

Exploring the plexus of context and consequences: An empirical test of a theory of disaster vulnerability



Michel Dückers^{a,*}, Georg Frerks^{b,c,d}, Jörn Birkmann^e

^a Impact - National Knowledge and Advice Centre for Psychosocial Care Concerning Critical Incidents, Partner in Arq Psychotrauma Expert Group, 1112 XE Diemen, The Netherlands

^b Conflict Prevention and Conflict Management, Centre for Conflict Studies, Utrecht University, 3512 BS, Utrecht, The Netherlands

^c International Security Studies, Faculty of Military Sciences, Netherlands Defense Academy, 3509 AA, Utrecht, The Netherlands

^d Disaster Studies, Sociology of Development and Change, Social Sciences Group, Wageningen University, 6706 KN, Wageningen, The Netherlands

^e Institute for Environment and Human Security, United Nations University, 53113 Bonn, Germany

ARTICLE INFO

Article history:

Received 13 March 2014

Received in revised form

9 February 2015

Accepted 8 April 2015

Available online 10 April 2015

Keywords:

Disasters

Disaster vulnerability

Culture

Quantitative research

ABSTRACT

What determines the disaster vulnerability of countries? In this study a theoretical model was tested, linking disaster vulnerability to physical hazards and cultural and historical factors. Associations between the World Vulnerability Index and Hofstede's cultural dimensions scores were explored using quantitative methods, while taking exposure to natural hazards into account. Data of 60 countries could be matched. Less exposed countries in this sample are significantly less vulnerable. Culturally, particularly countries with a lower power balance and a higher level of individualism are less vulnerable as well; two features linked to higher levels of wealth. Approximately 70% of the variance in vulnerability could be explained in this way. These results should, however, be interpreted with some caution as longitudinal data were unavailable and disaster vulnerability itself may be seen as a cultural derivate, making it impossible to clarify causal mechanisms. Despite these and other limitations, the study points at interesting associations that, firstly, should be expanded and replicated in larger samples, allowing more advanced analysis, and secondly, encourage a more thorough examination of different local contexts and cross-level interactions than was possible in this exploratory endeavor.

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1. Introduction

1.1. Increase in disaster vulnerability

Examining disasters through the lens of vulnerability confers real insights at the time when both the frequency and magnitude of such events are increasing. The total number of reported natural and technological disasters rose from 368 in 1992 to an average of about 650 per year for the period 2004–2013 [1]. Likewise, the growth in the number of natural disasters over the last decade was over 50% compared to the previous decade. The number of affected people by disasters rose to an average of 200 million people per year for the years 2004–2013, mostly in Africa and Asia and the damage averaged about US\$ 167 billion annually. The average number of deaths per year is more or less stabilising at 106,000 for the period 2004–2013 [1]. There are of course huge variations: in 2012 the number of casualties was 15,585, much lower than the peaks of over 250,000 in 2004 (the year of the tsunami in the

Indian Ocean) and over 300,000 in 2010 (the earthquake in Haiti). Fluctuations are interesting; more important however, is that the increase shown in the number and overall impact of natural and anthropogenic disasters is expected to continue as it is associated with the increased complexity and interdependency of societies [2], leading to cascading effects and mega-disasters [3]. Moreover, urbanization, environmental degradation, climate change, mismanagement of natural resources, conflicts and state failure, and 'bad' governance are considered worldwide drivers for increased disaster vulnerability [4].

1.2. Understanding vulnerability

Disaster vulnerability has many different connotations, depending on the research orientation and perspective [5]. It is common to define vulnerability as the "characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard." [6]. Vulnerability is usually a socially constructed potential for harm, expressed on a scale from no damage to total loss. Since losses vary geographically, over time, and among different social groups,

* Corresponding author.

E-mail address: m.duckers@impact.arq (M. Dückers).

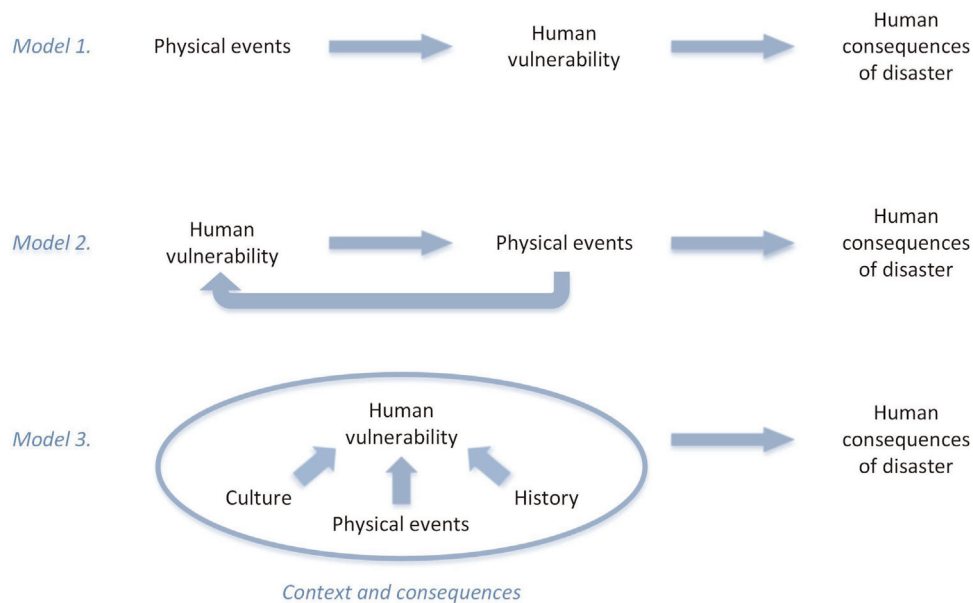


Fig. 1. Three models of disaster (Source: [9]).

vulnerability also varies over time and space [5]. This makes vulnerability a dynamic concept, which can only be understood in relation to its causes and consequences. White provides a convenient starting point. He employed a human ecology approach to study natural hazards, initially with a focus on flood hazards where he realised that it is not only the hazard that should be adjusted but also the human exposure to the hazard [7]. The result is a linear model, portraying how the influence of physical events on the human consequences of disaster is mediated by human vulnerability. This first model (Fig. 1) however, does not explicitly recognize the viewpoint that the causes and the phenomenology of disasters are defined by social processes and structures as well. Thus it is not only a geo- or bio-physical hazard, but also the social context that is necessary in order to understand “natural” disasters [8]. The so-called “radical critique” argues that, in the explanation of disaster, vulnerability carries more weight than hazard. As a result of feedback loops, hazard can be regarded as a trigger for the social processes that create vulnerability, which is the principal determinant of disaster potential [9]. According to Alexander the increasing knowledge of disasters and the social processes involved, and the complexity of life in the early 21st century demand a new model: “the vulnerability of human socio-economic systems is acted upon by physical hazards (whether natural or anthropogenic), as well as cultural and historical factors. The plexus of the context and consequences of these associations is what determines the form, entity and size of any ensuing disaster” [9,10].

1.3. Study objective

Alexander's model summarizes a complex interaction between elements, so broad and multifaceted that it can hardly be captured in words, let alone be measured. Nevertheless, the thought that the combination of culture, physical hazards and historical factors influences vulnerability serves as the point of reference for this study. Human societies can be analysed at different levels. The objective of this study is to test associations between elements of the model at the level of countries, operationalized using a combination of information from two sources: disaster vulnerability data and exposure data from the World Risk Index [11,12] and Hofstede's cultural dimensions scores [13–15]. A quantitative study of this type is rare and contributes to knowledge about the empirical associations between cultural features, exposure to

natural hazards and disaster vulnerability.

The nature of the key concepts, the main data sources and a number of expected relations are described hereafter, followed by a description of the results of the analysis, some critical reflections on how to interpret the results, and the main conclusions.

2. Key concepts, data sources and expected relations

2.1. Disaster vulnerability

Considerable research attention has been focused since the 1960s on components of biophysical vulnerability and the vulnerability of the built environment. Relatively more recently, the social, historical and political aspects of vulnerability received scholarly attention. These aspects are sometimes ignored because of the greater difficulty in quantifying them [5]. A person's individual vulnerability is still quite easily described using individual characteristics (age, gender, income, race, education, employment, psychosocial resilience), but wider issues at the community level or derived from political economy or power relations [16] are obviously often more difficult to grasp. Social vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond [17].

To date, there has been little research effort focused on comparing the social vulnerability of one place to another. The vulnerability index by Cutter and colleagues is an important example of an assessment tool. At a global level the World Risk Index is the most comprehensive tool to assess the disaster risk that a society or country is exposed to by external and internal factors [11,12]. The index is based on multiple indicators. Matrices are calculated for 173 countries; detailed information is publicly available and described in the World Risk Report 2012. The data collection required for its calculation is freely available and can be reliably accessed via the Internet, ensuring transparency and verifiability. In order to be mathematically aggregated into indices, the indicators are transformed in dimensionless rank levels between 0 and 1, i.e. they can be read as percentage values. The index illustrates that a country's disaster risk may depend on several factors, so that a country also has several means at its disposal to reduce risks [18]. Disaster vulnerability comprises the components

of susceptibility, lack of coping capacities and lack of adaptive capacities [11,12] which are further elaborated below.

2.1.1. Susceptibility

Susceptibility generally refers to the likelihood of harm, loss and disruption in an extreme event triggered by a natural or anthropogenic hazard. Thus susceptibility describes structural characteristics and framework conditions of a society. Several subcategories outlining the living conditions in a country have been chosen to represent susceptibility in the vulnerability index: public infrastructure (share of population without access to improved sanitation and share of population without access to clean water), nutrition (share of population undernourished), poverty and dependencies (share of under 15- and over 65-year-olds in the working population and share of population living on less than USD 1.25 per day), and economic capacity and income distribution (gross domestic product per capita, purchasing power parity and the Gini index for income inequality). A fifth subcategory, housing conditions, is considered an important susceptibility factor; it has however not been included in the index so far due to a lack of global data.

2.1.2. Lack of coping capacities

Coping capacities comprise various abilities of individuals, societies and exposed elements (e.g. critical infrastructure such as nuclear power plants) to minimize negative impacts of natural and anthropogenic hazards through direct action and available resources. Coping capacities encompass measures and capabilities that are immediately available to reduce harm and damages in the occurrence of an event. Five subcategories of coping capacities are distinguished. Three of the subcategories are currently covered by data: government and authorities (Corruption Perceptions Index and Failed States Index), medical services (number of physicians per 10,000 inhabitants and number of hospital beds per 10,000 inhabitants), and material coverage (insurances, with life insurances excluded). The other two subcategories disaster preparedness and early warning as well as social networks are included in the coping capacities component. However, currently no global data referring to them is available. Hence it has not been possible thus far to give them a place in the index. The index does contain the opposite value, the lack of coping capacities, which results from the value 1 minus the coping capacities.

2.1.3. Lack of adaptive capacities

Adaptation is a long-term process that also includes structural changes [18,19]. Adaptation encompasses measures and strategies dealing with and attempting to address negative impacts of future natural hazards and climate change. Five subcategories are chosen for calculation, describing capacities for long-term adaptation and change within a society. For four subcategories suitable data is available: education and research (adult literacy rate and combined gross school enrollment), gender equity (gender parity in education and share of female representatives in the national parliament), environmental status/ecosystem protection (water resources, biodiversity and habitat protection, forest management, and agricultural management), and life expectancy at birth and investments (public and private health expenditure). Owing to insufficient global data, the subcategory of adaptation strategies could not be integrated into the calculations. In analogy to the coping capacities, the lack of adaptive capacities is included in the index.

2.2. Exposure to natural hazards

The term exposure refers to entities such as populations, built-up areas, infrastructure components, and environmental areas,

exposed to the effects of natural hazards (earthquakes, cyclones, droughts and floods). In the World Risk Report, exposure relates to the annual average number of individuals potentially exposed to hazardous events [11]. The hazard frequency is also taken into account. Physical exposure data of the PREVIEW Global Risk Data Platform of the United Nations Environmental Program have been used to calculate exposure to earthquakes, cyclones, floods and droughts. These data include the number of people per approximately twenty square kilometers exposed on average to the natural hazards per country per year. Furthermore, the number of people who would potentially be affected by a one meter sea level rise are considered. This is based, firstly, on data from the Center for Remote Sensing of Ice Sheets at the University of Kansas. Secondly, the data are combined with population statistics of the Global Rural–Urban Mapping Project carried out by the Center for International Earth Science Information Network at Columbia University. This is aided by geographical information system data in order to establish the potential exposure of communities to rising sea level; only half of the people exposed to droughts and to sea level rise have been weighted and the drought calculation model bears some uncertainties [20]. An annual average exposure to sea level rise cannot be calculated, in spite of a considerable hazard potential being an issue affecting numerous coastal regions. In order to calculate the exposure index that describes the share of the population exposed per country, in the World Risk Report 2012 all exposed people per natural hazard have been added up and divided by the number of inhabitants per country. Important to note is that the reports provide an overview of vulnerability scores in combination with exposure rates for 173 countries [11].

The exposure rate is included in this study to measure the physical events as incorporated in Alexander's model. Based on interactions within the plexus of context and consequences, both a positive and a negative association between exposure and vulnerability can be expected, as exposure might be interrelated with cultural phenomena and historical developments, assuming that exposure rates are related with more or less stable geophysical circumstances. A positive association implies that countries with higher exposure rates are more vulnerable. The exposure, in combination with certain cultural characteristics, could have prevented countries – more susceptible and with less coping and adaptive capabilities – to achieve a lower vulnerability level. A negative association implies that countries with higher exposure rates are less vulnerable, because their populations were confronted with a need to protect and reinforce themselves and nurture resilience. In that case exposure, throughout time, might have shaped the right cultural conditions.

2.3. Cultural dimensions

Culture plays a central role in the phenomenology of vulnerability. Several authors point to the fact that vulnerability cannot exist without culture: “Vulnerable sites are those where people live, work and visit” (p. 6) [21]. Douglas and Wildavsky stated that what is seen as negative or damaged depends on cultural norms and patterns of interpretation [22]. At the same time culture is a complex and holistic concept. Numerous definitions of culture exist, some more essentializing than others. Tylor's definition is classic: “culture or civilization, taken in its wide ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society” (p. 1) [23]. Other authors emphasize that culture is comprised of characteristics that distinguish the members of one group or category of people from others [13–24]. Or it can be viewed as “problem-solving tool[s] that enable individuals to survive in a particular environment” (p. 43) [25]. However, these

notions of culture as comprising rather permanent attributes have received serious criticisms. Culture is increasingly seen as a dynamic, interactive and contingent concept, being shaped by the agentic experience of reality while being at the same time the shaper of that reality. More recently, scholars, i.e. in post-colonial traditions, have critiqued the idea of culture as a fixed or solidified and territorialized ('national') feature. Here they highlight the constructed, negotiated and hybrid nature of the notion of culture that is considered subject to power dynamics and processes of contestation and negotiation, and which is increasingly difficult to locate in space [26]. In accordance with the tenor of these criticisms whilst acknowledging that these views do nuance and go beyond the notion of culture as captured in the datasets employed in the current study, the results should be interpreted with some caution (see Subsection 5.2). Also, further qualitative follow-up studies are recommended to more fully grasp the dynamics at work.

2.3.1. Disaster culture

In disaster research culture has received a considerable amount of attention, for instance by anthropologists like Oliver-Smith and Hoffman [10–27]. A group of disaster scholars coined the notion of 'disaster culture', referring to "those adjustments, actual and potential, social, psychological and physical, which are used by residents of such areas in their efforts to cope with disasters which have struck or which tradition indicates may strike in the future" (p. 195) [28]. The concept was first used by Anderson [29], while Wenger and Weller [30–32] have further developed the notion and included an analytical framework to grapple with the different elements of disaster culture. Disaster subcultures can assume many forms (norms, values, knowledge and technology), and are viewed as organizational response patterns, socialization mechanisms and a blueprint for individual and group behavior before, during, and after a hazard agent impacts a community. In this way, exposure to hazard shapes a human reaction pattern. As soon as such patterns influence vulnerability, disaster cultures become part of Alexander's plexus of context and consequences.

2.3.2. Six dimensions

Defining culture is one thing, measuring it another. The data set used in this study finds its origin in large-scale survey research since the 1970s by Hofstede and colleagues. Their efforts resulted in a dataset containing cultural dimensions scores of many countries [14,15,33,34]. The cultural dimensions are:

1. *Power distance*, related to the different solutions to the basic problem of human inequality.
2. *Uncertainty avoidance*, related to the level of stress in a society in the face of an unknown future.
3. *Individualism versus collectivism*, related to the integration of individuals into primary groups.
4. *Masculinity versus femininity*, related to the division of roles between women and men.
5. *Long-term versus short-term orientation*, related to the choice of focus for people's efforts: the future or the present and past.
6. *Indulgence versus restraint*, related to the gratification versus control of basic human desires related to enjoying life.

Recent validations of the six dimensions showed no loss of validity, indicating that the country differences these dimensions described, are indeed, basic and enduring [13]. The dimensions are summarized hereafter on the basis of different publications by Hofstede and colleagues [13–15].

2.3.3. Power distance

The power distance index measures the extent to which the less powerful members of organizations and institutions like the

family accept and expect that power is distributed unequally. This represents inequality (more versus less) as defined from below, not from above, suggesting that a society's level of inequality is endorsed by the followers as much as by the leaders. In countries with a small power distance the use of power should be legitimate and is subject to e.g. moral criteria of 'good' and 'bad'. Such countries have pluralist instead of autocratic governments, based on majority vote and which transition peacefully. Hierarchy means inequality of role – not existential inequality – and is established for convenience. Corruption is rare, scandals end political careers and are not covered up. Income distribution is rather even. Religions stress the equality of believers. Countries with a large power distance score differently on all these aspects.

Since several of the aforementioned associations refer to topics included in the vulnerability index, particularly in the constituting parts of susceptibility and lack of coping capacities, the hypothesis is that countries with a small power distance (or equal power distribution) are less vulnerable to disaster.

2.3.4. Uncertainty avoidance

This dimension indicates to what extent members of a culture feel either uncomfortable or comfortable in unstructured situations. Disasters are unstructured situations and thus unknown, surprising, and different from usual. Uncertainty-avoiding cultures try to minimize the possibility of such situations by strict laws and rules, safety and security measures, and on the philosophical and religious level by a belief in absolute truth. Weak uncertainty avoidance cultures are less rigid, which is reflected in e.g. lower stress and anxiety, higher self-control, higher scores on subjective health and well-being, tolerance of deviating persons and ideas, feeling comfortable with ambiguity and chaos, and dislike of written and unwritten rules. Religion, philosophy and science in cases of weak uncertainty avoidance are characterized by relativism and empiricism, not by grand theories and ultimate truths.

It is difficult to relate these characteristics to elements incorporated in the vulnerability index. Higher levels of self-control, tolerance and subjective health and well-being suggest that weak uncertainty avoidance is accompanied by lower vulnerability. Then again, laws, rules, safety and security measures are valuable for disaster preparedness and risk mitigation, if however, not too strict and in combination with a climate of psychological safety where people dare to discuss rules and practices. Based upon this logic, if a particular association is to be assumed, a lower degree of uncertainty avoidance is probably accompanied by lower vulnerability. Societies will then undertake pragmatic preparation activities to minimize the occurrence of unknown and unusual circumstances such as disasters, and will take precautionary measures to minimize disaster impact.

2.3.5. Individualism versus collectivism

Collectivism, the degree to which individuals are integrated into groups, is the opposite of individualism. In individualistic societies the ties between individuals are loose – everyone is expected to take care of themselves and their immediate family. The purpose of education is learning how to learn, speaking one's mind is considered healthy, personal opinions are expected, and task prevails over relationship. In collectivistic societies people from birth onwards are integrated into strong, cohesive in-groups, often extended families which continue protecting them in exchange for unquestioning loyalty. The purpose of education is learning how to do, harmony should always be maintained, opinions are predetermined by in-groups, and relationship prevails over task.

Earlier research found an association between individualism, a lower power balance, and socio-economic country features (more on this later) [14]. Therefore a positive relation between

individualism and vulnerability is likely to come out of the analysis.

2.3.6. Masculinity versus femininity

The fourth dimension has to do with the distribution of gender roles in a society. The assertive pole has been called masculine and the modest caring pole feminine. Hofstede found that the values of women differ less among societies than the values of men that, from one country to another, differ from highly assertive and competitive (and maximally different from feminine values) to modest and caring (and similar to feminine values). In masculine societies men decide about the number of children, the number of women in elected political positions is limited, boys do not cry but should fight, and the strong are admired. Femininity means that family size is decided by women, the portion of women in elected political positions is higher, fighting is disapproved, and there is sympathy for the weak.

It could be hypothesized that higher levels of masculinity are accompanied by, among others, a lower proportion of woman in national parliaments and gender parity in education, and thus, in a higher disaster vulnerability rate.

2.3.7. Long-term versus short-term orientation

A typical difference between cultures with a short-term or a long-term orientation is that most important events in life in a short-term oriented culture occurred in the past or take place now, while in a long-term oriented culture they will occur in the future. Long-term orientation means that people will adapt to circumstances and that what is good and bad depends on the situation, not on universal guidelines. The same is the case with traditions. In a short-term oriented culture traditions are sacred, in a long-term oriented culture traditions are adapted to changed circumstances. Moreover, a long-term oriented country is not too proud

to try to learn from other countries. Resources are not spent and consumed directly. Because of the large savings quote, funds are available for investment.

Countries with a long-term orientation are likely to be less vulnerable because reducing disaster vulnerability requires anticipation of future hazards and long-term investments in capacity.

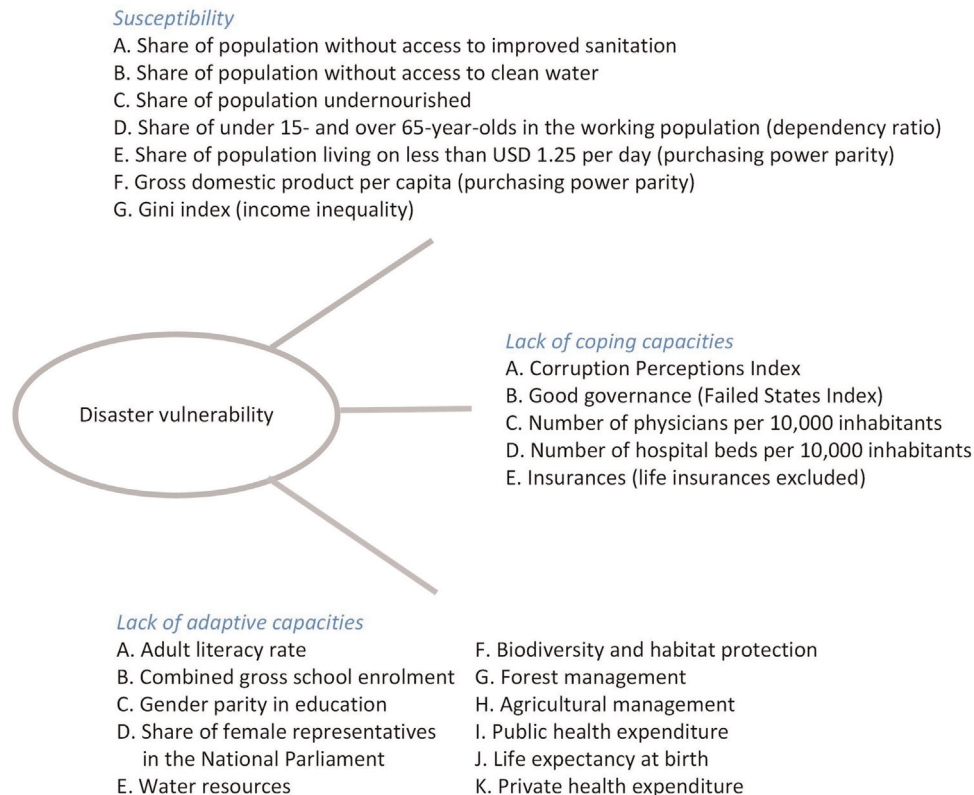
2.3.8. Indulgence versus restraint

Indulgence stands for a society that allows relatively free gratification of basic and natural human drives related to enjoying life and having fun. Indulgent societies are characterized by a higher percentage of people declaring themselves very happy, a perception of personal life control (opposed to a perception of helplessness), freedom of speech is considered important and maintaining order is not given a high priority. Restraint stands for a society that suppresses gratification of needs and regulates it by means of strict social norms. A negative correlation was found between indulgence versus restraint and long-term versus short-term orientation.

Indulgent societies can be expected to be less vulnerable because people are more optimistic and happy and have a personal sense of control. Happiness is linked to several aspects embedded in the vulnerability index, such as income equality and good governance [35,36].

3. Methods

In the previous section the main data sources were described. The disaster vulnerability data (see Fig. 2), exposure to natural hazards and the cultural dimensions scores were collected and verified in previous research programs. All data is publicly accessible. By combining the data sets, the relation between the variables



Source: World Risk Report 2012

Fig. 2. Disaster vulnerability: overview of dimensions and components.

could be examined at the country level. Correlations were calculated. Next, a stepwise regression analysis was conducted with vulnerability as the dependent variable. The cultural dimensions scores were added one after the other, followed by the exposure rate (independent variables), to make their distinctive explanatory value and the changes in statistical outcomes transparent. This step was followed, firstly, by an exploratory factor analysis and, secondly, by comparing the composition of different country groups, ranking countries based on their vulnerability and cultural dimensions scores. Additional steps were taken to further explore patterns identified. The data can be found in the Appendix. All analyses were performed in IBM SPSS Statistics, version 21.

4. Results

4.1. Describing the data

Disaster vulnerability and exposure data could be matched to the cultural dimensions scores of 60 countries. Since the vulnerability scores in the World Risk Report 2012 are computed using the combined indicators per component, the reliability of the scale could be confirmed in the current study sample (Cronbach $\alpha=0.88$). The sum of components is almost perfectly correlated with the vulnerability score in the World Risk Report 2012 ($r=0.997$; $P<0.01$). The vulnerability score is included in the further analysis.

In Table 1 means, standard deviations, and minimum and maximum values of the sample are presented, as well as the correlations between the variables. Significant correlations are found between power distance and individualism versus collectivism, between power distance and indulgence versus restraint, between long-term versus short-term orientation and indulgence versus restraint, and between individualism versus collectivism and exposure to natural hazards. Vulnerability is correlated significantly with power distance, individualism versus collectivism, long-term versus short-term orientation, indulgence versus restraint, and the exposure to natural hazards.

4.2. Stepwise regression analysis

The next step is to determine the extent to which the cultural dimensions statistically explain the level of vulnerability. The six dimensions are added one after the other in the linear regression model. As a final step the exposure to natural hazards is included. This makes it possible to see how estimates change when additional variables are taken into account (Table 2). Model 1 shows how an

increase in power distance is positively associated with higher vulnerability. In this model 37% of the variance is explained. An increase in uncertainty avoidance in model 2 has no significant effect on vulnerability; the percentage of explained variance is hardly affected. Adding individualism versus collectivism in model 3 boosts the level of explained variance up to 53%. Higher levels of individualism are accompanied by lower vulnerability rates. Because the effect size of power distance is halved, the influence of this dimension appears to be confounded by the level of individualism.

The fourth model does not add anything. Variation in masculinity versus femininity has no significant positive or negative effect on vulnerability and the percentage of explained variance is unchanged. In model 5 long-term versus short-term orientation is added, bringing the level of explained variance up to 59%. When the long-term orientation score is higher, this has a negative effect on vulnerability. Model 6, moreover, includes indulgence versus restraint. Power distance and long-term versus short-term orientation are confounded by this last dimension. Higher indulgence scores have a negative effect on vulnerability. Explained variance is now 70%.

In the final model the redundant masculinity versus femininity dimension is replaced by the exposure to natural hazards. The statistical effect of an increase in exposure is insignificant in this model, and apparently confounded by cultural dimensions - a variant of model 1 with only the exposure variable reveals a significant effect on vulnerability when the exposure rate increases ($B=0.30$; $SE=14$; $Beta=0.28$; $P<0.05$); after adding cultural variables the effect size shrinks. In model 7 vulnerability is explained for 69%. Power distance, individualism versus restraint, uncertainty avoidance, long-term versus short-term orientation, and indulgence versus restraint all have a significant effect on vulnerability.

4.3. Exploratory factor analysis

An exploratory factor analysis has been performed, based on all seven variables. Three constructs appear to exist within the data. Only the first construct, the strongest one, consists of three elements: disaster vulnerability; power distance; and individualism versus collectivism. Scale reliability is good (Cronbach $\alpha=0.79$; individualism versus collectivism has a negative loading and was therefore recoded by extracting the maximum dimension score from the score of each country). The exploratory factor analysis confirms the pattern revealed by the regression analysis. More vulnerable countries have a more unequal power distribution and a more collectivistic culture.

Table 1
Distributional information and correlations.

	Distributional information				Correlations							
	N	Mean	SD	Min–Max	PDI	UAI	IVC	MVF	LVS	IVR	VUL	EXP
PDI	60	58.43	20.98	11–104	–							
UAI	60	67.55	22.99	8–112	0.22	–						
IVC	60	46.58	23.62	12–91	–0.65**	–0.23	–					
MVF	60	49.05	20.59	5–110	0.17	0.03	0.03	–				
LVS	60	48.85	22.49	13–100	0.03	–0.02	0.14	–0.03	–			
IVR	60	47.98	22.39	0–100	–0.30*	–0.11	0.14	0.08	–0.53**	–		
VUL	60	39.05	9.76	27–64	0.60**	0.02	–0.68**	0.09	–0.29*	–0.27*	–	
EXP	60	14.77	8.83	2–52	0.22	0.02	–0.26*	0.19	–0.07	0.06	0.28*	–

Legend: N = Number of cases (countries), SD=Standard deviation, PDI=Power distance, UAI=Uncertainty avoidance, IVC=Individualism versus collectivism, MVF=Masculinity versus femininity, LVS=Long-term versus short-term orientation, IVR=Indulgence versus restraint, VUL=Vulnerability score (based on susceptibility, lack of coping capacities and lack of adaptive capacities), EXP=Exposure.

* $P<0.05$.
** $P<0.01$.

Table 2
Regression estimates.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	B (SE; Beta)	B (SE; Beta)	B (SE; Beta)	B (SE; Beta)	B (SE; Beta)	B (SE; Beta)	B (SE; Beta)
Constant (Intercept)	22.63 ^{**} (3.02; NA)	25.19 ^{**} (3.88; NA)	45.48 ^{**} (5.84; NA)	44.88 ^{**} (5.93; NA)	47.40 ^{**} (5.70; NA)	63.00 ^{**} (6.16; NA)	61.46 ^{**} (6.29; NA)
PDI, Power distance	0.28 ^{**} (0.05; 0.60)	0.29 ^{**} (0.05; 0.63)	0.14 [*] (0.06; 0.30)	0.13 [*] (0.06; 0.28)	0.15 [*] (0.06; 0.33)	0.10 (0.05; 0.21)	0.11 [*] (0.05; 0.24)
UAI, Uncertainty avoidance	-	-0.05 (0.05; -0.11)	-0.07 (0.04; -0.16)	-0.07 (0.04; -0.16)	-0.07 (0.04; -0.16)	-0.08 [*] (0.03; -0.19)	-0.08 [*] (0.03; -0.18)
IVC, Individualism versus collectivism	-	-	-0.22 ^{**} (0.05; -0.52)	-0.22 ^{**} (0.05; -0.54)	-0.19 [*] (0.05; -0.47)	-0.19 [*] (0.04; -0.47)	-0.17 [*] (0.04; -0.41)
MVF, Masculinity versus femininity	-	-	0.03 (0.05; 0.07)	0.03 (0.05; 0.07)	0.03 (0.04; 0.06)	0.06 (0.04; 0.12)	-
IVS, Long-term versus short-term orientation	-	-	-	-	-0.11 [*] (0.04; -0.24)	-0.20 ^{**} (0.04; 0.46)	-0.20 ^{**} (0.04; -0.45)
IVR, Indulgence versus restraint	-	-	-	-	-	-0.18 ^{**} (0.04; -0.41)	-0.18 ^{**} (0.04; -0.40)
EXP, Exposure	-	-	-	-	-	-	0.12 (0.09; 0.11)
R ² (R Square Change)	37% (37%)	38% (1%)	53% (15%)	53% (0%)	59% (6%)	70% (11%)	69% (-1%)

Legend: B = Unstandardized coefficient, SE=Standard error, Beta=Standardized coefficient, R²= Percentage of explained variance.

* P < 0.05,

** P < 0.01

4.4. Group comparison

Next, the 60 countries were divided into three groups based on their disaster vulnerability score. Equal groups of 20 countries were not possible because the vulnerability scores of South Korea, Slovenia, Spain and the U.S.A. are the same:

1. *Group 1 (18 countries)*: Finland, Norway, Sweden, Switzerland, Austria, Denmark, Netherlands, Germany, Japan, Luxembourg, New Zealand, Australia, Belgium, France, Canada, Great Britain, Ireland, Singapore.
2. *Group 2 (21 countries)*: South Korea, Slovenia, Spain, U.S.A., Czech Republic, Estonia, Greece, Italy, Portugal, Lithuania, Poland, Slovak Republic, Malta, Uruguay, Croatia, Hungary, Latvia, Bulgaria, Argentina, Chile, Russia.
3. *Group 3 (21 countries)*: Romania, Serbia, Trinidad and Tobago, Brazil, Malaysia, Mexico, Turkey, Thailand, Venezuela, China, Iran, Colombia, Peru, Vietnam, El Salvador, Philippines, Morocco, Indonesia, India, Bangladesh, Pakistan.

Group analysis supports the pattern found in the regression analysis. In Fig. 3 the average group scores are displayed. Power distance and individualism versus collectivism show the strongest relation. The association between vulnerability and the other cultural dimensions is less clear. What the bar chart also shows is that there is hardly a perceivable difference in scores on masculinity versus femininity between the three groups.

5. Discussion

5.1. Why to interpret the results with caution

Before presenting the main conclusions, several reasons are discussed why the results of this study should be interpreted with caution.

5.1.1. Operationalization of the theoretical model

Alexander's model was operationalized only partly. It served as a vantage point to explore the relation between culture and disaster vulnerability at the country level, while taking into account the exposure to natural hazards. Multiple statistical associations were found, but they are not necessarily causal. Long-term data on culture, exposure (natural as well as anthropogenic), and disaster vulnerability are not available at the moment. This is also why one of the remaining elements of the model was omitted in the analysis: history. The current exercise does not allow disentanglement of potential interrelations between culture, physical events and history. Indeed, it might be that exposure is more or less constant on the longer term – although climate change is considered to generate higher prevalence rates [37,38]. In that case history is possibly embedded in exposure rates. Also, the cultural data might, at least partly, reflect the (history of) physical events in each country. Besides indications of confounding effects between exposure and culture, the dataset is not really suited to test moderating of mediating effects between culture, physical events, history, and vulnerability. Empirically, the “context and consequences” map of the model still contains some terra incognita. Research devoted to mechanisms at different levels and cross-level interactions through time is highly welcome.

5.1.2. Difficulties in studying culture and vulnerability

Some scholars consider the best way to study cultures is through cross-cultural comparisons. At the same time others are reluctant to accept this approach as it premises that one could distinguish where one culture ends and the other begins and by

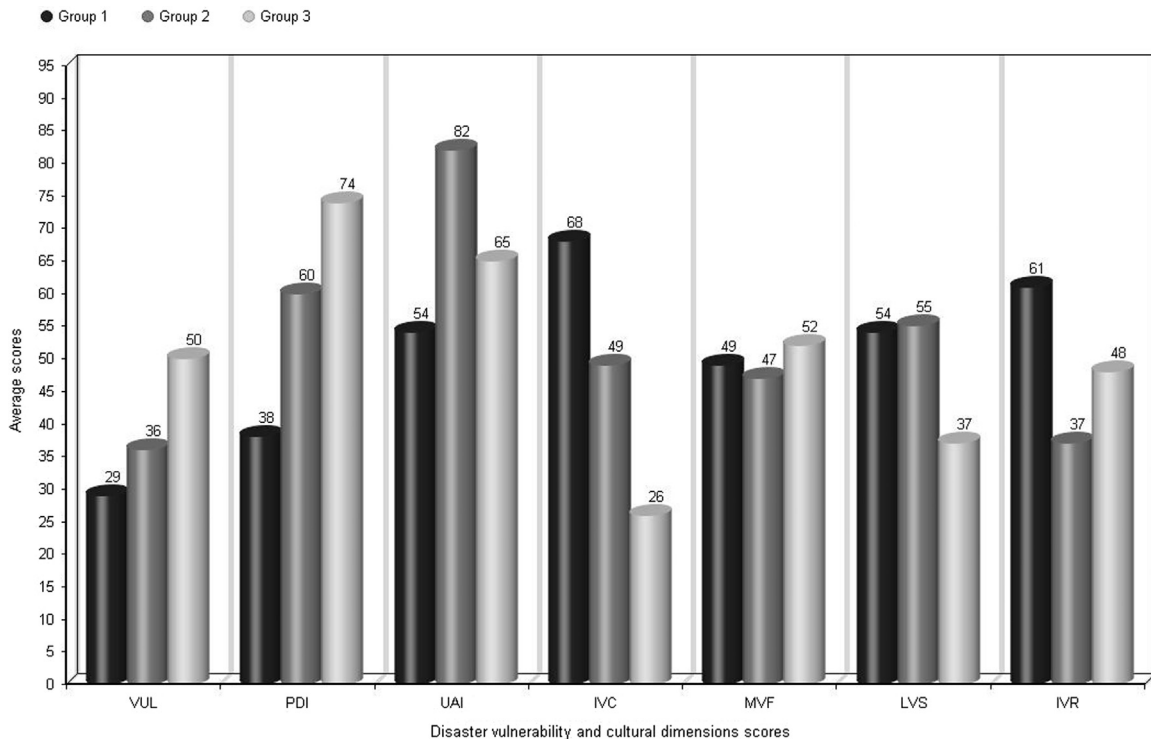


Fig. 3. Average disaster vulnerability and cultural dimensions scores (60 countries are divided into three groups based on the disaster vulnerability score). *Legend:* VUL=Vulnerability score, PDI=Power distance, UAI=Uncertainty avoidance, IVC=Individualism versus collectivism, MVF=Masculinity versus femininity, LVS=Long-term versus short-term orientation, IVR=Indulgence versus restraint.

that deny cross-cultural flows and influences. Hofstede recognizes the issue of cultural borders. The averages of a country do not equate to individuals of that country. Even though this model has proven to be quite often correct when applied to the general population, one must be aware that not all individuals or even regions with subcultures fit into the mold. It is to be used as a guide to understanding the difference in culture between countries, not as law set in stone [39].

Although the study focuses on national culture, patterns at the individual or the local group level can be strikingly different from what is found at the national level and may need a different interpretation. It is questionable whether general patterns provide enough basis to formulate theories on how individual citizens deal with matters of vulnerability. After all, one of the weaknesses of much cross-cultural research is not recognizing the difference between analysis at the societal level and at the individual level; this not only amounts to confusing anthropology and psychology, but also leads to errors of interpretation and application [39]. It is necessary to be on guard for ecologic and individualistic fallacies – the inaccurate attribution of group features to the individual and vice versa. Moreover, some “disaster cultures”, the specific culture – typified by knowledge, norms, artefacts and behavior – developed by certain societies and groups in order to respond or adapt to disasters, may reflect national characteristics and may be derived from national culture, but disaster cultures or subcultures can also be based on very localized conditions and have a more sub-national or local nature [40].

Of further note is that the cultural dimensions data have been collected through questionnaires, which have their own limitations. In some cultures the context of the question asked is as important as its content. Especially in group-oriented cultures, individuals might tend to answer questions as if they were addressed to ‘their’ group. While on the other hand in an individualistic culture like the United States, the answers will most likely be answered and perceived through the eyes of that individual.

Another issue is whether disaster vulnerability, as operationalized here, can be considered a cultural feature itself. The various datasets used represent what can be called cultural resultants and outcomes like public health expenditure, corruption, good governance, income equality, gender parity in education, and literacy. Hofstede’s cultural dimensions reflect something else, namely norms, values and ideas. The variables are both linked to culture or influenced by it; they are however undeniably different.

Then there is the question about whose culture should be the reference point for any cross-country study on culture and disaster risk. At the global level culture can acquire a connotation of domination. Bankoff for example criticizes the very concept of vulnerability being a western notion representing the values and principles of western culture. According to Bankoff, the ultimate aim underlying the concept is to depict large parts of the world as dangerous and hostile, providing justification for interference and intervention [41]. A suitable reference point is preferably neutral or unprejudiced, and at a minimum transparent. The six dimensions of national cultures were adopted here as a reference point, or a “thermometer”, under the assumption that these criteria are met. Norms, values and beliefs were measured at the individual level in different countries using the same approach. Aggregated scores vary between countries on continuums that appear descriptive, not normative. Yet, one always has to be a bit careful with such assumptions.

And there is another luring misunderstanding to avoid. The vulnerability index embodies elements such as corruption, good governance, a national parliament with female representatives, et cetera. This fits with Bankoff’s criticism of vulnerability as being a concept reflecting western culture. By no means should the study be seen as an encouragement to revisit the modernization debate of the 1960s and 1970s, where several theorists framed underdevelopment as a fundamentally cultural phenomenon rather than a historical structural one. Banfield, for example, stated that in order to realize a high degree of economic development and democratic political order in a human society, a high degree of organization is

needed. He positioned culture as “the limiting factor which determines the amount and character of organization and therefore of progress in the less developed parts of the world” (p. 9) [42]. Propositions like these and critique of them reflect academic debate, but draw attention away from the concepts and associations studied. The question to what extent elements of vulnerability and cultural dimensions can or cannot be influenced, exceeds the scope of this study which covers one slice of a timeline – a timeline that can be viewed as a historical process in which factors such as culture, physical events, and history influence vulnerability. Many interesting phenomena, serving as a possible influential factor, are integrated in the process and visible in the isolated slice, like wealth, for instance. The vulnerability index reflects national wealth, which explains the confirmed association between vulnerability, and individualism and low power balance. “All wealth-related phenomena tend to correlate with both these dimensions. Differences in national wealth can be considered a more parsimonious explanation of these other phenomena than differences in culture. In correlation with the cultural dimensions, it is therefore advisable to always include the wealth variable. After controlling for national wealth, correlations with culture usually disappear (p. 8).” [13]. Hofstede’s advice is relevant for researchers of particular country characteristics. Still, the study of disaster vulnerability is inconclusive without wealth. Alexander accentuated that, “although poverty and vulnerability to disasters are not perfectly synonymous, they are nearly so, and conversely, wealth can be equated with protection and safety. This simple balance, however, does not reduce the potential for massive financial losses in areas where both hazards and physical capital are heavily concentrated” (p. 2) [9].

5.1.3. Limitations of the vulnerability index

In addition to limitations and concerns already addressed, some limitations of the World Vulnerability Index must be mentioned. A wide array of datasets from different sources are used to bring together social and economic dimensions and natural hazard analysis [43]. When data was missing, robust statistical imputation techniques were conducted to cover the missing data [44]. The properties and validity of the datasets present a limitation towards the homogeneity

of the data. The homogeneity across all countries varies since countries differ from each other, especially large countries in comparison with small (e.g. the difference between China and Luxembourg) [43].

The datasets used are not designed for this purpose; they are incorporated simply because they are available [45]. In the vulnerability index indicators have been assigned to three constructs. The reliability coefficient is good and the index has been thoroughly tested [43]. Other solutions are possible, but in this study the existing index was used, without alterations. Although the index is at present a helpful source to understand disaster risk internationally, the statistical work is still work in progress and there is scope for follow-up work covering more relevant data.

5.2. Conclusions

In summary, this study is an examination of associations at the level of countries between the exposure to natural hazards, cultural characteristics and the vulnerability of countries, in the context of a theoretical model. Countries less exposed to natural hazards are significantly less vulnerable. Besides masculinity, each of Hofstede’s cultural dimensions contributed significantly to explaining the encountered variance in disaster vulnerability in a sample of 60 countries. Particularly countries with a small power distance and higher degrees of individualism are found to be less vulnerable to disaster, which is in line with earlier research pointing at an association between both cultural aspects and socio-economic country features. Statistically, approximately 70% of disaster vulnerability variance at country level could be explained. Associations are not the same as causal relations and there are other advisable precautions in interpretation. Nevertheless, the results of the statistical analysis are robust and significant. They corroborate earlier conceptual and qualitative work in, among others, the anthropology of disaster and on disaster cultures and subcultures.

Appendix A

See Table A1 here.

Table A1
Country culture and disaster vulnerability data.

#	Country	Cultural dimensions scores						World Risk Report				
		PDI	UAI	IVC	MVF	LVS	IVR	VUL	SUS	LCC	LAC	EXP
1	Argentina	49	86	46	56	20	62	40	22	62	36	10
2	Australia	36	51	90	61	21	71	30	14	42	35	15
3	Austria	11	70	55	79	60	63	28	14	36	33	14
4	Bangladesh	80	60	20	55	47	20	64	43	87	61	32
5	Belgium	65	94	75	54	82	57	30	15	43	32	12
6	Brazil	69	76	38	49	44	59	45	25	68	42	10
7	Bulgaria	70	85	30	40	69	16	39	17	59	41	12
8	Canada	39	48	80	52	36	68	31	14	45	34	10
9	Chile	63	86	23	28	31	68	40	21	58	40	31
10	China	80	30	20	66	87	24	49	29	72	46	14
11	Colombia	67	80	13	64	13	83	50	30	77	43	14
12	Croatia	73	80	33	40	58	33	38	17	60	36	12
13	Czech Republic	57	74	58	57	70	29	34	14	52	36	11
14	Denmark	18	23	74	16	35	70	28	14	39	32	11
15	El Salvador	66	94	19	40	20	89	52	29	77	50	33
16	Estonia	40	60	60	30	82	16	35	18	52	34	7
17	Finland	33	59	63	26	38	57	27	15	38	30	8
18	France	68	86	71	43	63	48	30	15	42	33	9
19	Germany	35	65	67	66	83	40	29	15	39	33	11
20	Great Britain	35	35	89	66	51	69	31	16	46	33	12
21	Greece	60	112	35	57	45	50	35	17	52	36	21
22	Hungary	46	82	80	88	58	31	38	16	55	41	16
23	India	77	40	48	56	51	26	61	41	82	60	12
24	Indonesia	78	48	14	46	62	38	55	35	82	49	19
25	Iran	58	59	41	43	14	40	49	18	80	48	10
26	Ireland	28	35	70	68	24	65	31	15	42	34	15
27	Italy	50	75	76	70	61	30	35	16	55	33	14

Table A1 (continued)

#	Country	Cultural dimensions scores						World Risk Report				
		PDI	UAI	IVC	MVF	LVS	IVR	VUL	SUS	LCC	LAC	EXP
28	Japan	54	92	46	95	88	42	29	17	36	36	46
29	Korea South	60	85	18	39	100	29	33	14	46	39	15
30	Latvia	44	63	70	9	69	13	38	21	58	35	9
31	Lithuania	42	65	60	19	82	16	36	20	53	36	9
32	Luxembourg	40	70	60	50	64	56	29	12	41	35	9
33	Malaysia	104	36	26	50	41	57	45	21	70	43	15
34	Malta	56	96	59	47	47	66	37	14	54	43	2
35	Mexico	81	82	30	69	24	97	46	24	72	43	14
36	Morocco	70	68	46	53	14	25	54	29	76	58	13
37	Netherlands	38	53	80	14	67	68	28	14	39	30	31
38	New Zealand	22	49	79	58	33	75	29	16	40	30	15
39	Norway	31	50	69	8	35	55	27	14	38	29	9
40	Pakistan	55	70	14	50	50	0	64	39	87	65	11
41	Peru	64	87	16	42	25	46	50	31	75	44	14
42	Philippines	94	44	32	64	27	42	53	34	83	43	52
43	Poland	68	93	60	64	38	29	36	17	55	35	10
44	Portugal	63	104	27	31	28	33	35	17	49	39	11
45	Romania	90	90	30	42	52	20	43	22	64	43	16
46	Russia	93	95	39	36	81	20	41	21	60	42	9
47	Serbia	86	92	25	43	52	28	43	19	68	40	18
48	Singapore	74	8	20	48	72	46	32	14	47	36	8
49	Slovak Republic	104	51	52	110	77	28	36	14	57	38	10
50	Slovenia	71	88	27	19	49	48	33	14	51	33	12
51	Spain	57	86	51	42	48	44	33	15	51	34	10
52	Sweden	31	29	71	5	53	78	27	14	37	30	8
53	Switzerland	34	58	68	70	74	66	27	14	37	31	10
54	Thailand	64	64	20	34	32	45	47	22	76	43	14
55	Trinidad and Tobago	47	55	16	58	13	80	44	19	71	42	18
56	Turkey	66	85	37	45	46	49	46	20	70	49	12
57	U.S.A.	40	46	91	62	26	68	33	17	48	33	12
58	Uruguay	61	100	36	38	26	53	37	21	51	39	11
59	Venezuela	81	76	12	73	16	100	47	23	75	42	13
60	Vietnam	70	30	20	40	57	35	51	29	77	47	25

Legend: PDI=Power distance, UAI=Uncertainty avoidance, IVC=Individualism versus collectivism, MVF=Masculinity versus femininity, LVS=Long-term versus short-term orientation, IVR=Indulgence versus restraint, VUL=Vulnerability score (based on SUS, LCC and LAC), SUS=Susceptibility, LCC=Lack of coping capacities, LAC=Lack of adaptive capacities, EXP=Exposure Data sources: Hofstede Cultural Data and World Risk Report 2012.

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