Global Trends in Water-Related Disasters Using Publicly Available Database for Hazard and Risk Assessment

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1. Introduction

Water-related disasters such as floods, landslides and droughts are inducing huge loss of human lives and properties and agricultural production. According to the Emergency Events Database (EM-DAT; Guha-Sapir et al., 2016), due to the water-related disasters about 1 million people were killed and the total amount of damages leached to USD 794 billion between 1980 and 2014 globally. Furthermore, extreme weather events are considered to be increased and strengthened in association with the ongoing global climate change, which could boost damages on human safety and economic activities.

Global risk maps are helpful for decision makes to determine action plans. Existing studies on risk assessment of the water-related disaster has considered frequency/intensity of the disasters and potentially-affected area considering geographical conditions. However, degree of the damages can also be affected by socio-economic situations which include preparedness and resilience against the disasters. In this study, a procedure to evaluate degree of the risk with considering socio-economic indicators was developed and tested.

2. Materials and Methods

2.1. Definition of "Risk"

According to UN definition (Cardona 2005), degree of the 'risk' of loss by water-related disasters is generally a function of 'hazard', 'exposure' and 'vulnerability'; 'hazard' is frequency of a certain period within criteria of its magnitude; 'exposure' is number or amount of the objects which could be affected by the hazards; and 'vulnerability' is degree of how the geographical and socio-economical situations may allow damages. The socio-economical aspect of 'vulnerability' can be regarded as 'adaptation capacity', and on the other hand, 'exposure' is inseparable from the geographical contribution of 'vulnerability'.

Here, amount which is considered affected due to geographical situations were defined as 'vulnerability', and degree of impact depending on the socio-economical adequacy was called as 'adaptive capacity'. In this study, the degree of 'risk' was evaluated by multiplying scores of 'hazard', 'vulnerability' and 'adaptation capacity'; each score of 'hazard', 'vulnerability' and 'adaptation capacity' was calculated as integration of data which were freely available in the internet with the following procedures.

2.2. Data Sources

Data for scoring each of 'hazard', 'vulnerability' and 'adaptation capacity' used in this study were freely available in the websites of international organizations. The list of the data is shown in Table 1. In this study, averaged values of the data from 2000 to 2015 were utilized to map indicators for risk assessment.

2.3. Scoring Procedures

Each of the data was ranked into five scores; the criteria were manually set to almost evenly divide number of countries in each of the ranks. Values of the criteria are shown in Table 2.

The scores of 'risk' were calculated as a geometrical mean of those of 'hazard', 'vulnerability' and 'adaptation capacity'. The indicators for 'adaptation capacity' were merged into one score; here, the indicators in each of the groups ('education', 'income', 'infrastructure' and 'health') were weighted according to their significance, and then the averaged value of the integrated scores for these four groups was regarded as the score of 'adaptation capacity'. Values for the weighting are shown in Table 3.

Table 1. List of the data used in this study.

Variables	Kinds of disaster/ Group of indicators		Data used	Sources
Hazard	Floods		Number of grids – inundated > 5 cm by 100-year flood hazard	UNEP, 2013 IWMI 2016
	Landslides		Number of grids – > 'low frequency' triggered by precipitation	UNEP, 2013
	Drought		Areal average of drought severity	WRI, 2015 IWMI 2016
Vulner-ability	Floods	Residents	Population affected by 100-year flood	WRI, 2015
		Economy	GDP affected by 100-year flood	WRI, 2015
	Others	Residents	Rural population	WB, 2016
		Economy	GDP of agricultural production	WB, 2016
Adaptation Capacity	Income		GNI per capita	UNDP, 2016
			Population in multidimensional poverty	UNDP, 2016
	Infrastructure		Access to information and technology	WB, 2016
			Mobile phone subscriptions	UNDP, 2016
			International inbound tourists per total population	UNDP, 2016
	Education		Adult literacy rate	UNDP, 2016
			Mean year of schooling	UNDP, 2016
			Public expenditure on education	UNDP, 2016
	Health		Density of physicians	WHO, 2016
			Nursing/ midwifery personnel density	WHO, 2016
			Pharmaceutical personnel density	WHO, 2016
			Other health workers density (excluding dentists)	WHO, 2016
			Hospital bed density	WB, 2016

Table 2. Criteria of the scores.

Variables	Data used [Unit]	Values corresponding the scores				
		1	2	3	4	5
Hazard	Number of grids –inundated > 5 cm by 100-year flood [%]	< 2	< 5	< 10	< 20	≥ 20
	Number of grids – > 'low frequency' by precipitation [%]	< 20	< 40	< 60	< 80	≥ 80
	Areal average of drought severity	< 1	< 1.5	< 2	< 3	≥ 3
Vulner-ability	Population affected by 100-year flood [%]	< 2	< 5	< 10	< 20	≥ 20
	GDP affected by 100-year flood [USD 1000 per capita]	< 0.2	< 0.5	< 1	< 2	≥ 2
	Rural population [per km^2]	< 5	< 20	< 100	< 200	≥ 200
	GDP of agricultural production [USD 1000 per capita]	< 0.1	< 0.2	< 0.4	< 0.8	≥ 0.8
Adaptation Capacity	GNI per capita [USD 1000]	≥ 20	< 20	< 10	< 5	< 2
	Population in multidimensional poverty [%]	< 5	< 10	< 20	< 50	≥ 50
	Access to information and technology [USD per capita]	≥ 100	< 100	< 20	< 5	< 1
	Mobile phone subscriptions [per person]	≥ 1	< 1	< 0.8	< 0.6	< 0.4
	International inbound tourists [per 1000 people]	≥ 500	< 500	< 100	< 10	< 1
	Adult literacy rate (ages 15/older) [%]	≥ 90	< 90	< 70	< 50	< 30
	Mean year of schooling [years]	≥ 10	< 10	< 7	< 5	< 3
	Public expenditure on education [% of GDP]	≥ 10	< 10	< 5	< 2	< 1
	Density of physicians [per 1000 people]	≥ 2	< 2	< 1	< 0.5	< 0.1
	Nursing/midwifery personnel density [per 1000 people]	≥ 5	< 5	< 2	< 1	< 0.5
	Pharmaceutical personnel density [per 1000 people]	≥ 1	< 1	< 0.5	< 0.1	<0.02
	Other health workers density [per 1000 people]	≥ 2	< 2	< 1	< 0.5	< 0.1
	Hospital bed density [per 1000 people]	≥ 10	< 10	< 5	< 3	< 1

3. Results and Discussion

In this study, the statistical data of water-related disasters for 193 countries were collected, and eventually the overall 'risk' was evaluated in 157 countries; the rest countries did not have enough data for the analysis. The maps for scores of 'hazard', 'vulnerability' and 'adaptation capacity' as examples are shown in Fig. 1.

Table 3. Weights of the indicators for scoring of 'adaptation capacity'.

Group of indicators	Data used	Weights
Income	GNI per capita	0.5
	Population in multidimensional poverty	0.5
Infrastructure	Access to information and technology	0.5
	Mobile phone subscriptions	0.3
	International inbound tourists per total population	0.2
Education	Adult literacy rate	0.4
	Mean year of schooling	0.4
	Public expenditure on education	0.2
Health	Density of physicians	0.3
	Nursing/ midwifery personnel density	0.2
	Pharmaceutical personnel density	0.1
	Other health worker density (excluding dentists)	0.1
	Hospital bed density	0.3

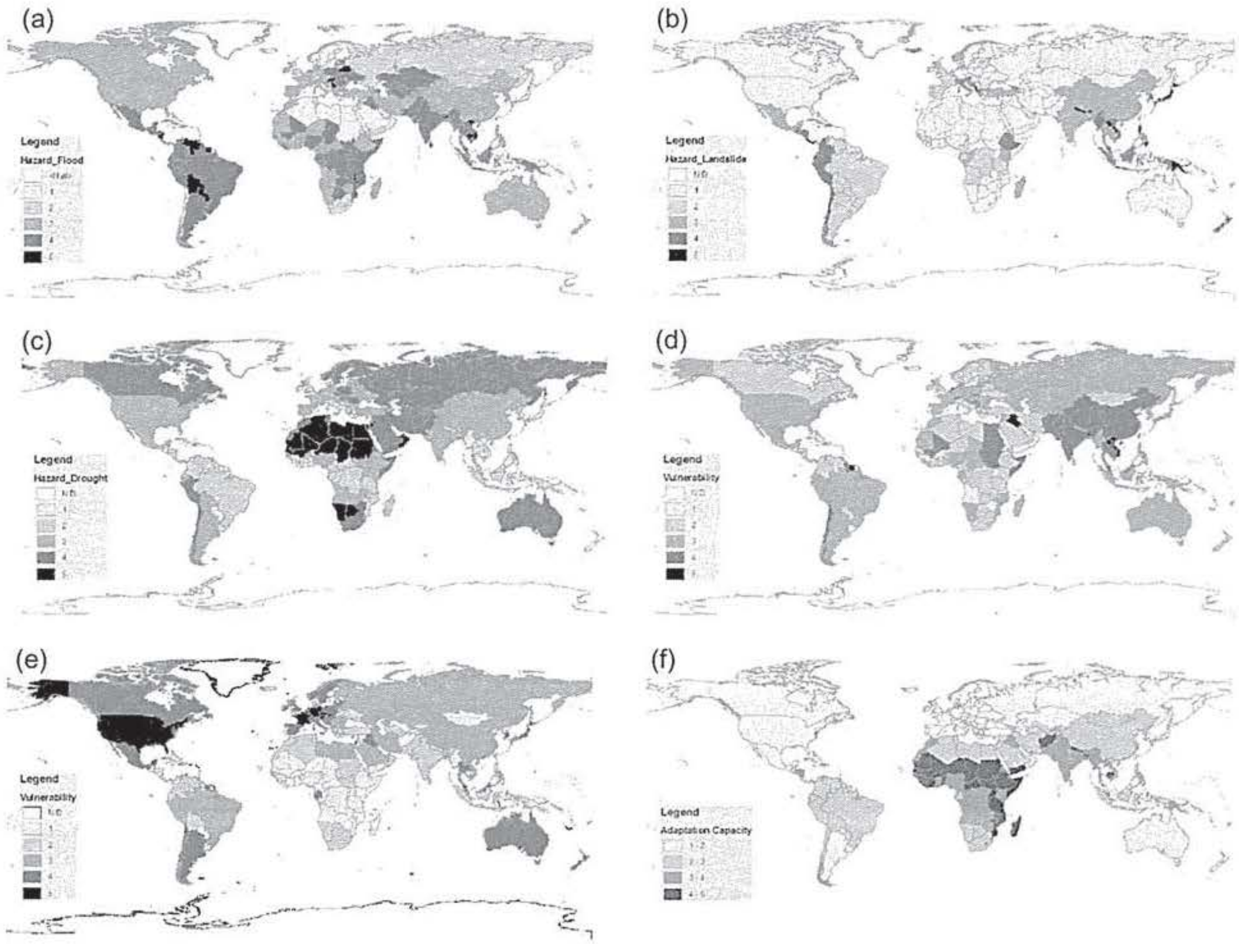

Fig. 1. Maps of the scores for the global risk analyses; (a) 'hazard' of floods; (b) 'hazard' of landslides; (c) 'hazard' of drought; (d) 'vulnerability' for floods on people; (e) 'vulnerability' for floods on economy; and (f) 'adaptation capacity'.

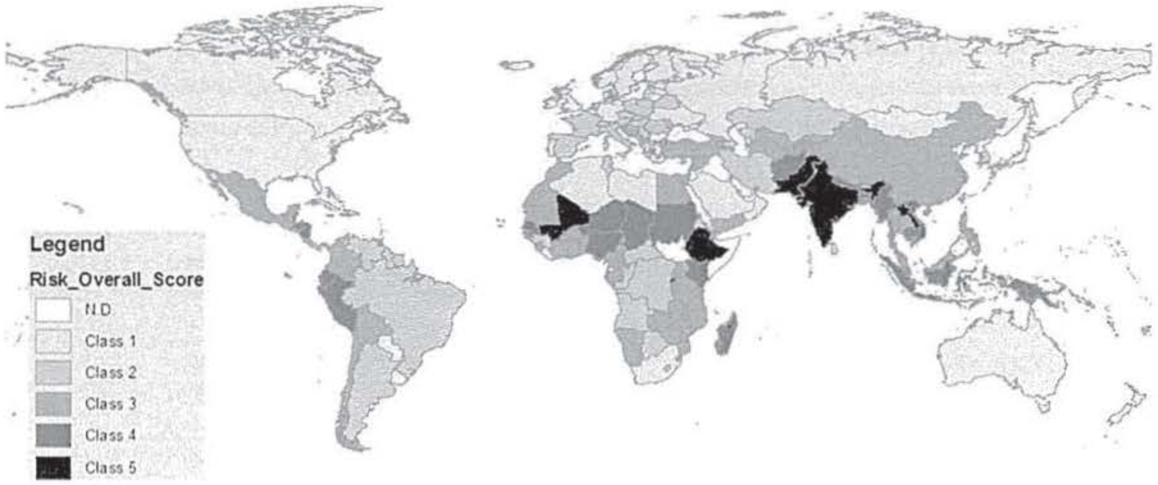

Fig. 2. Global map of overall 'risk' score evaluated by the procedure shown in this study.

The map for the evaluated score of overall 'risk' is shown in Fig. 2; The countries were classified according to the evaluated scores, and then six counties in Asia and Africa were categorized into the fifth class (with the total score of more than 19). These countries are likely to be exposed severe weather situation and have relatively dense population and economy even with rooms to improve their socio-economical situations.

4. Conclusion

Procedures to illustrate global risk maps with considering adaptation capacity were developed and tested. This could be applicable to further analyses for instance in future climate change and with improved social conditions and infrastructures. Utilization of freely-available information could be also helpful to decision makers in developing countries. The results seemed generally appropriate, but as future tasks comparison to records of the disasters their damages would be necessary for validation.

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