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THE VULNERABILITY OF FISHING-DEPENDENT ECONOMIES TO DISASTERS

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THE VULNERABILITY OF FISHING-DEPENDENT ECONOMIES TO DISASTERS

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PREPARATION OF THIS DOCUMENT

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ABSTRACT

This circular examines the vulnerability of fishing-dependent communities to natural disasters. The objective was to identify countries that are particularly vulnerable to disasters but also those that are less resilient. Fisheries and fishing-dependent people are often located in places that are at particularly high risk of extreme events such as flooding, cyclones, and tsunamis, while inland fisheries can be significantly affected by droughts and floods. In addition to the tragic loss of life, disasters can have direct impacts on livelihoods such as destruction of gear, infrastructure and productive assets, such as boats, landing sites, and post-harvesting facilities. Indirect impacts can also be important through disruption to markets and through reducing harvesting capacity and access to markets, food supply and employment, thereby affecting both local livelihoods and the overall economy. The circular concludes that the fishery sectors of African and Southeast Asian countries are most vulnerable to disasters, according to both frequency and mortality exposure indicators, fishery-dependence, and capacity to adapt. Recommendations are made with respect to strengthening understanding of vulnerability measurement.

CONTENTS

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ABBREVIATIONS AND ACRONYMS

CAIT	Climate Analysis Indicator Tool
CIA	Central Intelligence Agency
EM-DAT	Emergency Events Database
FAO	Food and Agriculture Organization of the United Nations
FIVMS	FAO Food Insecurity and Vulnerability Information and Mapping System
GDP	gross domestic product
GIEWS	Global Information and Early Warning System
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy For Disaster Risk Reduction
OCHA	Office for the Coordination of Humanitarian Affairs
UNDP	United Nations Development Programme
UNISDR	United Nations Strategy for Disaster Risk Reduction
WRI	World Resources Institute

1. INTRODUCTION

Worldwide, capture fisheries and aquaculture supplied about 148 million tonnes of fish in 2010 (with a total value of US$217.5 billion), of which about 128 million tonnes was utilized as food for people. Fish and fish products provided slightly more than 16 percent of the world population's intake of animal protein and 6.5 percent of all protein consumed. Globally, fish provides about 3 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein. Fish and fishery products represent a valuable source of protein and essential micronutrients for balanced nutrition and good health Fishery products are one of the most highly traded food and feed commodities, globally. The number of fishers and fish farmers has been growing faster than employment in traditional agriculture in the past three decades, mainly in developing countries (FAO, 2012). Production and consumption of fish products is also concentrated in the developing world, contributing significantly to both total gross domestic product (GDP) and agricultural GDP as well as food security (FAO, 2007). The sector is also an important source of livelihoods for women – for nine major fish producing nations, it is estimated that women represent 47 percent of those employed in the fisheries sector, including post-harvesting activities (The WorldFish Center, 2008). However, many fisheries worldwide have declined sharply in recent decades due to overfishing (Pauly *et al*., 1998), and many major fishing grounds are concentrated in zones that are further threatened by pollution, mismanagement of freshwater, and habitat and coastal zone modification.

Fisheries and fishing-dependent people are often located in places that are at particularly high risk of extreme events. Coastal fisheries and floodplain fisheries can, for example, be subject to flooding, cyclones and tsunamis while inland fisheries can be significantly affected by droughts and floods. The impact pathways of disasters[1] on fisheries and dependent livelihoods are multiple. For example, storm and severe weather events can destroy or severely damage infrastructure and productive assets such as boats, landing sites, post-harvesting facilities and roads. This can lead to a decrease in harvesting capacity and access to markets, affecting both local livelihoods and the overall economy. In Antigua and Barbuda, 16 percent of the fishing fleet was destroyed or lost and 18 percent damaged due to Hurricane Luis in 1995, resulting in an estimated decrease of 24 percent in gross revenues (Mahon, 2002). During Hurricane Katrina in 2005, the businesses of about 95 percent of the 62 seafood dealers in Mississippi were destroyed or their infrastructure so severely damaged that commercial fisher folk were unable to sell their catch or buy fuel or ice from them (Buck, 2005). Disasters can also have serious consequences for food security, nutrition and health. Infrastructure damage due to extreme events or flooding can cut access to local markets, reducing the availability of food products as well as increasing their prices, resulting in higher incidences of malnutrition in communities (Niiya, 1998). In addition, extreme events can decrease safety at sea, and increase the prevalence of injuries and mortalities (Birkmann and Fernando, 2008; De Silva and Yamao, 2007). Loss of life can be the most severe impact in fishing communities, affecting not only surviving household members but also potentially upsetting economic and social activities and systems outside the immediate family (Westlund *et al*., 2007).

The identification of countries and areas at high risk from disasters can lead to increased attention to and investment in disaster risk identification, reduction and transfer (Dilley, 2006). Identifying where and when conditions of vulnerability are present creates the potential for acting to reduce risks before disasters occur (Dilley, 2006). While disaster risk analyses have been undertaken in recent years (see for example Dilley *et al*., 2005), despite the particular vulnerability of the fishing sector to natural disasters, no sectoral analysis has yet been undertaken at the global level.

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[1] Disasters imply tragic human, economic and social costs and are distinct from hazards, which are events such as earthquakes or flooding. "Hazards only translate into disasters when societies are vulnerable to them" (Dayton-Johnson, 2004).

Identifying potentially vulnerable national economies to the impacts of natural disasters on their fisheries sector will allow for better sector planning and targeting of resources and investments, enable the identification of where finer-scale vulnerability analyses should be carried out, and highlight where more-detailed spatial fisheries baseline information should be assembled to inform aid responses for rebuilding fisheries livelihoods.

The objective of this paper is to provide a preliminary, global, indicator-based analysis of the relative vulnerabilities of national economies to the impacts of disasters on fisheries. A vulnerability assessment framework is used to identify countries that are the most highly exposed to natural hazards, are highly dependent on the fisheries sector and have limited societal abilities to respond and adapt to the impacts of natural hazards and resulting disasters.

2. CONCEPTS AND METHODS

2.1 Vulnerability to natural hazards

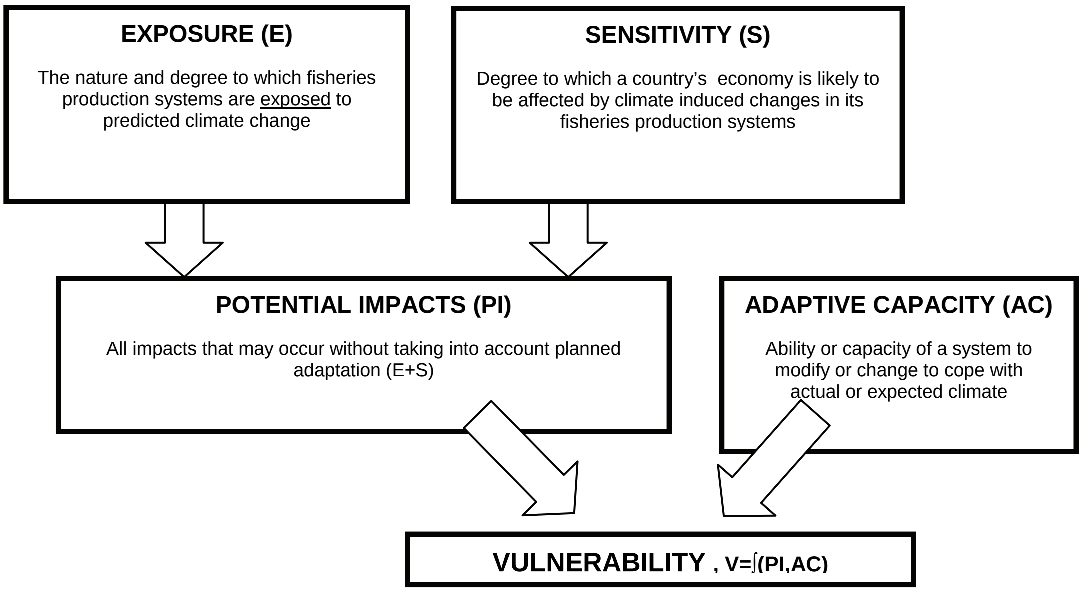
The concept of vulnerability is often considered to have its roots in the study of natural hazards (Hewitt, 1983). In the early twentieth century, Dewey put forward the idea that humanity lives in a hazardous world that results in human insecurity and, therefore, that environmental hazards are not independent from society but are shaped and defined by human actions (Dewey, 1929, cited in Mileti, 1999). Other authors have investigated how society in the United States of America could adjust to floods focussing on : (i) the identification and distribution of hazards; (ii) the range of adjustments that are available to society and individuals; and (iii) how people perceive and make choices regarding hazard events (Cutter, Mitchell and Scott, 2000). This earlier work considered only hazards themselves and failed to address the particular contexts in which they were embedded (Cutter 1996).

As a result, disaster and hazard research evolved to incorporate the concept of vulnerability as socially, culturally and economically constructed, where vulnerability is the result of a process, starting from root causes and resulting in unsafe conditions (Greiving, Fleischhauer and Lückenkötter, 2006).

Since the 1990s, research on the impacts of climate change on society has further developed the concept of vulnerability, with the Intergovernmental Panel on Climate Change (IPCC) defining vulnerability to climate change as: “The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.” (McCarthy *et al*., 2001).

According to this conceptualization, vulnerability is, therefore, made up of a number of components, including exposure, sensitivity to hazards, and the capacity to adapt. From a fisheries perspective, few studies have examined the vulnerability of the fishing sector to climate change and hazards. Two exceptions are global-scale vulnerability assessments of capture fisheries (Allison *et al*., 2009) and aquaculture (Handyside *et al*., 2006) to climate change. Figure 1 presents the conceptual model used in both studies, where vulnerability is a function of the potential impacts of climate change, reduced or modified by peoples’ or institutions’ adaptive capacity.

FIGURE 1
Vulnerability components



Sources: Allison *et al*. (2005); Allison *et al*. (2009).

This study uses a similar framework to understand how the vulnerability of a national economy may arise from the interaction of natural hazards (exposure), the sensitivity of the economy to changes in the country's fisheries, and the societal capacity to adapt to these changes.

2.2 Spatial and temporal scales

For this study, a global-scale vulnerability assessment was conducted, using country as the unit of analysis. Vulnerability is highly context-specific, rarely unfolding at the level of a nation State, arguably making the use of national-level indicators inadequate. However, the strength of national-scale assessments is that they allow for comparisons of vulnerability and adaptive capacity across different regions (Adger *et al*., 2004). In addition, standardized data are more widely available at the country level, and subnational vulnerability is strongly influenced by processes that operate at the national scale (Adger *et al*., 2004).

The aim of this assessment is to capture a snapshot of the present-day vulnerability to disaster risks of national economies that depend on the fisheries sector. Thus, data for the sensitivity and adaptive capacity components represent current socio-economic conditions of the system studied, while exposure is based on current risk to disasters.

2.3. Vulnerability components: constructing indicators

2.3.1 Exposure

In recent years, there has been a strong increase in the amount of destruction caused by natural hazards (ISDR, 2009). This is likely to have had wide-ranging impacts upon the global fishery sector for three main reasons. First, fishing communities, vessels and infrastructure are usually situated in low-lying coastal areas, making them particularly prone to storms, storm surges or tsunamis, and strong winds. Inland fisheries along rivers or lakes and aquaculture ponds are exposed to flooding, droughts and earthquakes. Second, while fish producers worldwide may suffer from large total economic losses due to damaged or destroyed fishing gear and equipment, fishers in developing countries face additional risks because they often live close to the bodies of water upon which they depend, exposing not only their fishing equipment but also their homes, their lives, and the lives of family members. Third, ecological damage to coastal or riverine structures can be devastating for fish stocks, which in turn can cost subsistence or small-scale fishers their primary source of income or food.

The objective of this paper is to assess the impact of disasters on the fishery sector at a country level, including impacts on the contributions that both inland and marine fish production make to the fishing sector of a nation. For this reason, the analysis includes not only “coastal disasters” such as tsunamis or tropical storms but also “inland disasters” such as earthquakes and droughts. Disasters with potential impacts on the fishery sector for which data are available include droughts, earthquakes (seismic activity), floods and storms and are derived from the Emergency Events Data Base categories (EM-DAT, 2009). The data set compiled differs from the World Bank multiexposure data set used in its global study on disaster risk as it excluded volcanoes and landslides. Thus, differences in final exposure and vulnerability results are expected. As stated above, disasters may have effects on many aspects of the sector, including: the lives and well-being of fishers; vessels, equipment, homes and other assets; fish stock abundance and fishery production; community, fisheries, shipping, and transport infrastructure; and levels of income and trade. To capture this broad range of impacts on the fishery sector, two measures of exposure have been use: one based on the frequency of disasters and the other based on disaster-associated mortalities. For the purposes of this study, the most relevant measure of exposure would have been one related to levels of socio-economic damage resulting from disasters. However, reliable data were not available at the scale of the analysis and, therefore, the choice of exposure indicators was restricted. For the purposes of the analysis, the assumption is made that both exposure indicators, disaster frequency and intensity (mortality), over the 20-year period (1980–2000), are indicative of the general risk to natural disaster within countries.

The indicator on the frequency of disasters provides a measure of the level of exposure in terms of number of extreme events experienced by countries. These data were derived from the EM-DAT (2009) database. Events are included in this database if any of the following criteria are met: (i) ten or more people were reported killed; (ii) 100 people were reported to have been affected; (iii) there was a declaration of a state of emergency; or (iv) there was a call for international assistance. The criteria for including each disaster guarantees that only those events were counted that had at least some impact on the respective population regardless of disaster type and strength. The data on the frequency of disasters were combined by summing the number of disasters (droughts, earthquakes [seismic activity], floods and storms) from 1980 to 2000 for each country.

However, impacts of disasters also manifest as loss of human life, which can have substantial consequences for fisheries-dependent communities and the national economies of many developing countries. This metric can provide an indication of the magnitude of extreme events in terms of destruction. Data on disaster-related mortalities were obtained from the United Nations Development Programme (UNDP, 2004). These estimates were scaled with reference to national population sizes (i.e. number of mortalities per one million inhabitants), in order to provide a relative measure of the loss of life at the national scale. Anomalously high mortality values resulting from very rare events were excluded from the analysis. These events included Hurricane Mitch in Nicaragua and Honduras, and droughts in the Sudan and Mozambique.

To examine different dimensions of vulnerability to disasters, it was decided to use both exposure indicators separately in order to calculate two different vulnerability indices. Although the two indicators selected may in some cases be related, each indicator captures different aspects of disaster impacts, which may have different implications for stakeholders involved in understanding, mitigating and responding to extreme events. The frequency of disasters captures the biophysical impact of the disaster on a country. It may provide a more relevant indicator to stakeholders that need to assess levels of total financial damage to the fishery sector. The disaster-associated mortality, as a proxy of disaster intensity, may be most relevant to stakeholders that are looking to plan or prioritize aid or relief in order to support the fishery sector in developing countries.

2.3.2 Sensitivity

The sensitivity index aims to assess how "sensitive" countries are to natural hazards by understanding their dependence on fisheries production systems in terms of food security, economic dependence, and number of fishers involved in the activity. The analysis used the same fishery-dependence indicator variables as Allison *et al*. (2009), describing the sensitivity of the fisheries sector in terms of fisheries production (landings), and the contributions of fisheries to employment, export income and dietary protein (Table 1). All of these factors combined are assumed to result in a higher vulnerability: the higher the landings, contributions to employment and food security as well as exports, the greater the propensity to be vulnerable to the impact of a natural hazard on the fisheries sector. Other global studies on disaster (UNDP, World Bank) are not sectoral, and, with the inclusion of fishery-specific indicator, differences in final results are expected.

2.3.3 Adaptive capacity

According to the IPCC (McCarthy *et al*., 2001), adaptive capacity is the ability or capacity of a system (e.g. sector, country or region) to evolve and adapt to new situations as they arise, and/or to apply novel responses to address the change. The determinants of adaptive capacity include a variety of elements such as social capital, human capital, and the appropriateness and effectiveness of governance structures (Brooks, Adger and Kelly, 2005; Vincent, 2004).

Studies have shown that countries with higher income, higher educational attainment, greater openness, complete financial systems with, for example, good level of access to domestic credit and foreign exchange reserves, as well as effective governance structures incur fewer losses from natural disasters (Kim, 2009; Toya and Skidmore, 2005). For example, higher educational attainment may enable citizens to make a series of choices ranging from engaging in safe construction practices to assessing potential risk that result in fewer deaths when a disaster strikes (Toya and Skidmore, 2005).

In addition, poorer infrastructure and less-developed communications and transportation systems are often described as hindrances to adequate responses to natural disasters (Cutter *et al*., 2008) as well as the establishment of *ex-ante* adaptation strategies (i.e. early warning systems). The adaptive capacity index in this study is a composite of indicators of human development (healthy life expectancy, education, governance and size of economy), infrastructure (road density) and communication (mobile telephone users) (Table 1).

TABLE 1
Summary of variables used to calculate exposure, sensitivity (as fisheries dependence) and adaptive capacity, and their interpretation

Component	Interpretation	Variable	References
Exposure	Disaster frequency	Frequency of disaster events per country (1980–2000)	EM-DAT (2009)
	Disaster intensity	Average number of people killed per country, per million (1980–2000)	UNDP (2004)
Sensitivity	Composite index of employment and dependency on fisheries	Number of fisherfolk (2000)	WRI
		Fisheries export value as proportion (%) of total export value (averaged over 2003–06)	FAO FishStat Plus and World Bank Development Indicators 2008
		Proportion (%) of economically active population (2000) involved in the fishery sector	World Bank Development Indicators 2008 and WRI
		Total fisheries landings (tonnes, averaged over 2003–06)	FAO FishStat Plus
	Index of nutritional dependence	Fish protein as proportion of all animal protein (% g person^{-1} day^{-1}, 2003)	FAOStat
Adaptive Capacity	Health	Healthy life expectancy (years, 2005)	CAIT 2009
	Education	Literacy rates (% of people literate at age15 years, 2005)	CAIT 2009
		School enrolment ratios (% in primary, secondary and tertiary education, 2005)	CAIT 2009
	Governance	Political stability (e.g. perceptions of the likelihood of armed conflict) 2007	CAIT 2009
		Government effectiveness (e.g. bureaucratic quality) 2007	CAIT 2009
		Regulatory quality (e.g. regulatory burden, market friendliness) 2007	CAIT 2009
		Rule of law (e.g. black markets, enforceability of contracts) 2007	CAIT 2009
		Voice and accountability (e.g. free and fair elections, political rights); 2007	CAIT 2009
		Corruption (e.g. prevalence among public officials) 2007	CAIT 2009
	Size of economy	GDP per capita (purchasing power parity, current international USD, averaged over 2003–06)	World Bank Development Indicators 2008
	Communication	Mobile cellular subscribers per 100 inhabitants (averaged over 2003–06)	World Bank Development Indicators 2008
	Infrastructure	Road density (kilometres of total road network per thousand square kilometres of land area averaged over 2003–06)	CIA Country Factbook

2.3.4 Vulnerability

The exposure, sensitivity and adaptive capacity indicators are incorporated into a vulnerability index as per the conceptual framework described by Allison *et al*. (2009). Values for all variables were normalized by indexing them according to the following general formula:

Index value = (actual value – minimum value) × 100 / (maximum value – minimum value)

Component indices (i.e. exposure, sensitivity, and adaptive capacity) were derived by averaging the indicator variables within them, with equal weightings for each of the indicators. The component indices were then indexed and averaged to provide the final vulnerability indices (one for each of the two measures of exposure). The components of vulnerability can be combined in different ways, with different weightings, but in this preliminary analysis the three components are treated equally on the assumption that no clear understanding exists on the interactions between the different components (see Allison *et al*., 2009). For the purposes of this study, indicators are indexed to a scale of from 0 to 100, where 0 represents the minimum value (i.e. low sensitivity) in the data set and 100 represents the maximum value (i.e. high sensitivity). A full set of indicators could be calculated for the 143 countries for which all component indicator data were available. For presentation, final indicator scores were categorized into "high", "moderate", "low" and "very low" quartiles.

3. RESULTS

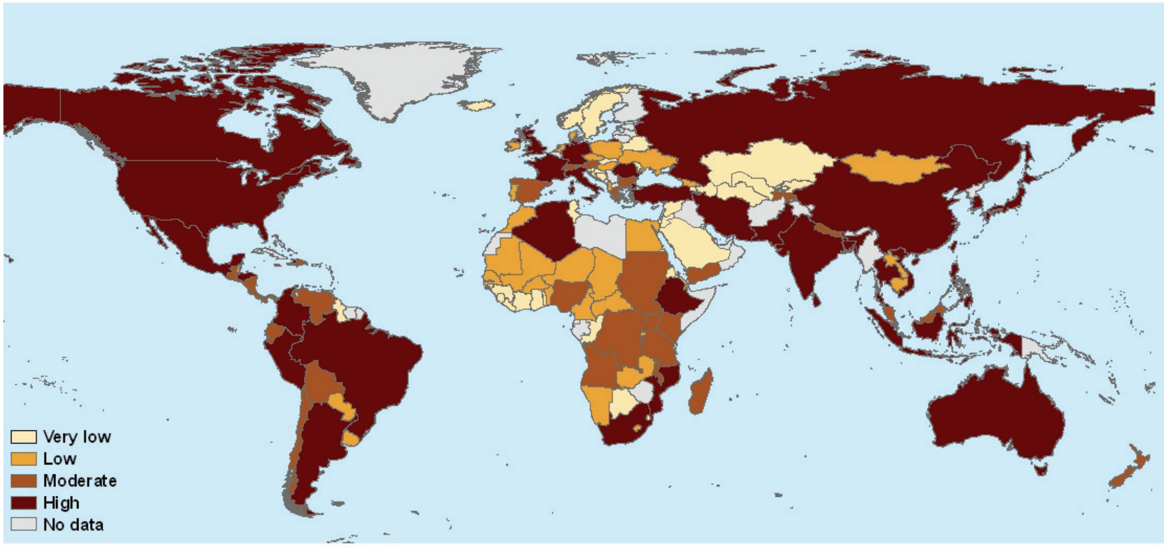
3.1 Exposure

3.1.1. Frequency of natural disasters

In the last 20 years, countries in Asia and the Americas have had the greatest number of disaster events (Figure 2). China and the United States of America have experienced the highest frequency of disasters, with 530 and 478 registered events, respectively. This is more than twice the average number of disasters experienced by other countries in the top quartiles, such as the Philippines (276), India (275), Indonesia (191) and Bangladesh (177).

FIGURE 1

Frequency of natural disasters by country. Colours represent quartiles with yellow for the lowest quartile, dark brown for the upper quartile (highest index value), and grey where no data were available.

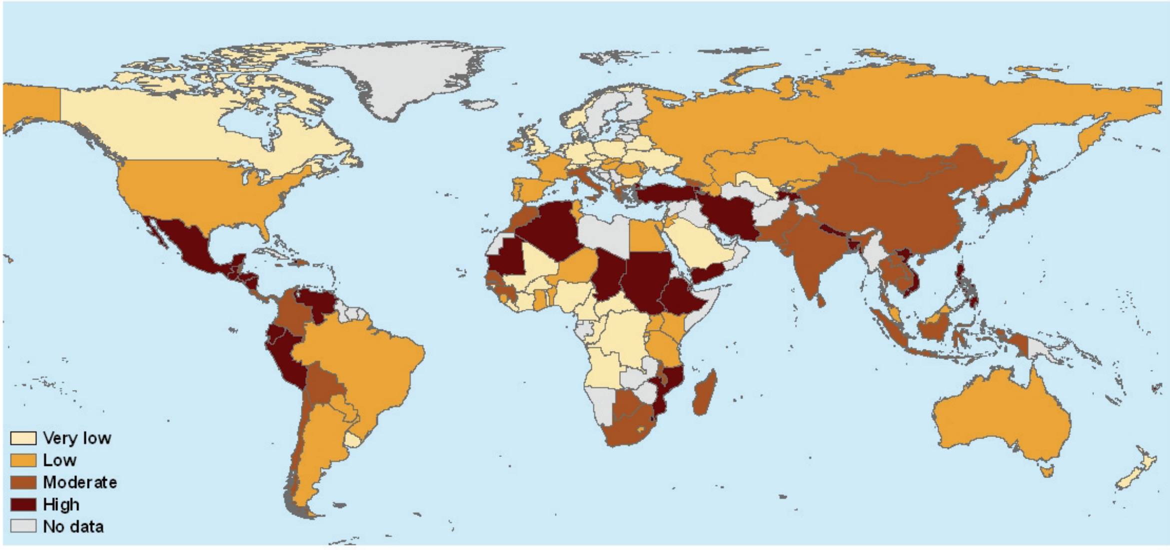


Notes: Colours represent quartiles with yellow for the lowest quartile, dark brown for the upper quartile (highest index value), and grey where no data were available.
The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

3.1.2. Mortality

In terms of disaster-associated mortality, the top quartile of nations most exposed to natural disasters consists mainly of African, Asian, South American and small island nations. The countries with the highest mortality levels are located in sub-Saharan Africa (Mozambique, the Sudan, Ethiopia) and Europe (Armenia) (Table 2). Events causing the greatest loss of lives include: droughts in Mozambique, Armenia, the Sudan and Ethiopia; floods in Bangladesh and Venezuela (Bolivarian Republic of); earthquakes in Armenia and Iran (Islamic Republic of); and storms in Honduras, Bangladesh, and Nicaragua.

FIGURE 3
Mortality caused by natural disasters by country.



Notes: Colours represent quartiles with yellow for the lowest quartile, dark brown for the upper quartile (highest index value), and grey where no data were available.
The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

3.1.3. Frequency and mortality: untangling their effect on exposure

Ten out of the countries in the top quartile (36 countries) with the highest disaster occurrence are considered high-income countries, whereas Italy is the only high-income country that is part of the first quartile according to the mortality ranking. Outside of the top quartile of countries experiencing high disaster-associated mortality, Japan is the first high-income country ranking at number 45, followed by Greece (61) and the United States of America (72). Conversely, developing countries experience a greater loss of life, with the highest mortalities in African, Asian and South American countries. Out of the countries in the top mortality quartile, 13 are low-income countries compared with seven low-income countries in the frequency quartile.

When comparing the two exposure indices (one based on the frequency of disasters, and the other on disaster-associated mortality), the ranking of countries changes substantially. The United States of America, China, the Philippines and India rank in the top quartile when the frequency data are used as an indicator of exposure, and in the second and third quartiles when mortality rates are used. A series of factors can explain this discrepancy, such as that the intensity of the events are lower, leading to decreased mortality. The absolute number of persons killed in China and India might be high but, given the large populations of these countries, when mortalities are expressed in relative terms as the number of people killed per million, the values significantly decrease. The low mortality rates in the United States of America, regardless of high frequency of events, might be attributed to greater disaster recovery capabilities.

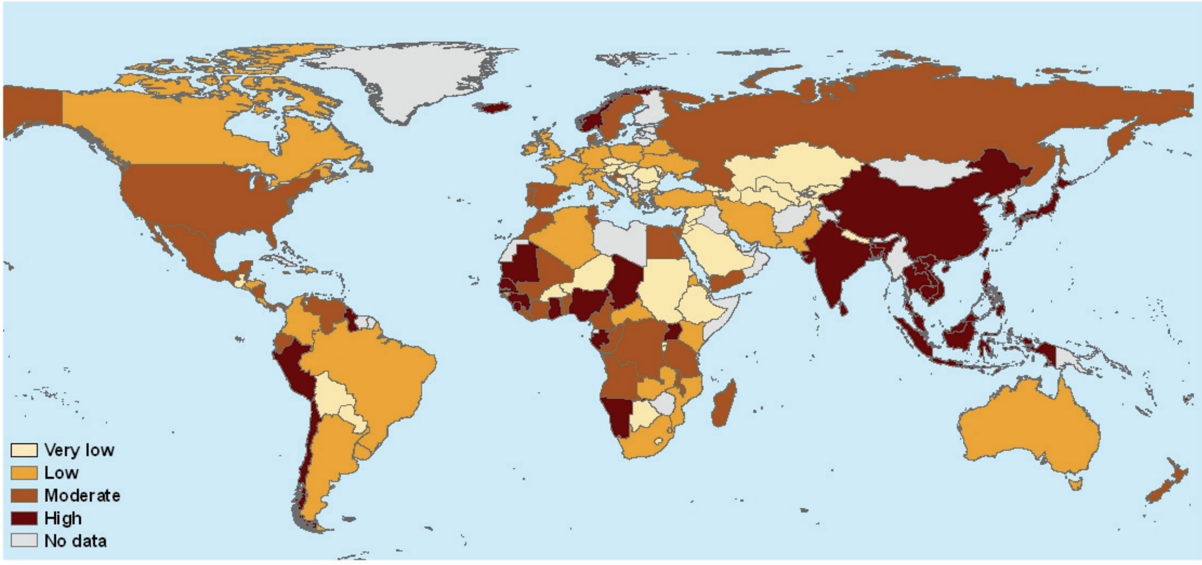
TABLE 2
The ranking of disaster exposure according to frequency and morality in the highest quartile

Country exposure based on frequency	Exposure ranking	Country exposure based on mortality
United States of America (70)	1	Mozambique (31)
China (55)	2	Armenia (132)
Philippines (17)	3	Sudan (44)
India (38)	4	Ethiopia (25)
Indonesia (52)	5	Honduras (31)
Bangladesh (7)	6	Venezuela (Bolivarian Republic of) (50)
Iran (Islamic Republic of) (9)	7	Bangladesh (6)
Viet Nam (25)	8	Mauritania (73)
Japan (44)	9	Iran (Islamic Republic of) (7)
Mexico (26)	10	Nicaragua (50)
Australia (82)	11	Swaziland (102)
Brazil (77)	12	Vanuatu (61)
Thailand (54)	13	Chad (76)
Pakistan (47)	14	Saint Lucia (100)
France (95)	15	El Salvador (50)
Russian Federation (72)	16	Djibouti (87)
Colombia (37)	17	Philippines (3)
Turkey (18)	18	Turkey (18)
Haiti (21)	19	Solomon Islands (89)
Peru (32)	20	Tajikistan (57)
Republic of Korea (45)	21	Haiti (19)
Algeria (30)	22	Nepal (39)
South Africa (57)	23	Fiji (48)
Canada (105)	24	Yemen (61)
Ethiopia (4)	25	Viet Nam (8)
Romania (85)	26	Mexico (10)
Argentina (88)	27	Guatemala (48)
United Kingdom	28	Samoa (119)
Italy (35)	29	Comoros (126)
Sri Lanka (58)	30	Algeria (22)
Mozambique (1)	31	Ecuador (61)
Honduras (5)	32	Peru (20)
Germany (125)	33	Cape Verde (126)
Greece (60)	34	Madagascar (35)
Madagascar (34)	35	Italy (29)
Kenya (74)	36	Cambodia (73)

3.2 Sensitivity or dependence of national economies on the fisheries sector

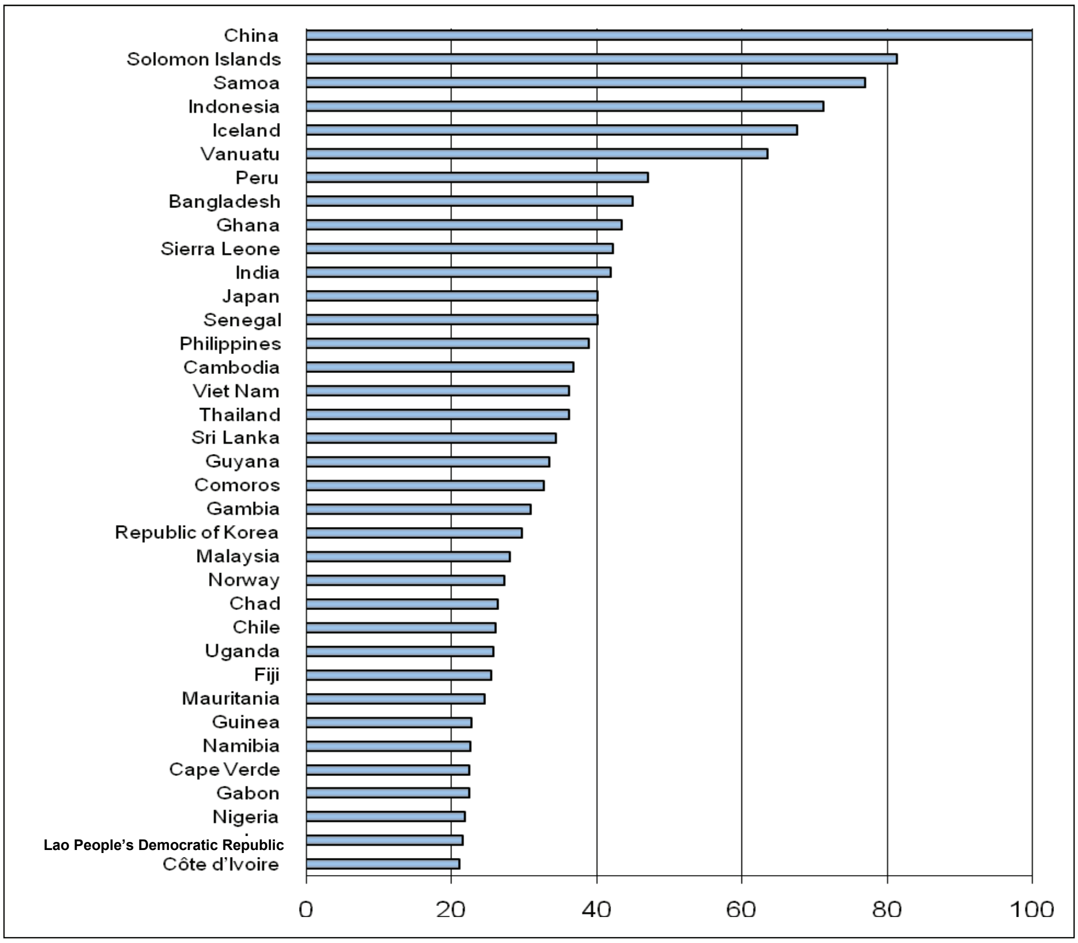
The top quartile of countries whose national economies are most dependent on fisheries includes Asian countries and Pacific island States, with countries such as China, Solomon Islands and Indonesia having the highest values of fishing-dependence (Figures 4 and 5). Also included within this quartile are coastal African nations such as Ghana and Senegal, while the only landlocked country with a high dependence on fisheries is Uganda in Africa. Only three developed countries, (Japan, Iceland and Norway) and three Latin American countries (Peru, Chile and Guyana) are among the most dependent on the fisheries sector.

FIGURE 4
Fisheries sensitivity



Notes: Colours represent quartiles with yellow for the lowest quartile, dark brown for the upper quartile (highest index value), and grey where no data were available.
The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

FIGURE 5
Top quartile of most dependent national economies on the fisheries sector (n = 143)



Note: The highest dependence level is set equal to a value of 100.

TABLE 3
The importance of the fisheries sector to employment

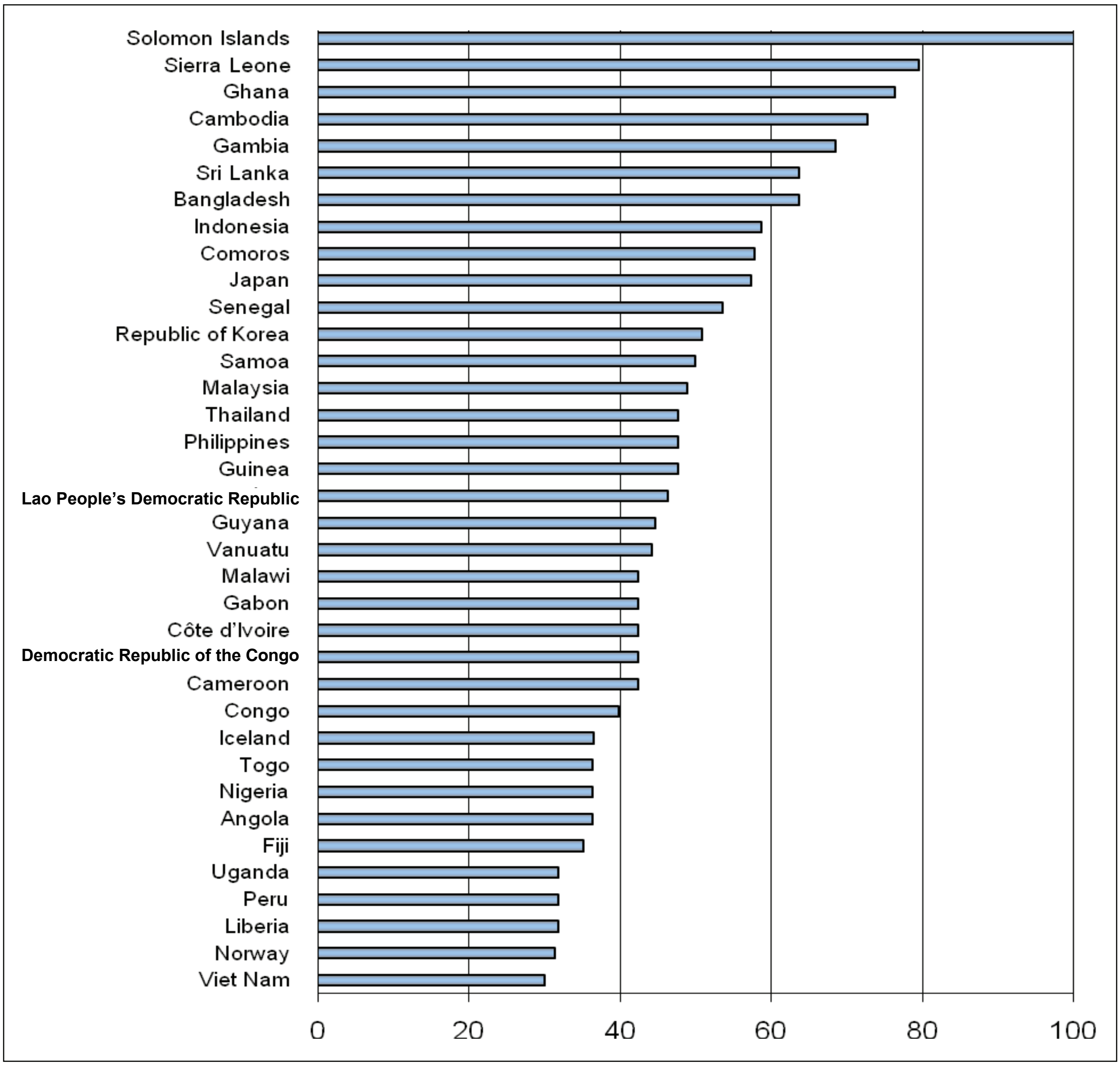
Rank	Country	Indexed fisherfolk % EAP	Index absolute no. fisherfolk	Quartile position – absolute no. of fisherfolk
1	Samoa	100.00	0.10	2
2	Chad	46.43	2.45	4
3	Solomon Islands	33.65	0.09	2
4	Saint Vincent and the Grenadines	28.57	0.02	1
5	Indonesia	26.99	41.84	4
6	Iceland	18.92	0.05	2
7	Comoros	17.55	0.06	2
8	Cape Verde	17.12	0.04	1
9	Ecuador	16.85	1.33	4
10	Croatia	16.61	0.53	4
11	Philippines	16.44	8.10	4
12	Fiji	14.73	0.07	2
13	Saint Lucia	14.39	0.02	1
14	Mali	13.79	0.57	4
15	Viet Nam	13.45	8.17	4
16	Ghana	13.36	1.88	4
17	Benin	11.05	0.51	4
18	Bangladesh	10.84	10.79	4
19	Guyana	10.72	0.05	2
20	Belize	10.48	0.02	1
21	Jamaica	10.10	0.19	3
22	Sri Lanka	9.42	1.20	4
23	Barbados	9.40	0.02	1
24	China	8.49	100.00	4
25	Mauritius	8.12	0.07	2
26	Tunisia	8.08	0.42	3
27	Gabon	8.06	0.07	2
28	India	7.78	48.71	4
29	Senegal	6.55	0.45	3
30	Nigeria	6.55	3.93	4
31	Egypt	6.45	2.04	4
32	Cambodia	6.35	0.60	4
33	Trinidad and Tobago	6.34	0.06	2
34	Madagascar	5.77	0.68	4
35	Morocco	5.42	0.87	4
36	Thailand	5.31	2.90	4

Notes: The 36 countries highly dependent on fisheries as a source of employment (the top quartile of the data set) are ranked by the index of percentage of fisherfolk in the economically active population (EAP); for comparison, the index of absolute number of fisherfolk and associated quartiles are presented. All rankings are relative to the entire data set (n = 143 countries).

If the sensitivity index is disaggregated, countries with the largest landings are those traditionally considered major fishing nations, such as China, Peru, the United States of America and Indonesia. In terms of absolute number of fisherfolk, the top quartile is dominated by Asian countries with China, India, Indonesia and Bangladesh having the highest absolute number of fisherfolk. They are followed by countries in Africa (Nigeria, Chad, Egypt and Ghana) and the Americas (the United States of

America and Brazil) as well as the Russian Federation. However, when the importance of the fisheries sector is considered in terms of total employment (i.e. number of fisherfolk as a percentage of the economically active population), the ranking changes. Countries such as the Russian Federation and the United States of America drop into the third quartile while small island States shift to the top quartile of high relative sector employment. This highlights the fact that, while in absolute numbers, small island States do not represent a significant proportion of the global labour force working in the fisheries sector, at the national level, the fisheries sector plays an important role in employment (Table 3). Nutritional reliance on fish as a source of animal protein was highest in Pacific islands, Southeast Asia and Africa (Figure 6).

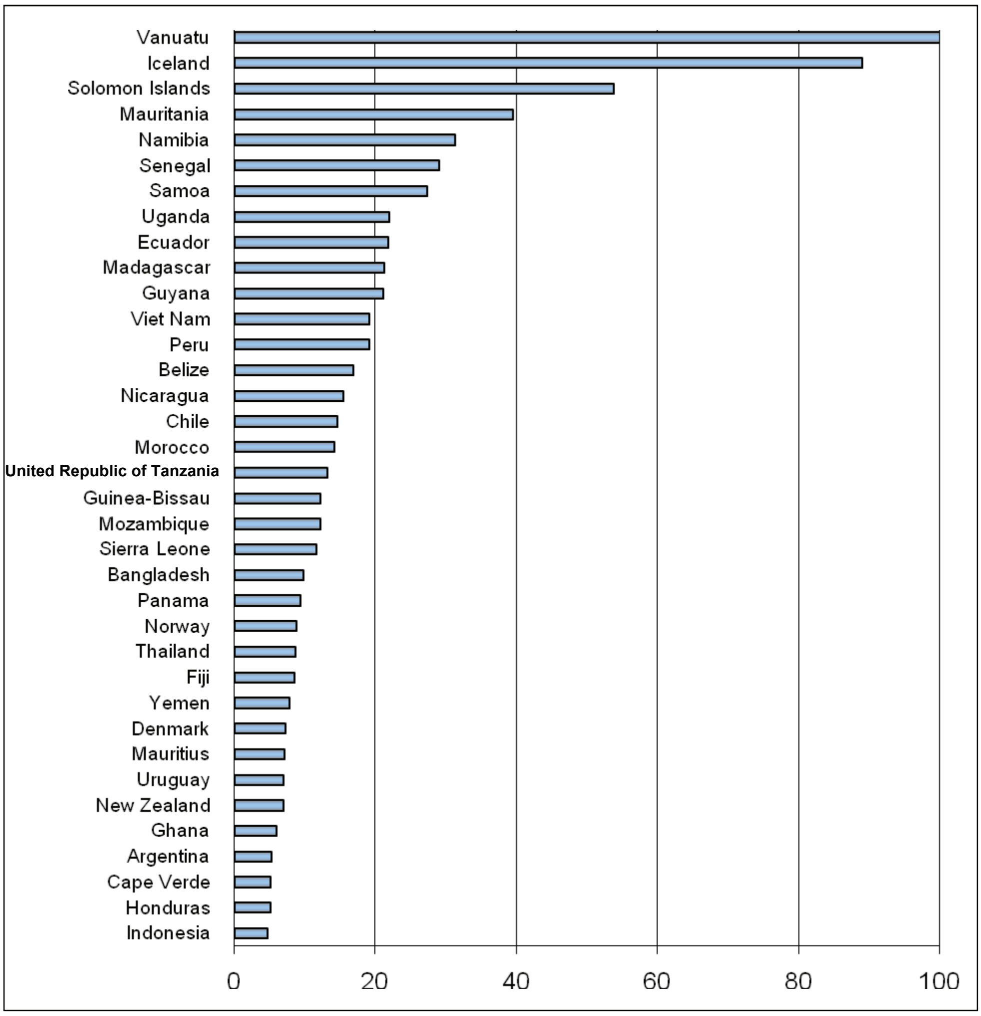
FIGURE 6
Top quartile of nutritional dependence (n = 143)



Note: The highest dependence level is set equal to a value of 100.

Dependence on income from fisheries exports was highest in small island States (Vanuatu and Solomon Islands), coastal nations of Africa, central and south America, countries located in Southeast Asia and some high-latitude nations such as Iceland, Norway and Denmark. The lowest quartiles consisted mainly of landlocked countries, especially in Africa (the Democratic Republic of the Congo, Chad and Cameroon). However, these countries are characterized by high dependence on the nutritional benefits of fisheries, highlighting the fact that the fisheries sector, while not a significant contributor to the economy in terms of foreign exchange, plays a crucial role in terms of food security. It is worth noting that 47 countries and territories had to be excluded from the original FAO Fishstat data set owing to a lack of data on value and quantity of exports.

FIGURE 7
Top quartile of export dependence (n = 143)

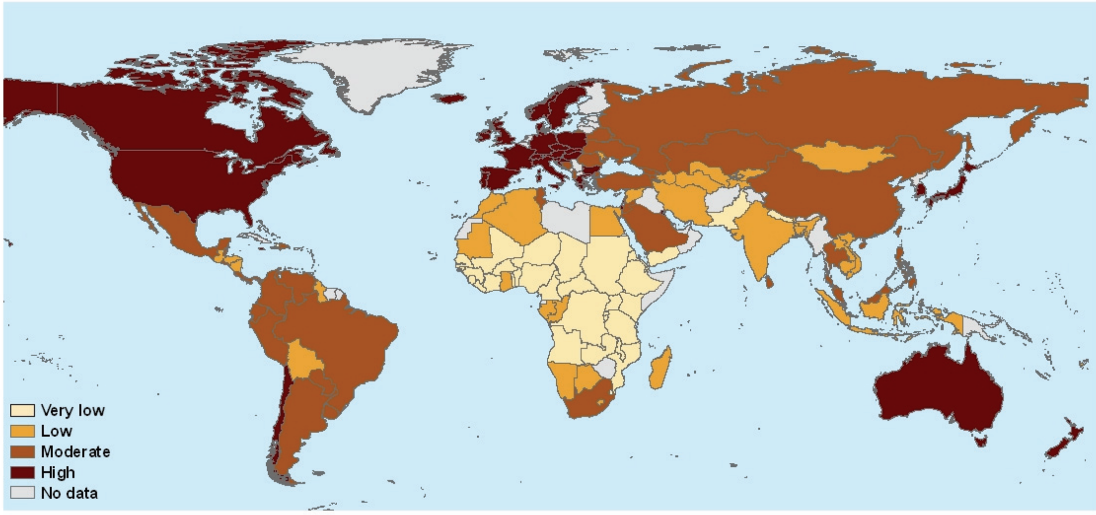


Note: The highest dependence level is set equal to a value of 100.

3.3 Adaptive capacity

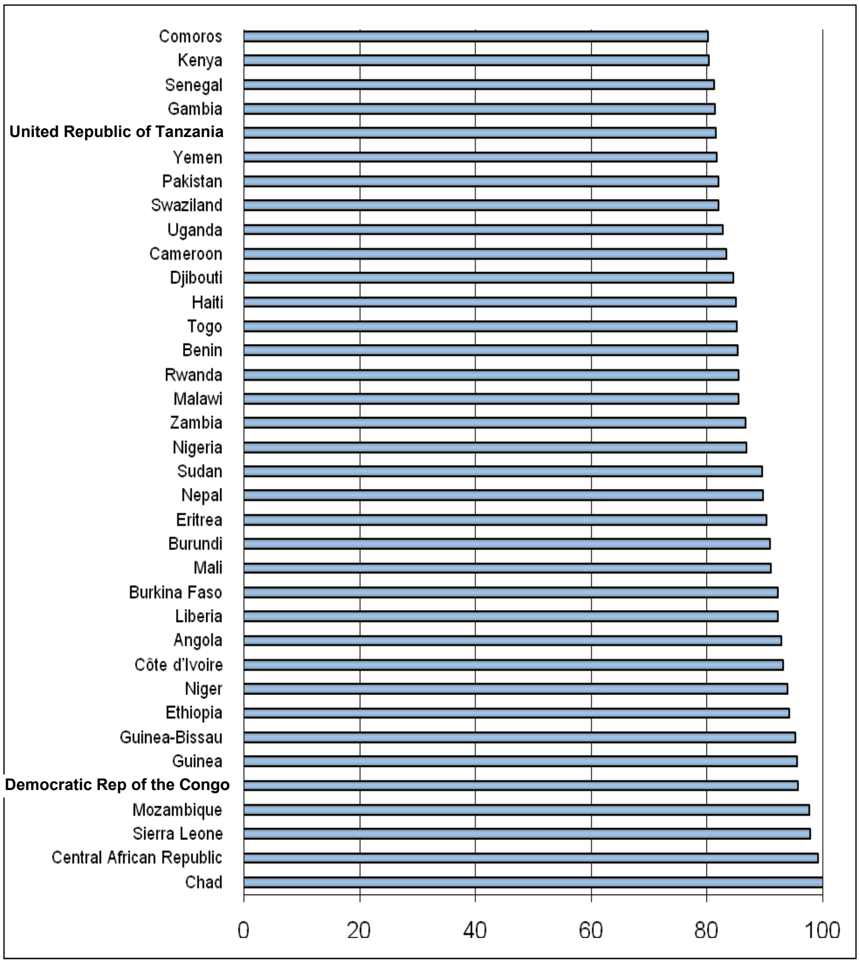
Countries with a low adaptive capacity are almost exclusively located in sub-Saharan Africa, with countries such as Chad, the Central African Republic, Sierra Leone and Mozambique having the lowest adaptive capacity of the total data set (Figures 8 and 9). Countries with the highest adaptive capacity are mainly developed countries such as European nations, Japan and, in the Americas, Canada, the United States of America and Chile.

FIGURE 8
Adaptive capacity of the fisheries sector to disasters.



Notes: Colours represent quartiles with yellow for the lowest quartile, dark brown for the upper quartile (highest index value), and grey where no data were available.
The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

FIGURE 9
Top quartile of countries with the lowest adaptive capacity (n = 143)



Note: The lowest ability to adapt is set equal to a value of 100.

3.4 Vulnerability

The fishery sectors of African and Southeast Asian countries are most vulnerable to disasters, according to both frequency and mortality exposure indicators, fishery dependence, and capacity to adapt. For some countries, such as the United States of America, Armenia, the Sudan, Philippines and Honduras, vulnerability scores are very different depending on which measure of exposure is used. The United States of America is the only high-income country that is highly vulnerable to the impacts of disaster on fisheries, although only when the frequency of disaster was used as the measure of exposure. By contrast, Armenia, the Sudan, Philippines and Honduras are only categorized as highly vulnerable when exposure is based on natural-disaster-associated mortalities.

Of the top quartile of countries most vulnerable to the impacts of disaster on the fishery sector, two-thirds are African nations if frequency is used as the indicator of exposure (Table 4). However, within this quartile the countries with the highest vulnerability are primarily Asian nations (China, Indonesia, India, Solomon Islands and Bangladesh). This pattern changes when mortality is used as an indicator of exposure, and the three mostly highly vulnerable nations to disaster impacts on the fishery sector are all situated in Africa, but again including Solomon Islands and China.

TABLE 4
Vulnerability ranking with different exposure indicators

Exposure based on frequency	Vulnerability rankings	Exposure based on mortality
China (5)	1	Mozambique (25)
Indonesia (10)	2	Ethiopia (35)
India (23)	3	Sudan (50)
Solomon Islands (4)	4	Solomon Islands (4)
Bangladesh (8)	5	China (1)
Philippines (40)	6	Armenia (104)
Sierra Leone (7)	7	Sierra Leone (7)
Vanuatu (9)	8	Bangladesh (5)
United States of America (120)	9	Vanuatu (8)
Samoa (12)	10	Indonesia (2)
Chad (11)	11	Chad (11)
Senegal (13)	12	Samoa (10)
Viet Nam (37)	13	Senegal (12)
Ghana (15)	14	Guinea (16)
Democratic Republic of the Congo (18)	15	Ghana (14)
Guinea (14)	16	Mauritania (30)
Cambodia (17)	17	Cambodia (17)
Peru (27)	18	Democratic Republic of the Congo (15)
Côte d’Ivoire (20)	19	Comoros (23)
Nigeria (26)	20	Côte d’Ivoire (19)
Angola (24)	21	Honduras (69)
Gambia (22)	22	Gambia (22)
Comoros (19)	23	India (3)
Uganda (25)	24	Angola (21)
Mozambique (1)	25	Uganda (24)
Malawi (29)	26	Nigeria (20)
United Republic of Tanzania (33)	27	Peru (18)
Liberia (28)	28	Liberia (28)
Thailand (54)	29	Malawi (26)
Mauritania (16)	30	Central African Republic (31)
Central African Republic (30)	31	Togo (33)
Cameroon (32)	32	Cameroon (32)
Togo (31)	33	United Republic of Tanzania (27)

Exposure based on frequency	Vulnerability rankings	Exposure based on mortality
Mali (35)	34	Guinea-Bissau (38)
Ethiopia (2)	35	Mali (34)
Pakistan (59)	36	Benin (37)

Note: Numbers in parentheses show the placement if the respective other exposure indicator is used.

4. RECOMMENDATION FOR FUTURE RESEARCH

This study identifies the following as areas of research to be further investigated:

1. Combine the two vulnerability indicators (Table 5). Compare different types of indicator aggregation (arithmetic, geometric means, and weighting) and explore relationship between indicators.

TABLE 5
Vulnerability ranking with different exposure indicators and the two exposure values combined

Vulnerability based on disaster frequency	Vulnerability rankings	Vulnerability based on disaster mortality	Both exposure values combined
China (5)	1	Mozambique (25)	China
Indonesia (10)	2	Ethiopia (35)	Solomon Islands
India (23)	3	Sudan (50)	Indonesia
Solomon Islands (4)	4	Solomon Islands (4)	Bangladesh
Bangladesh (8)	5	China (1)	Sierra Leone
Philippines (40)	6	Armenia (104)	Vanuatu
Sierra Leone (7)	7	Sierra Leone (7)	Chad
Vanuatu (9)	8	Bangladesh (5)	Samoa
United States of America (120)	9	Vanuatu (8)	Senegal
Samoa (12)	10	Indonesia (2)	India
Chad (11)	11	Chad (11)	Mozambique
Senegal (13)	12	Samoa (10)	Ghana
Viet Nam (37)	13	Senegal (12)	Guinea
Ghana (15)	14	Guinea (16)	Democratic Republic of the Congo
Democratic Republic of the Congo (18)	15	Ghana (14)	Cambodia
Guinea (14)	16	Mauritania (30)	Ethiopia
Cambodia (17)	17	Cambodia (17)	Côte d’Ivoire
Peru (27)	18	Democratic Republic of the Congo (15)	Comoros
Côte d’Ivoire (20)	19	Comoros (23)	Gambia
Nigeria (26)	20	Côte d’Ivoire (19)	Angola
Angola (24)	21	Honduras (69)	Peru
Gambia (22)	22	Gambia (22)	Mauritania
Comoros (19)	23	India (3)	Nigeria
Uganda (25)	24	Angola (21)	Philippines
Mozambique (1)	25	Uganda (24)	Uganda
Malawi (29)	26	Nigeria (20)	Viet Nam
United Republic of Tanzania (33)	27	Peru (18)	Sudan
Liberia (28)	28	Liberia (28)	Malawi
Thailand (54)	29	Malawi (26)	Liberia
Mauritania (16)	30	Central African Republic (31)	United Republic of Tanzania
Central African Republic (30)	31	Togo (33)	Central African Republic
Cameroon (32)	32	Cameroon (32)	Cameroon
Togo (31)	33	United Republic of Tanzania (27)	Togo
Mali (35)	34	Guinea-Bissau (38)	Mali
Ethiopia (2)	35	Mali (34)	Guinea-Bissau
Pakistan (59)	36	Benin (37)	Benin

Note: Numbers in parentheses show the placement if the respective other exposure indicator is used.

2. Compare the vulnerability of climate change to the fishery sector (Allison *et al*., 2009) with the vulnerability to natural disasters.
3. Refine dependence indicators. To obtain a better understanding of the importance of fish products in terms of food security, availability (consumption per capita) should be combined with nutritional importance (percentage of animal protein intake).
4. Include indicators and measurements of hunger, malnutrition and food insecurity (e.g. *The State of Food Insecurity in the World*) in adaptive capacity. Food insecurity is often exacerbated by natural disasters. Disasters can intensify poverty, reducing access to staple food and reducing availability through destruction of crops and reduction in fish yields. Data sets developed by the FAO Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) global initiative should be integrated in disaster-related vulnerability indicator development. Owing to its focus on national studies and the incomplete coverage globally, the FAO Global Information and Early Warning System (GIEWS) will be useful for regional or cross-national analysis.
5. Include official development assistance indicators in adaptive capacity. Classification by income with GDP does not necessarily reflect development status and dependence on overseas assistance. In addition, final vulnerability results should be ranked according to income groups and lending categories in order to help donors and development and emergency relief agencies identify rapidly and target countries that have the least capacity to adapt economically.
6. Discuss the relevance of using rankings of this type for disaster risk management. Temporal coverage in the data set used for the present study is extremely varied (e.g. 2004 data compared with 2009 data) on some of the main indices (e.g. mortality). Reducing vulnerability to disaster is a "moving target", as vulnerability changes over time with economic growth and development and stressors such as conflicts and political instability. The indicator-based approach might require yearly or biannual updates in order to make results relevant for donors and development and emergency relief agencies seeking to plan investments and interventions. Under the "One United Nations" approach, it is suggested that compatibility between databases and collection of data and updates are conducted in collaboration between different UN Agencies and other donors (Office for the Coordination of Humanitarian Affairs [OCHA], United Nations Strategy for Disaster Risk Reduction [UNISDR], FAO data sets. etc.).
7. Vulnerability analysis for whom? Why do we need indicators? Finally, an expert consultation with users of these types of indicators is warranted as well as an analysis of their policy relevance. It is important to tailor indicators and proxy measurements that reflect the differential needs of identified users with respect, for example, to content, level of detail, format and frequency.

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