

SUPPLEMENTARY INFORMATION

Sea level rise and wellbeing implications for coastal communities: a global evidence map

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1. Literature search

Table 1.1. Search strings used to search the scientific literature, both in Web search in both Web of Science and Scopus. All string combinations are composed of three parts: location (1), coastal hazard (2) and human wellbeing (3), resulting in 15 possible combinations.

Part of search	Category	Web of Science string	Scopus string
1. Location	Coastal	coast* OR shore* OR island* OR "low elevation" OR littoral OR waterfront* OR seaside* OR seascape* OR seashore* OR seaboard* OR beach* OR maritime* OR atoll* OR delta* OR "low-lying"	coast* OR shore* OR island* OR {low elevation} OR littoral OR waterfront* OR seaside* OR seascape* OR seashore* OR seaboard* OR beach* OR maritime* OR atoll* OR delta* OR {low-lying}
2. Coastal hazard	Flooding	flood* OR inundat* OR "storm surge**" OR submerg*	flood* OR inundat* OR "storm surge**" OR submerg*
	Erosion	("erosion" OR erod* OR retreat* OR "land loss" OR "loss of land") OR ((recession OR reced*) NEAR/3 (shore* OR beach* OR coast* OR land))	{(erosion} OR erod* OR retreat* OR {land loss} OR {loss of land}) OR ((recession OR reced*) W/3 (shore* OR beach* OR coast* OR land))
	Salinization	(salini?ation OR salination) OR ((intrusion OR intrud* OR encroachment) NEAR/6 (seawater OR saltwater OR salt OR salinity OR groundwater))	(salini?ation OR salination) OR ((intrusion OR intrud* OR encroachment) W/6 (seawater OR saltwater OR salt OR salinity OR groundwater))
3. Human wellbeing	Economic living standards	poor* OR poverty OR rich* OR wealth OR "high income" OR "low-income" OR "socioeconomic status" OR monetary OR income OR econom* OR job* OR occupation OR career OR livelihood* OR wage* OR salar* OR pay* OR financ* OR "savings" OR loan	poor* OR poverty OR rich* OR wealth OR {high income} OR {low-income} OR {socioeconomic status} OR monetary OR income OR econom* OR job* OR occupation OR career OR livelihood* OR wage* OR salar* OR pay* OR financ* OR {savings} OR loan
	Material living standards	(asset* OR hous* OR dwell* OR home OR tenure OR infrastructure OR "buildings" OR "*roads" OR vehicle OR car OR bike	(asset* OR hous* OR dwell* OR home OR tenure OR infrastructure OR {buildings} OR "*roads" OR vehicle OR

		OR train OR airplane OR boat OR telecom*) OR ((resource* OR water) NEAR/5 (scarc* OR access)) OR ((electricity OR fuel OR heating) NEAR/10 (famil* OR people OR resident*)) OR (transportation NOT (transportation NEAR/4 (sediment* OR sand)))	car OR bike OR train OR airplane OR boat OR telecom*) OR ((resource* OR water) W/5 (scarc* OR access)) OR ((electricity OR fuel OR heating) W/10 (famil* OR people OR resident*)) OR (transportation AND NOT (transportation W/4 (sediment* OR sand)))
Health		(health* OR hospital* OR medic* OR diseas* OR infection* OR "ill" OR "illness*" OR injur* OR disorder OR sick* OR mental* OR emotion* OR anxiet* OR psycho* OR depress* OR "satisfaction" OR "happiness" OR "subjective well*" OR "self-esteem" OR "quality of life" OR longevity OR "life expectancy" OR death* OR "human casualties") OR ((human OR population OR "lives" OR "life") NEAR/3 (lost OR loss*)) OR ((food OR nutrition) NEAR/2 (security OR insecurity OR scarcity))	(health* OR hospital* OR medic* OR diseas* OR infection* OR {ill} OR "illness*" OR injur* OR disorder OR sick* OR mental* OR emotion* OR anxiet* OR psycho* OR depress* OR {satisfaction} OR {happiness} OR "subjective well*" OR {self-esteem} OR {quality of life} OR longevity OR {life expectancy} OR death* OR {human casualties}) OR ((human OR population OR life) W/3 (lost OR loss*)) OR ((food OR nutrition) W/2 (security OR insecurity OR scarcity))
Education		knowledge OR educat* OR school* OR universit* OR *literate OR *literacy OR "learning"	knowledge OR educat* OR school* OR universit* OR *literate OR *literacy OR {learning}
Community & Sense of Place		"cultur*" OR "tradition*" OR religio* OR sacred OR spirit* OR heritage OR "sense of home" OR "place-belongingness" OR "place attachment" OR "sense of belonging" OR "sense of place"	"cultur*" OR "tradition*" OR religio* OR sacred OR spirit* OR heritage OR {sense of home} OR {place-belongingness} OR {place attachment} OR {sense of belonging} OR {sense of place}

Table 1.2. Example string combinations for searching the literature on 'flooding' and 'economic living standards'

Database	Full search string
Web of Science	(TS=(coast* OR shore* OR island* OR "low elevation" OR littoral OR waterfront* OR seaside* OR seascape* OR seashore* OR seaboard* OR beach* OR maritime* OR atoll* OR delta* OR "low-lying") AND TS=(flood* OR inundat* OR "storm surge*" OR submerg*) AND TS=(poor* OR poverty OR rich* OR wealth OR "high income" OR "low-income" OR "socioeconomic status" OR monetary OR income OR econom* OR job* OR occupation OR career OR livelihood* OR wage* OR salar* OR pay* OR financ* OR "savings" OR loan) NOT TS=(review) NOT TI=(model* OR index method*)) AND (DT==("ARTICLE"))
Scopus	(TITLE-ABS-KEY (coast* OR shore* OR island* OR {low elevation} OR littoral OR waterfront* OR seaside* OR seascape* OR seashore* OR seaboard* OR beach* OR maritime* OR atoll* OR delta* OR {low-lying}) AND TITLE-ABS-KEY (flood* OR inundat* OR "storm surge*" OR submerg*) AND TITLE-ABS-KEY (poor* OR poverty OR rich* OR wealth OR {high income} OR {low-income} OR {socioeconomic status} OR monetary OR income OR econom* OR job* OR occupation OR career OR livelihood* OR wage* OR salar* OR pay* OR financ* OR {savings} OR loan) AND NOT TITLE-ABS-KEY (review) AND NOT SRCTITLE (model* OR index AND method*)) AND (LIMIT-TO (DOCTYPE , "ar"))

2. AI-assisted steps: prompts and performance

Note 2.1. Performance metrics and equations for assessing AI performance

For a confusion matrix (with two classes)

		Reference	
		yes	no
Model decision	yes	TP	FP
	no	FN	TN

Where,

TP: true positive

TN: true negative

FP: false positive

FN: false negative

For each class, we can calculate:

Accuracy

Fraction of correct predictions over n items

$$A = \frac{TP+TN}{TP+TN+FP+FN}$$

Precision

Number of correct predictions in class x over the total number of items predicted in class x

$$P = \frac{TP}{TP+FP}$$

Recall [also called 'sensitivity']

Number of correct predictions in class x over the total number of items expected in class x

$$R = \frac{TP}{TP+FN}$$

F-1 score

Harmonic mean of precision and recall (equally weighted)

$$F_1 = 2 \cdot \frac{P \cdot R}{P + R}$$

Overall metrics in multi-class analysis

To summarize across classes, precision and recall can be calculated in two ways.

Micro-precision and micro-recall are weighted according to the number of cases per class, and therefore have a bias for larger classes.

$$\text{Microprecision} = \frac{TP_{class\ 1}+TP_{class\ 2}+\dots+TP_{class\ n}}{TP_{class\ 1}+FP_{class\ 1}+TP_{class\ 2}+FP_{class\ 2}+\dots+TP_{class\ n}+FP_{class\ n}}$$

$$\text{Microrecall} = \frac{TP_{class\ 1}+TP_{class\ 2}+\dots+TP_{class\ n}}{TP_{class\ 1}+FN_{class\ 1}+TP_{class\ 2}+FN_{class\ 2}+\dots+TP_{class\ n}+FN_{class\ n}}$$

Macro-precision and macro-recall weigh all classes equally and is a mean of the precision or recall of every class.

$$\text{Macroprecision} = \frac{precision_{class\ 1}+precision_{class\ 2}+\dots+precision_{class\ n}}{n}$$

$$\text{Macrorecall} = \frac{recall_{class\ 1}+recall_{class\ 2}+\dots+recall_{class\ n}}{n}$$

Regardless of the method used, the overall F1-score remains a harmonic mean of the overall precision and overall recall calculated. For this analysis, we use micro metrics for the relevancy classification step (see 2.3), to account for largely imbalanced classes, and we use macro metrics for the geolocation step, where we expect classes to be of similar sizes (see 2.7) (Lee et al., 2024; Grandini et al., 2020).

Table 2.2. Model prompt for relevancy classification.

This prompt is split in different parts and can be adapted for each of the 15 relationships tested, according to the elements in color. Possible strings for each of the 5 elements are provided below.

I am conducting a systematic literature review on the relationship between coastal [string 1] and human wellbeing, in particular [string 3]. The following article is to be potentially included in my review, but I need to know if it is relevant to my topic or not. Your task is the following. Read the paper's title and abstract and assess if it is relevant for my topic. Here are the criteria to assess relevancy (both points 1 and 2 must be valid to accept a paper). First, the paper must discuss [string 2]. Second, the paper must also discuss at least one element from the following list of [string 3] elements: • [string 4] This list contains only some examples of [string 3] elements. Other elements that seem to fit in these points might also be accepted. Do not extrapolate; stick to what is explicitly stated in the title and abstract. For example, if an abstract mentions [string 5]. If no [string 3] aspect is explicitly stated, do not accept this abstract. Your answer should respect the following template. If the paper is accepted: 'yes', example of [string 3] elements identified in the text. If the paper is rejected: 'no', short justification for your decision in 15 words or less.	Description of the project
	Description of the task
	Inclusion criteria 1
	Inclusion criteria 2
	Additional explanations
	Answer format

Category	String 1	String 2	String 3	String 4	String 5
F	flooding	floods, inundations or storm surges			
E	erosion	coastal erosion, or receding shorelines, or landslides.			
S	salinization	salinization, meaning the intrusion of saltwater in			

		coastal groundwater resources.			
ELS			economic living standards	<ul style="list-style-type: none"> • poverty, or wealth, or socioeconomic status, or financial inequalities • the economy, or economic aspects • monetary aspects, or money • employment, or jobs, or occupations, or careers, or livelihoods • wages, or salary, or income, or pays • finances, or investments, or savings, or loans 	material damage, do not extrapolate to potential economic impacts.
MLS			material living standards	<ul style="list-style-type: none"> • material assets (not economic assets) • houses, or apartments, or dwellings, or homes • residential areas • all types of infrastructures • damages to towns, or settlements • buildings • the built environment • shelters for protection during disasters • roads, or railroads, or bridges, or highways • modes of transport (cars, bikes, planes, trains, boats, buses, metros, etc.) • access to material resources (except water resources) • telecommunications • households' energy needs (electricity, fuel, heating, etc.). 	economic damage, do not extrapolate to potential material impacts.

				<ul style="list-style-type: none"> • homelessness, informal settlements. • property, or land tenure 	
HEA			human health	<ul style="list-style-type: none"> • health • hospitals, or medical centers • medicine • physical health • diseases, or infections, or illnesses, or injuries, or sickness • sick or ill people • health disorders • mental health • emotional health • psychological health • depression • emotions such as anxiety, stress, fear, sadness, happiness, etc. • subjective wellbeing, or quality of life, or life satisfaction • life expectancy, or longevity • deaths, or lost lives, or human casualties, or population losses, or human losses • food security, or food insecurity, or food scarcity, or nutrition security, or nutrition insecurity 	severe housing damage, do not extrapolate to potential health implications.
EDU			education and knowledge	<ul style="list-style-type: none"> • education (both formal and informal) • degrees awarded • people's knowledge • local knowledge, or traditional knowledge and skills • transfer of knowledge, or knowledge sharing • learning • courses 	severe building damage, do not extrapolate to potential learning implications.

				<ul style="list-style-type: none"> • trainings • schools, or highschools, or universities (education buildings) • students • literate or illiterate individuals • educated and less educated groups • access to education, and quality of education 	
CSP			community and sense of place	<ul style="list-style-type: none"> • sense of community, or sense of belonging • sense of place, or sense of home • land and place attachment • social infrastructure • culture, and important cultural places • cultural identity • heritage • heritage sites, and archaeological sites • traditions, and traditional values • religion, religious beliefs, religious places • sacred and spiritual elements 	severe building damage, do not extrapolate to potential sacred places impacted.

Table 2.3. Model performance for the relevancy classification step.

These validation metrics were computed on sets of 100 publications (human-labeled) for 5 randomly selected relationships among the 15 explored, covering at least once each coastal hazard and human wellbeing dimension. In this case, 'yes' stands for included papers, while 'no' stands for excluded papers. Details on calculations are provided in note 2.1.

Relationship tested	Confusion matrix			Accuracy	Overall micro-precision *	Overall micro-recall *	Overall micro F1-score *
F-ELS	Model	Reference		0.930	0.930	0.930	0.930
		yes	no				
		yes	5				
S-MLS	Model	Reference		0.900	0.900	0.900	0.900
		yes	no				
		yes	5				
E-HEA	Model	Reference		0.960	0.960	0.960	0.960
		yes	no				
		yes	1				
F-EDU	Model	Reference		0.960	0.960	0.960	0.960
		yes	no				
		yes	0				
E-CSP	Model	Reference		0.950	0.950	0.950	0.950
		yes	no				
		yes	3				

* Here we use micro-metrics due to largely imbalanced classes. As a result, and as this is a binary classification exercise, equations for accuracy, precision, recall and F1 scores are the same (see 2.1).

Table 2.4. Model prompt for abstract geolocation

The main prompt parts highlighted in the right column. The model is provided with a field containing the title and abstract of each paper.

<p>I am looking to retrieve geographical information about some papers. For each of them, I will send you their title and their abstract.</p>	Description of the task
<p>Your first goal is to provide me with the study location (from the title and abstract).</p>	Descriptive location
<p>Your second goal is to provide a clear label for that study:</p> <ul style="list-style-type: none"> ○ If the text contains a country name, return the ISO code ○ If the study is conducted at a smaller level than the country (village, province, etc.), extrapolate to the ISO code this place is in. ○ If the study is done in multiple countries, or at a scale larger than one country (Europe, Southeast Asia, etc.), return "regional". ○ If the study is conducted at the global scale, return "global". ○ If there is no mention of a location, indicate "NULL". <p>Do not extrapolate to where the study could be performed. Stick to the text and use the 5 points above to answer.</p> <p>Your final answer should be of the following format with no extra information.</p> <p>Study location: Study label: ISO code or "regional" or "global" or "NULL"</p>	Clearly labeled location
	Answer format

Note 2.5. Model performance for the abstract geolocation step.

These validation metrics were computed on a set of 100 randomly selected publications (human-labeled). Due to the large number of countries represented in the dataset, we choose to not represent the confusion matrix. Details on calculations are provided in note 2.1.

Accuracy = 0.960
Overall macro-precision = 0.951
Overall macro-recall = 0.957
Overall macro-F1 = 0.949

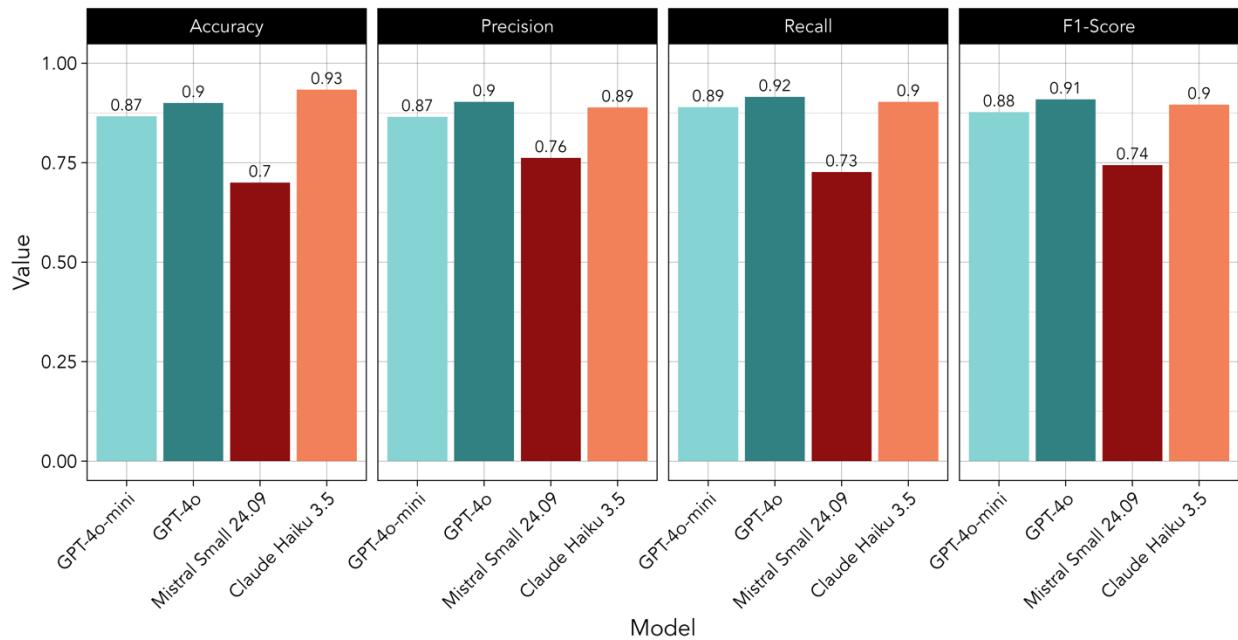
Table 2.6. Model prompt determining a study's framing.

The main prompt parts are highlighted in the right column. The model is provided with a field containing the title and abstract of each paper. This prompt is not used for an analysis for this research article but is part of our broader efforts to leverage LLMs for evidence synthesis.

I am conducting a review of academic research papers that discuss coastal hazards. Papers of this review can be framed in 3 different ways depending on what the focus of the research is.	Context
<ol style="list-style-type: none"> 1. Risk, if the aim of the paper is to assess vulnerabilities or potential risk faced by coastal places and communities. It focuses the sensitivities of place to future hazards by describing the current state of a place or by simulations/projected models/scenarios to quantify vulnerability or risk level to future events. 2. Adaptation, if the aim of the paper is turned towards adaptation actions that can help mitigate the impacts of future coastal hazards. This could be adaptive actions, plans, programs, or protection measures for the coast and communities. It can also evaluate the performance of an adaptation. Papers on adaptation are solution-oriented and promote resilience and mitigation. 3. Impact, if the research conducted is centered around the impacts that a coastal hazard has on a place or community. These are often impact assessments studies conducted during or after the event has occurred. These papers focus on real life events that occurred, and not models, or simulations. They describe or quantify actual impacts, not just risk. 	Define key concepts
Your task is the following. Read the paper's title + abstract in its entirety and determine how it is framed in relation to coastal hazards.	Task description
Your answer can only be one letter representing the category: "R" for risk, "A" for adaptation, "I" for impact. If a paper seems to fall in multiple categories, choose the one that best describes the focus of the authors' research as stated in the abstract.	Answer format

Figure 2.7. Comparing the performance of multiple large language models.

For the study framing task, we compare the use of model GPT 4o-mini to a higher intelligence model (GPT 4o) and two other compact models (Mistral Small 24.09 and Claude Haiku 3.5). All models are run three times on a set of 30 randomly selected publications with the prompt provided in 2.6. We select the final decision as a best 2 out of 3 and calculate performance metrics based on 2.1.



** Prices for 1 million input tokens in USD as of February 2025. GPT 4o-mini: 0.15\$. GPT 4o: 2.50\$. Mistral Small 24.09: 0.00\$ (when ran locally or for research purposes). Claude Haiku 3.5: 0.80\$.

3. Descriptive information

Table 3.1. Number of publications associated to each discipline.

We use the Web of Science Master Journal List to extract disciplines. As a result, a journal can be associated to multiple disciplines.

Discipline	Number of publications
Environmental Sciences	1261
Water Resources	1068
Geosciences, Multidisciplinary	853
Meteorology & Atmospheric Sciences	777
Environmental Studies	699
Engineering, Civil	327
Oceanography	297
Green & Sustainable Science & Technology	294
Geography	261
Marine & Freshwater Biology	162
Multidisciplinary Sciences	144
Engineering, Ocean	139
Public, Environmental & Occupational Health	129
Economics	119
Ecology	117
Geography, Physical	115
Engineering, Environmental	100
Regional & Urban Planning	78
Urban Studies	76
Engineering, Marine	70
Remote Sensing	67
Social Sciences, Interdisciplinary	60
Development Studies	56
Archaeology	55
Construction & Building Technology	53
Engineering, Geological	49
Geochemistry & Geophysics	47
Transportation Science & Technology	44
Imaging Science & Photographic Technology	34
Anthropology	32
Agronomy	31
International Relations	30
Other disciplines (with less than 30 publications)	124
NA	1296

Table 3.2. Original languages of publications included in this analysis.

Number of authors	Number of publications
English	5277
French	67
Spanish	60
Portuguese	49
Chinese	43
German	21
Undefined	14

Russian	12
Japanese	11
Italian	6
Croatian	4
Dutch	4
Malay	4
Turkish	4
Catalan	2

Chinese; English	1
Hungarian	1
Indonesian	1

Korean	1
Persian	1
Ukrainian	1

Table 3.3. Number of authors involved in publications.

Number of authors	Number of publications
1	782
2	996
3	1072
4	895
5	625
6	371
7	292
8	179
9	114
10	86
11	53
12	34

13	19
14	21
15	11
16	12
17	2
18	8
19	1
20	1
21	1
24	4
25	2
36	1
37	1
43	1

4. Multidimensionality

Figure 4.1. Multidimensionality aspect of publications linking coastal hazards to human wellbeing.

A, Number of coastal hazards discussed jointly in publication. The matrix above indicates which coastal hazards are explored together. B, Number of human wellbeing dimensions explored in publications. The matrix above indicated which dimensions are generally considered together. Most publications focus on either only one coastal hazard or one wellbeing dimension.

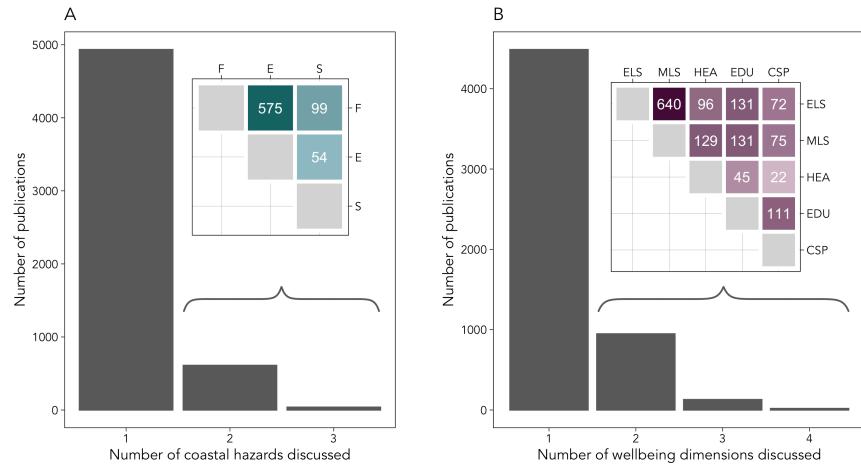
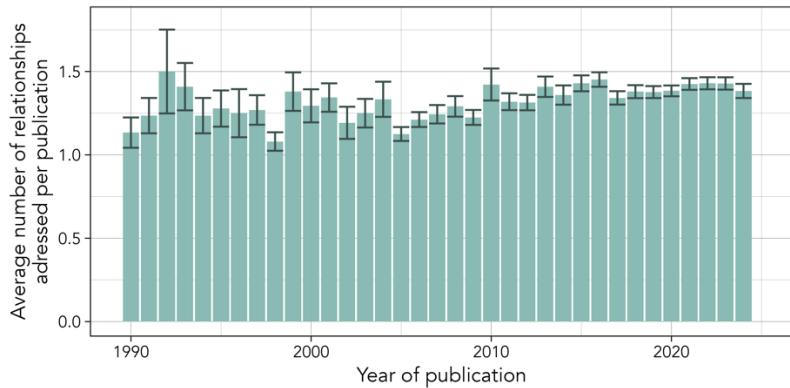


Figure 4.2. Multidimensionality aspect over time (1990-2024).

Here we define multidimensionality as the average number of relationships (among the 15 explored) that a paper touches on. Error bars represent standard error around the average.



5. Geographical distribution

Figure 5.1. Geographical distribution of human wellbeing evidence, by study location.

For each dimension of human wellbeing (HWB), these maps show the number of publications linking the HWB dimension to sea level rise, in each country studied. The codes are flooding (F), erosion (E), salinization (S).

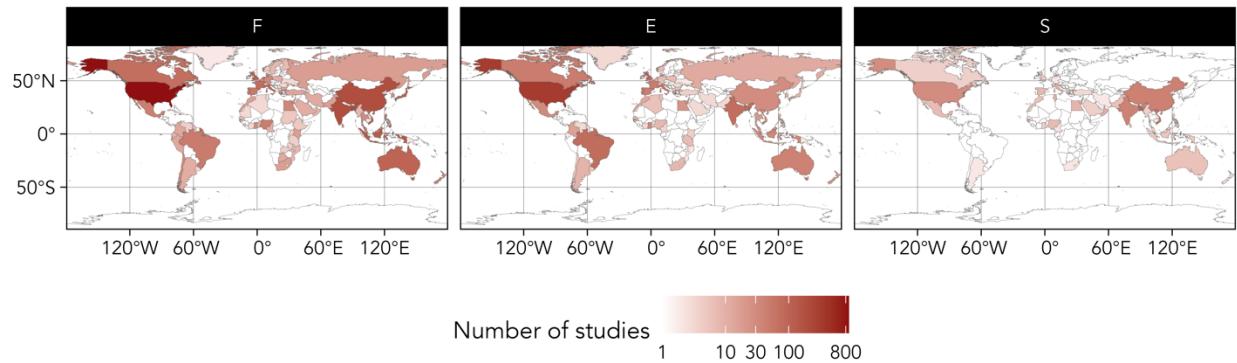


Figure 5.2. Geographical distribution of coastal hazard evidence, by study location.

For each coastal hazard, these maps show the number of publications linking the hazard to human wellbeing, in each country studied. The codes are economic (ELS) and material (MLS) living standards, health (HEA), education (EDU), community & sense of place (CSP).

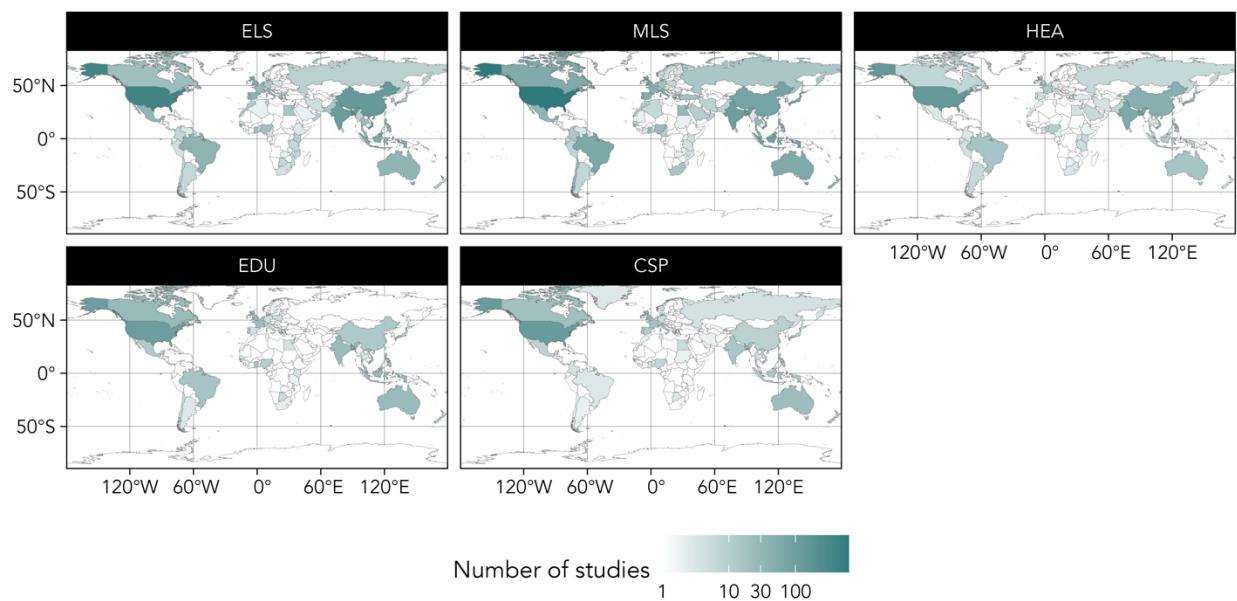


Figure 5.3. Flows from author location to study location, at the continent level.

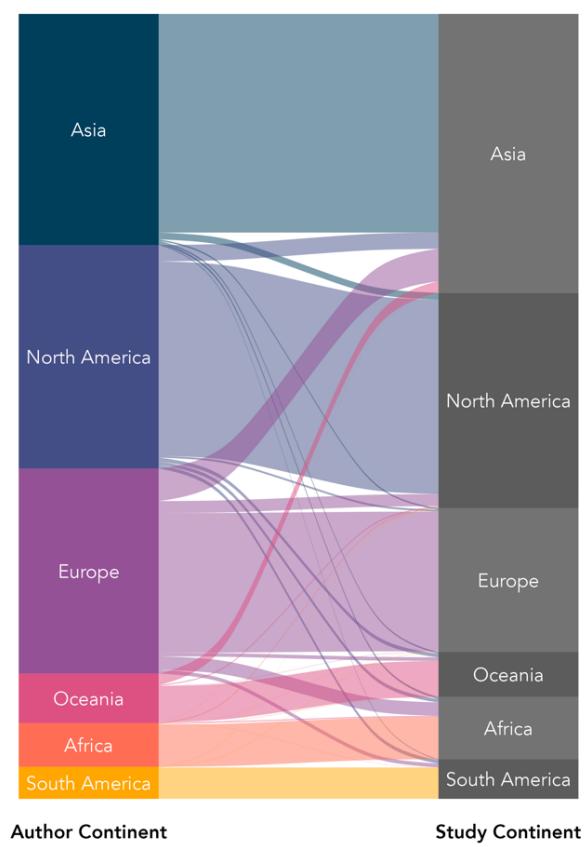


Figure 5.4. Author and study location over time, at the continent level

