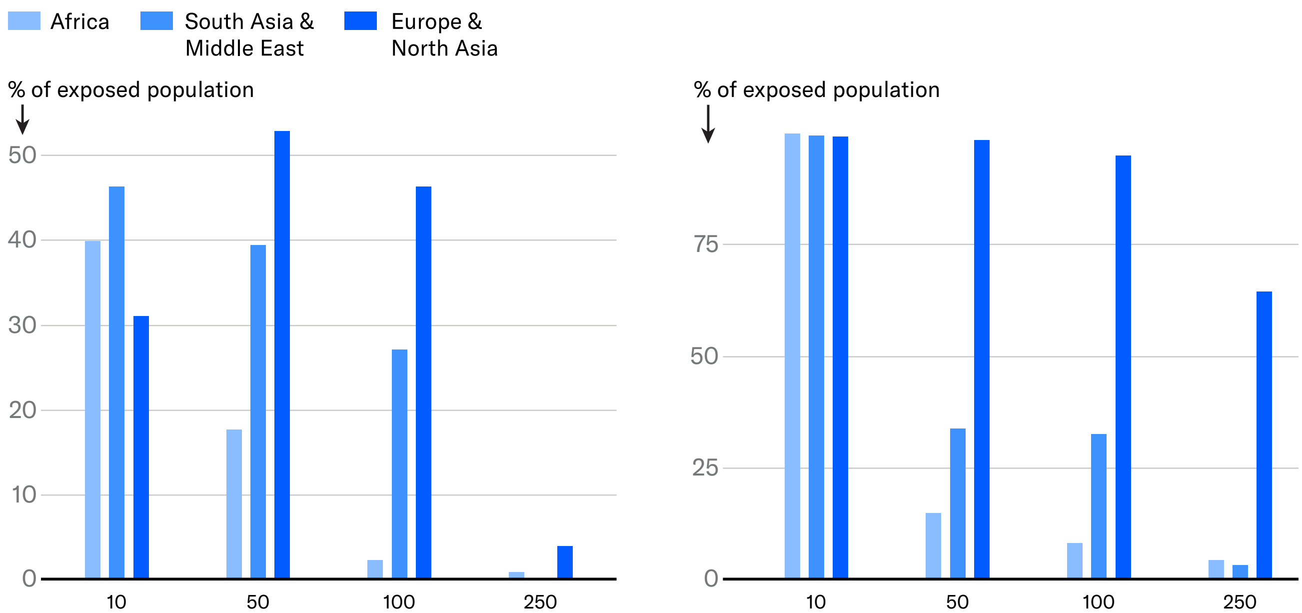


Figure 5 *Population exposed to a 1-meter flood depth protected by flood defenses as a percentage of the undefended, exposed population. Defended view based on 2020 population. Inland flood (a) and coastal flood (b).*

Figure 5 shows the population protected by flood defenses as a percentage of the population exposed to a flood depth higher than 1 meter for different return periods. The analysis has been conducted against three regions given the nuance in the implications of flood defenses on at-risk population in Europe incl. North Asia, Africa and South Asia incl. Middle East. The figure shows that, for both inland and coastal flooding in regions such as Europe where there is a relatively developed network of flood protection systems, a significant percentage of the population at risk is protected even for rare, high-risk events; in other regions, most of the population at risk is protected only against low-return period events. For example, specifically looking at inland flooding, in Europe at the 100-year return period there are approximately 8.2-million people protected by flood depths greater than 1-meter, representing 46% of the total number of inhabitants in the region. In Africa the proportion protected from these extreme severities stands at 1.3-million and represents just 2% of those at risk.

Based on this analysis, Moody's found that at the 100-year return period and for flood depths higher than 1 meter, 25% of the global population exposed to inland floods is protected by flood defenses while 36% of population exposed to coastal flood is protected by flood defenses.

As global population numbers change over time , shifts may occur in the distribution of people living in areas with or without flood defenses. Two primary factors can influence this: first, alterations in local flood defense systems, such as the introduction of protections against floods of a certain scale in previously unprotected areas, or increases to the standard of protection in areas with existing defenses; second is uneven population growth across defended and undefended regions. Assessing the first factor presents a challenge due to the inherent uncertainty surrounding future changes in flood defenses. Alternately, we can use existing population data and future projections to analyze changes in the population living in defended areas if we operate under the assumption that the current flood defense framework remains constant.

DEFENDED AND UNDEFENDED POPULATION AT RISK SINCE 2010

Inland

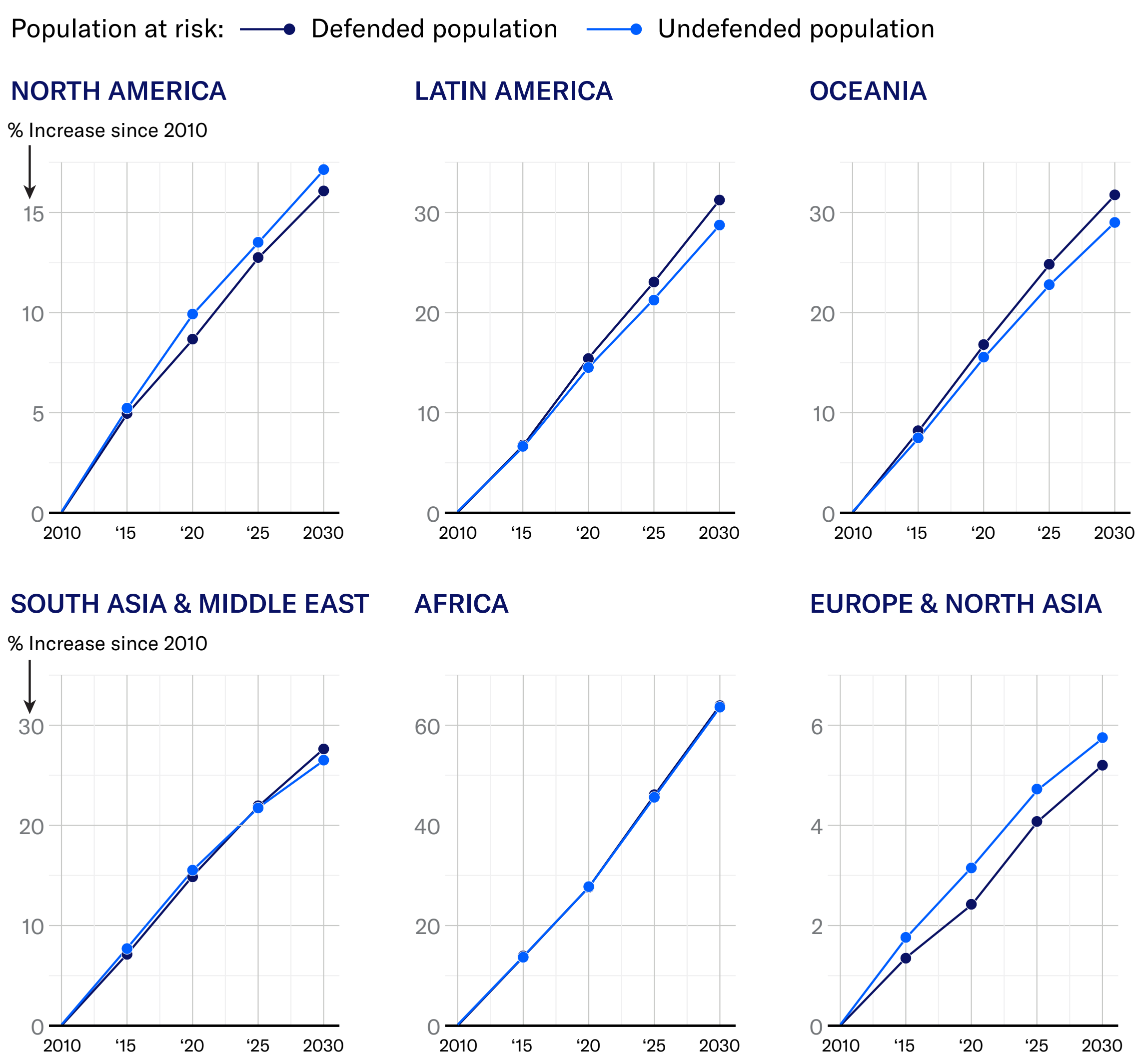


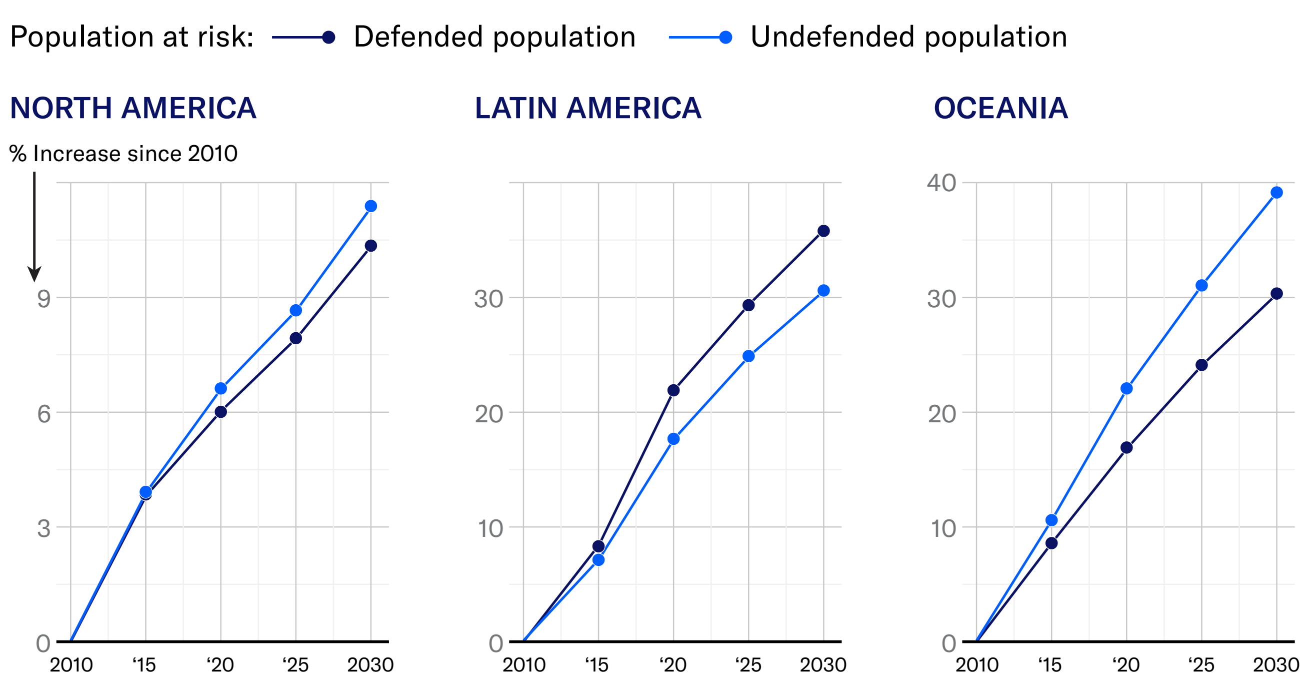
Figure 6 *Percentage increase of defended and undefended population at risk of inland flood from 2010-2030 with a five-year time step. Based only on population within a hazard region of 1-meter and above for a 100-year return period scenario. Each plot focuses on an individual world region.*

Figure 6 illustrates the percentage increase in the population exposed to inland flood risk since 2010 for the 100- year return period, differentiating between those that are currently defended from flooding and those that are undefended from flooding based upon existing levels of protection. The patterns that emerge are distinctly regional. For Europe and North America, the rate of increase is higher for the undefended population at risk than for the defended one. This suggests that despite existing flood defenses, a larger segment of the population is becoming vulnerable to flood risk, indicating a potential gap in the effectiveness of these defenses, or continued migration to areas that are unprotected by flooding. Conversely in Latin America and Oceania, the population protected by defenses is seeing a higher rate of increase than the unprotected one, illustrating that the growth rate is higher in areas that are currently experiencing some protection from defenses. In South Asia and Africa, the rate of increase is comparable for both defended and undefended scenarios, indicating balanced population growth. This could reflect similar rates of urbanization or population density increases in areas with and without flood defenses. The overarching theme is the universal increase in flood risk due to population growth. However, in North America and Europe we can observe a pronounced acceleration of this increase. These patterns underscore the importance of considering regional contexts when assessing flood risk and planning defenses.

Figure 7 presents an analysis analogous to that in Figure 6 but focuses on coastal flood risk. The trends mirror those observed for inland flooding albeit with some regional variations. For instance, in Oceania, the defended population sees a steeper rise in exposure to inland flooding than the undefended population. However, when it comes to coastal flooding, the undefended population experiences a greater rate of increase. There is a similar pattern in Europe, where the rate of increase in exposure to inland flooding is consistently higher for the undefended population, whereas the reverse is true for coastal flood exposure. In South Asia's case, the growth rate of the population at risk is balanced for both defended and undefended scenarios in the context of inland flooding. However, for coastal flooding, the defended population experiences a more pronounced increase.

DEFENDED AND UNDEFENDED POPULATION AT RISK SINCE 2010

Coastal



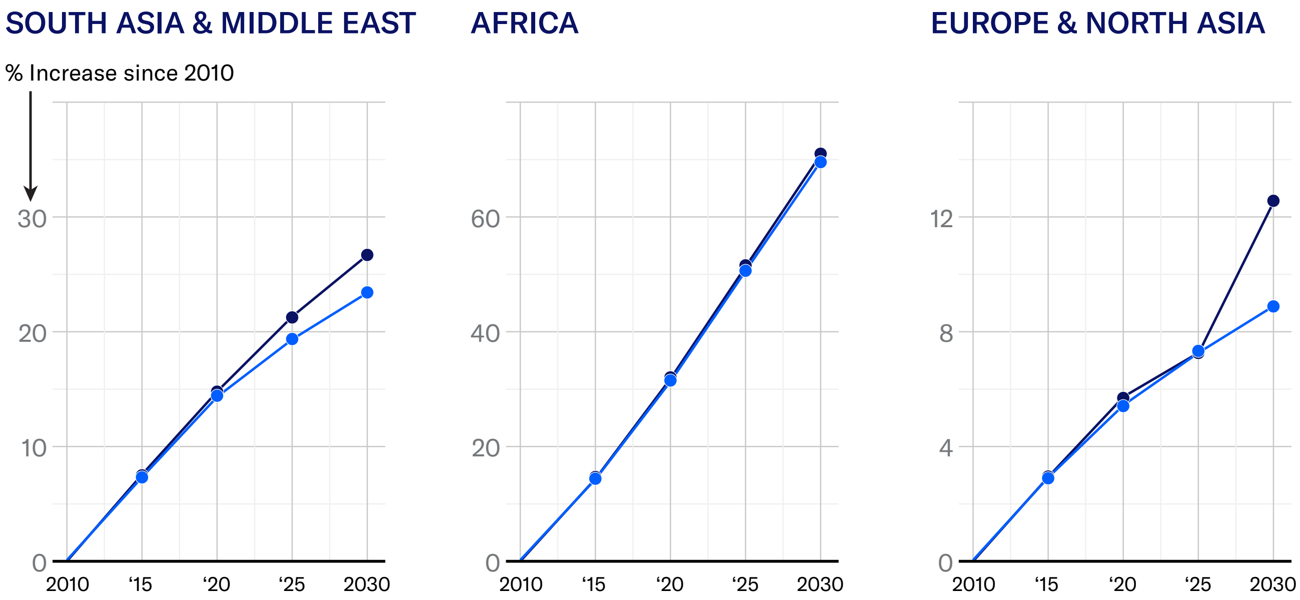


Figure 7 *Percentage increase of defended and undefended population at risk of coastal flood from 2010-2030 with a five-year time step. Based only on population within a hazard region of 1 meter and above for a 100-year return period scenario. Each plot focuses on an individual world region.*

While global population has been constantly increasing in most regions in the last 50 years, it is not clear whether the population exposed to flood risk has been growing at the same rate. In general, urban development strategies can vary greatly depending on the region or country, and these strategies often reflect the respective communities' risk tolerance. In areas that follow a risk-averse strategy, urban development is carefully planned and executed to minimize potential threats, such as flooding. This typically involves a series of preventative measures. One common measure is the implementation of strict zoning laws. These laws regulate land use to prevent construction in areas prone to flooding.

For instance, floodplains might be designated as green spaces, preventing residential or commercial construction in those areas. This not only minimizes the potential for flood damage but also preserves these areas for environmental and recreational purposes. Another measure could be the strategic focus on infrastructure development in areas not impacted by flood risks. This might involve investing heavily in transportation, utilities, and public services in these safer areas to attract the population and economic activity away from flood-prone zones.

Over the period 1975 to 2020 and for the projection to 2023 the population at risk of flooding increases with a higher rate than the total population. This pattern is consistent across all continents.

TOTAL AND FLOODED POPULATION INCREASE SINCE 1975

Inland

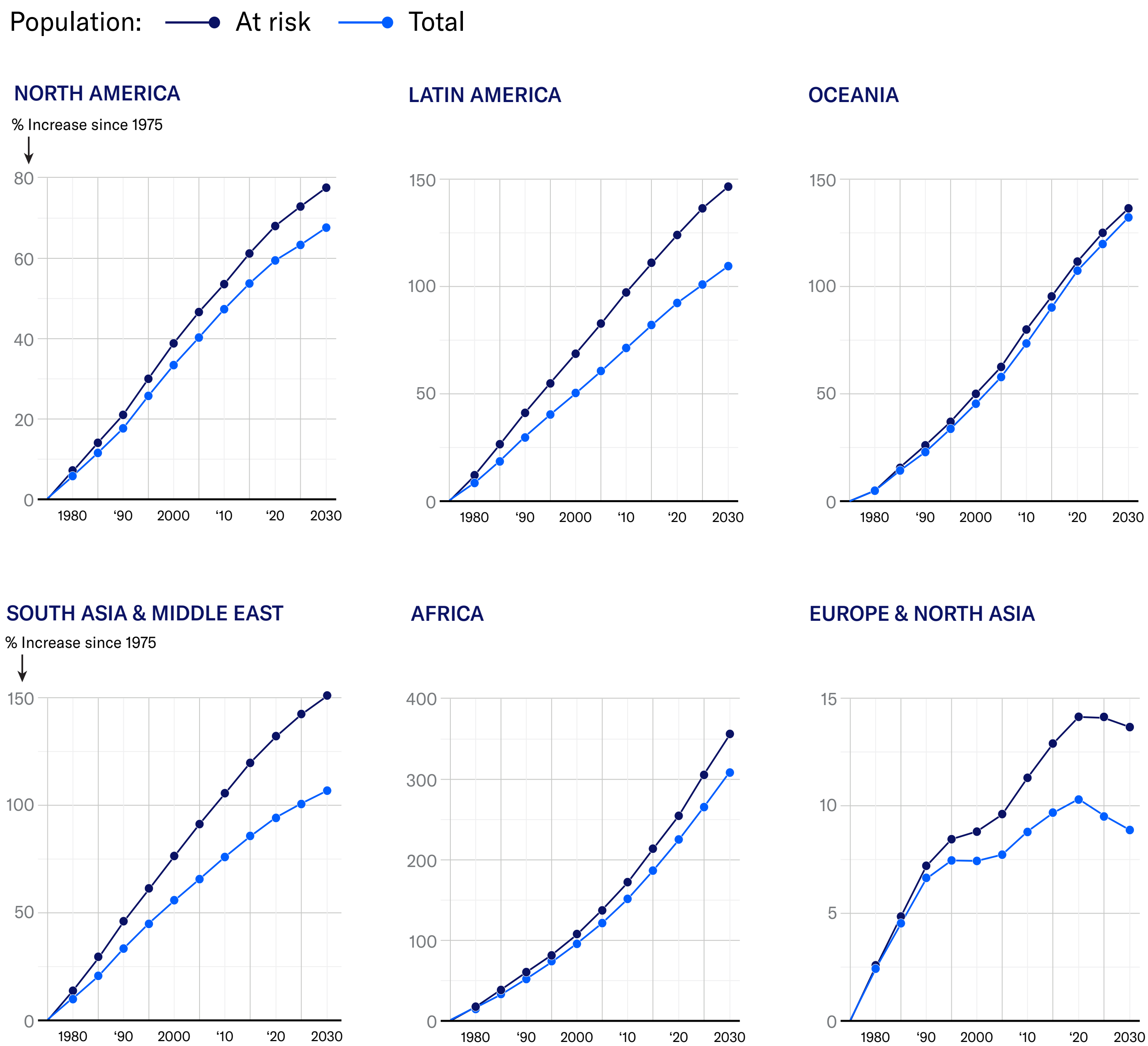


Figure 8 *Percentage increase of population and population at risk of inland flood from 1975-2030 with a five-year time step. Based on a 100-year return period, defended scenario. Each plot focuses on an individual world region.*

These strategies reflect different responses to the challenges of urban growth and environmental risk, and they can have significant implications for urban areas' resilience and sustainability.

The Global Human Settlement Layer dataset provides population growth data and projections from 1975-2030. The combination of this dataset with Moody's RMS Global Flood Data and Maps allows us to understand the evolution of the populations exposed to inland and coastal flood risk across the years. Figure 8 illustrates the increase of total population as well as population exposed to inland flood risk from 1975-2030. The results show a consistent pattern across all continents, in which the population at risk increases with a higher rate than the total population. This is consistent with recent studies that combine satellite imaging with population data to reveal that in many places the number of people living in flood- prone areas is growing faster than the number of people living outside of flood-prone areas [8]. Another study carried out by Max Tesselaar and others in 2023 shows that availability of flood insurance is a driver of population growth in floodplains in Europe [9]. Therefore, it is possible that in countries where people have access to flood insurance, the imbalance between population and population at risk growth is further exacerbated.

TOTAL AND FLOODED POPULATION INCREASE SINCE 1975

Inland

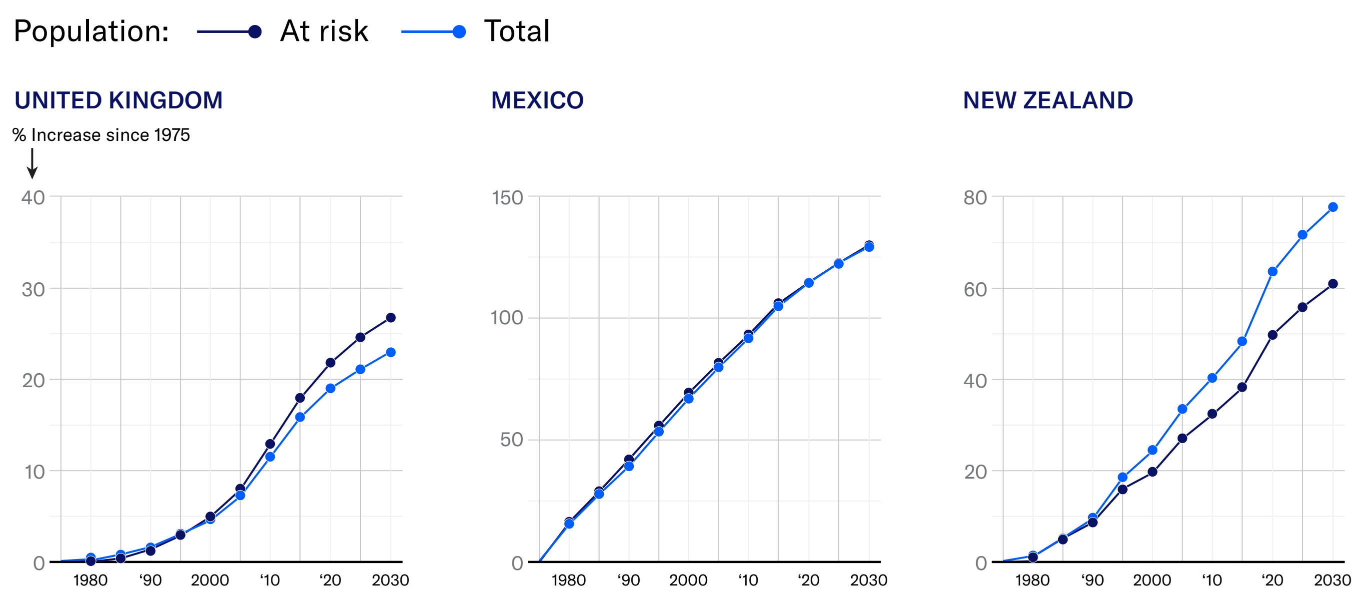


Figure 9 *Percentage increase of population and population at risk of inland flood from 1975-2030 with a five-year time step. Based on a 100-year return period, defended scenario. Each plot focuses on an individual country.*

However, when looking closely at the country level, the patterns can be quite different. Figure 9 shows the same plots but for three individual countries: the United Kingdom, Mexico, and New Zealand. While the UK shows a similar pattern to that observed at the continent level, Mexico demonstrates that the growth of population at risk changes evenly with the total population growth, and New Zealand shows that the growth of population at risk is slower than the total population growth.

To assess the behavior of individual countries and their approach to managing flood risk, it is possible to look at the difference between the growth of the population as a whole and the growth of the population at risk of flooding over the 1975-2020 time period. Where this figure is high, it indicates that the growth of the population is growing faster than the growth of at-risk population, perhaps relating to countries with a "risk-averse" strategy to flooding. Where this figure is negative it could insinuate a more "risk-tolerant" approach to flooding.

Table 4 takes a closer look at the top 5 countries where the delta between these two figures is highest and lowest based upon the 100-year return period scenario. Interestingly, all 5 countries that have the most risk-averse strategy are all based in Africa, equally four out of the top five countries with the most risk-tolerant approach are also in Africa. An explanation for such a high-density of countries in Africa being present in this analysis could be the pace of population growth in Africa compared with the rest of the world and the development and emergence of new population centers that may, or may not be at risk of flooding.

COUNTRY	CONTINENT	1975-2020 POPULATION INCREASE [%]	1975-2020 POPULATION AT RISK INCREASE [%]	INCREASE DIFFERENCE
South Sudan	Africa	184	86	98
Djibouti	Africa	423	330	94
Gabon	Africa	247	177	71
Eritrea	Africa	143	75	68
Burkina Faso	Africa	251	199	53
Angola	Africa	374	1,094	-720
Congo	Africa	249	792	-543
Nepal	Asia	110	332	-222
Kenya	Africa	281	482	-201
Equatorial Guinea	Africa	458	641	-183

Table 4 *Five countries with the highest difference in the population at risk of inland flooding and total country population between 1975 and 2020 (top table). Five countries with the lowest difference in the population at risk of inland flooding and total country population between 1975 and 2020 (bottom table). Based on countries with 2020 population above 1 million.*

In terms of coastal flooding, we found patterns of population and population at risk growth similar to the fluvial and pluvial cases. However, in all regions excluding North America and Africa, the difference between population and population at risk growth is much more pronounced. This suggests that there are different dynamics at play between population growth and associated flood risk depending on the type of flood and geographical location. The notable exception here is North America, where the growth pattern reversed at some point between 2000 and 2010. One plausible explanation for this trend could be an increase in risk awareness, particularly in areas that are frequently exposed to hurricanes. As people become more aware of the risks associated with living in these areas, they may choose to relocate to safer regions, thereby reducing the population at risk. This process needs to be facilitated by policies that prevent new developments in risky areas and, more generally, by improvements in the availability and accessibility of information about flood risks.

TOTAL AND FLOODED POPULATION INCREASE SINCE 1975

Coastal flood

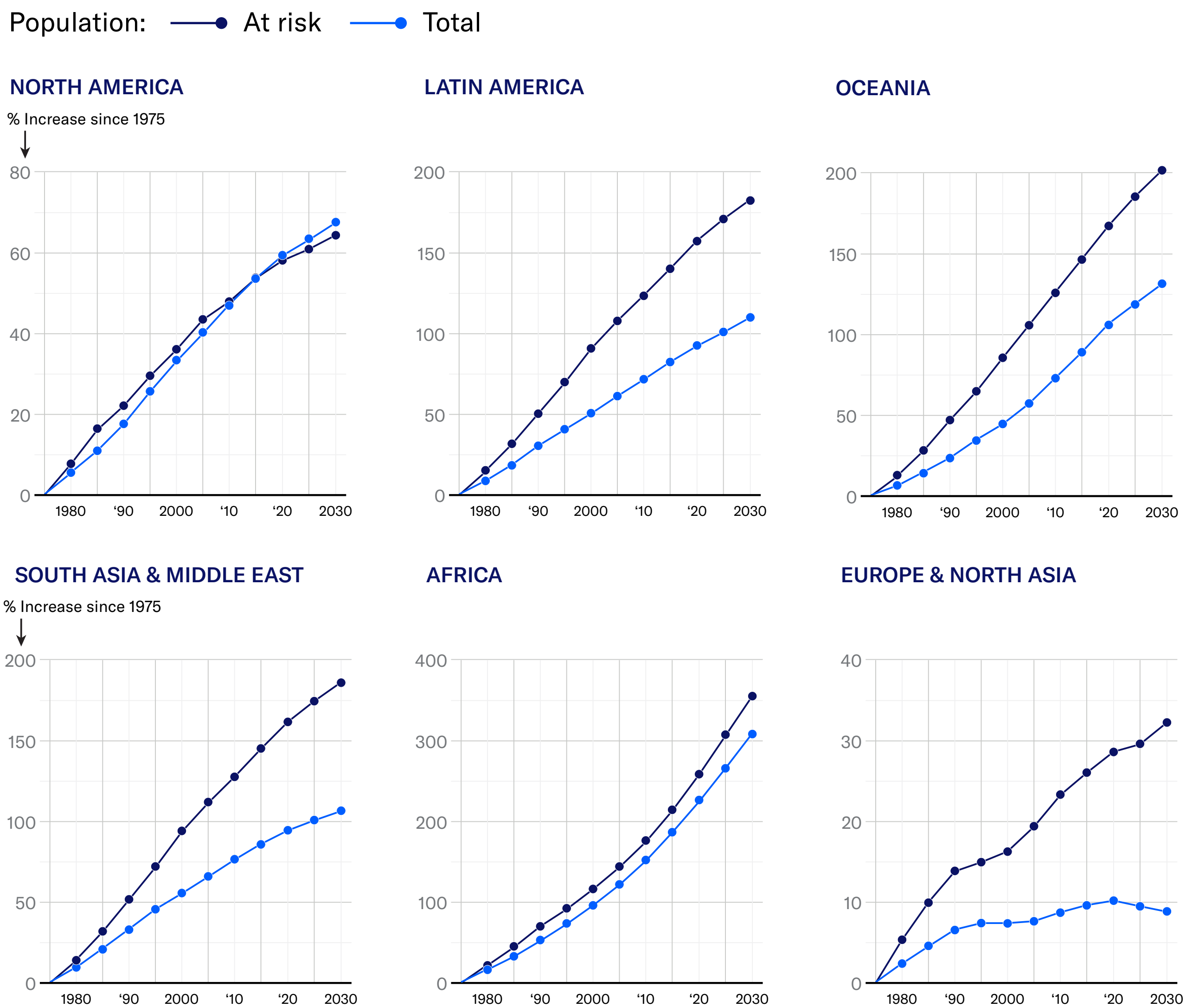


Figure 10 *Percentage increase of population and population at risk of coastal flood from 1975-2030 with a five-year time step. Based on a 100-year return period, defended scenario. Each plot focuses on an individual region.*

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