Securing recovery needs for Build Back Better (BBB) by linking Post-Disaster Needs Assessment (PDNA) with sectoral breakdown of World Risk Index (WRI)

Kozo Nagami,

PhD, Senior Representative, JICA Nepal Office, Japan International Cooperation Agency (JICA)

Kimio Takeya,

Prof., Distinguished Technical Advisor to the President, JICA

Abstract

Build Back Better (BBB) has been commonly accepted as a global recovery philosophy, but it still often remains as a political slogan not yet rigorously standardized among nations or disasters. According to the definition of BBB, "reducing existing risk (UNISDR (2016b)[i])" or "increasing resilience of nations or communities (UNISDR (2016c)[ii])" is necessary in the recovery process. Based on such definition, we should consider the costs for reducing the disaster vulnerability or risk that inherently existed before disasters as recovery needs even if such risk was not directly manifested as damage and loss fortunately.

On the other hand, the "Post-disaster Needs Assessments Guidelines (EU, UNDP and World Bank (2013)[iii])" (hereinafter referred to as "PDNA guidelines") were published as recovery needs assessment instruments, but they are presenting basic principles and procedural steps to estimate the recovery needs primarily based on what was damaged and lost with disasters i.e. visible physical damages in particular. Regarding the reflection of BBB, PDNA is basically estimating the recovery needs with considering costs of "quality improvement" for recovering the damages. However, PDNA is not explicitly taking into account the other factors that were not directly associated with the damages but have actually incurred the damages, although there is a conceptual description for calculation. These factors should be vulnerability or risks that had already existed in the nations or communities before the disaster. Consequently, the concluded recovery needs under current PDNA tend to focus on the visible damages but not putting priorities on the other invisible aspects like social, economic or institutional vulnerability.

In the Sendai Framework for Disaster Risk Reduction (SFDRR)[iv], "Understanding disaster risk" is adopted as the priority for action, and several risk assessment indices have been developed. As one of the most well-known indices, the World Risk Index (WRI) was initiated in 2011 and has been globally accepted as standards to evaluate the disaster risk at national level. Since BBB requires "reducing existing risk" or "increasing resilience of nations or communities", WRI might be utilized as a reference tool to formulate a valid recovery needs for BBB. With using WRI as a reference, we would be able to recognize the inherent vulnerability of the nations, and to properly identify the recovery priorities to reduce existing risks.

Recognizing such potential of WRI, this paper will, based on the preliminary analysis results, exhibit a basic framework of the sectoral breakdown of WRI as an initial step toward establishing a practical reference to guide recovery needs for BBB in Post-Disaster Needs Assessment (PDNA).

1. The definition of BBB

The definition of BBB has gone through a transition via the Third UN Word Conference for DRR (WCDRR) in Sendai, 2015 until today as shown in Table 1. In the SFDRR agreed at the 2015 WCDRR, BBB was first described as "including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters (UNISDR (2015a)[4])". Furthermore, in October 2015, Japan proposed to add "do not reborn the same vulnerability again through the reconstruction process (UNISDR (2015c)[v])" and stressed the importance of materializing disaster prevention such as structural measures in the reconstruction process to prevent the same damage from future disasters. In June 2016, "reducing existing risk, preventing the creation of new risk and building resilience (UNISDR (2016b)[1])" was proposed, and since September 2016, it has been said to be " increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration."

Table 1： Transition of BBB definition

Publication	Source	Description
Mar. 2004	UNISDR (2004)[vi]	No mention.
May 2009	UNISDR (2009)[vii]	There is a notion in the definition of Recovery as "valuable opportunity to develop and implement disaster risk reduction measures and to apply the "build back better" principle".
Mar. 2015	UNISDR (2015a)[4]	In the description of priority 4 as "Disasters have demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of a disaster, is a critical opportunity to "Build Back Better", including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters".
Aug. 2015	UNISDR (2015b)[viii]	The guiding principle to utilize the reconstruction process to improve living and environmental conditions including through integrating disaster risk reduction into development measures, making nations and communities more resilient to disasters.
Oct. 2015	UNISDR	The guiding principle to use a disaster as a trigger or chance to rebuild resilient society,

	(2015c)[5]	do not reborn the same vulnerability again through the reconstruction process, integrating disaster risk reduction into development measures, making nations and communities more resilient to disasters, including to improve living, environmental and livelihood conditions. – (Japan)
Mar. 2016	UNISDR (2016a)[ix]	Ditto
Jun. 2016	UNISDR (2016b)[1]	The guiding principle to utilize the recovery process to improve living and environmental conditions and social systems, by reducing existing risk, preventing the creation of new risk and building resilience.
Sep. 2016	UNISDR (2016c)[2]	The use of the recovery, rehabilitation and reconstruction phases after a disaster to increase the resilience of nations and communities through integrating disaster risk reduction measures into the restoration of physical infrastructure and societal systems, and into the revitalization of livelihoods, economies and the environment.
Nov. 2016	UNISDR (2016d)[x]	Ditto
Feb. 2017	UNISDR (2017a)[xi]	Ditto

As we could see, in recent years, BBB has been quite universal as a recovery philosophy, but it remains in the stage of conceptualization. However, instead of restoring to the past, “reducing existing risk” and “increase the resilience of nations and communities” are required as the basic principle of BBB at the time of completion of the recovery. In other words, in assessing success or failure of realizing BBB, it will be asked whether “reducing existing risk” and “increase the resilience of nations and communities” have been achieved through the recovery process.

2. Development and current states of PDNA

The damage assessment is one of the most important procedures for determining recovery policies and expenditures. The reason is that restoring damages brought by a disaster is the basic conventional common understanding of the disaster recovery. However, a variety of damage assessments are carried out by various institutions and organizations every time a catastrophe occurs in many parts of the world without common unified

damage assessment methods. Consequently, according to EU, UNDP and World Bank (2013)[3], "risks bringing a lack of clarity and confusion to stakeholders (are increasing) as they plan the recovery phase." According to Higuchi et al. (2012)[xii], this is also a case in Japan where several entities such as think tanks have released a wide range of estimated damage results immediately after the Great East Japan Earthquake in 2011 besides the official damage assessments made by the Cabinet Office. Such situation clearly indicates the difficulty of the damage assessment.

To respond to this problem, "there is a growing consensus on the need for standardized and comprehensive assessment in the post disaster period. Such an assessment must be multi-sectoral, addressing recovery needs related to infrastructure, shelter, livelihoods, and social and community services in a balanced and comprehensive manner (EU, UNDP and World Bank (2013))." Against this backdrop, the Economic Commission for Latin America and the Caribbean (ECLAC) developed the Damage and Loss Assessment (DaLA) methodology as the first edition of the Handbook for Disaster Assessment in 1991 and the second edition of the Handbook in 2003[xiii],[xiv]. After that, the United Nations Development Group (UNDG), the World Bank, and the European Union (EU) formed a series of agreements, including the "Joint declaration on Post-crisis assessment and recovery planning" on September 25, 2008. In 2013, the PDNA guidelines were announced on how to estimate the amount of damage and determine the amount of recovery needed.

The valuation approaches of the Damage ("direct damage" in DaLA) and Loss ("indirect losses" in DaLA) are presented in both ECLAC's DaLA and PDNA guidelines. According to PDNA guidelines, damage is referred to as "Value of total/partial destruction in infrastructure and assets." Loss is said to be "Value of changes on production of goods and services, delivery of services and access to services and goods", "Value of changes to governance", and "Value of changes to risks." This valuation approach of the PDNA guidelines is coming from the ECLAC's DaLA.

Table 2: Sectors to be included by the PDNA guidelines
(PDNA Guidelines)

Social Sectors	**Infrastructure Sectors**	**Productive Sectors**	**Cross-cutting Themes**
- Housing, land & settlements* - Education* - Health* - Culture* - Nutrition	- Water, sanitation and hygiene* - Community Infrastructure* - Energy & Electricity - Transport & Telecommunication	- Agriculture, livestock, fisheries* - Industry, Commerce & Trade - Tourism	- Governance* - Disaster risk reduction* - Environment* - Employment & livelihoods* - Gender*

Table 3: Elements of Recovery Needs

（summarized form pp. 35-36 of the PDNA Guidelines）

Item	Summarized calculation guidance
Reconstruction of infrastructure and physical assets	Calculated as: Value of Damage + Cost of “Quality improvement +Technological modernization + Relocation, when needed + Disaster risk reduction features + Multi-annual inflation”. (This may be dealt with on a case- by-case basis, though.)
Resumption of Production, Service Delivery and Access to Goods and Services	Calculated as: • Additional costs to service providers to restore basic services; and • Costs to provide Build Back Better (BBB) and equitable and affordable services to vulnerable groups and affected population to access services.
Restoration of Governance and Decision Making Processes	Calculated as: • Costs for additional human resources with improved technical skills and of capacities of service providers to undertake the recovery; • Costs for replacing lost records and upgrading documents of the various public services; and • Costs for addressing governance and social cohesion issues if disrupted.
Reducing Risks	The cost of integrating risk reduction measures plus additional costs to BBB for reducing risks and increasing preparedness.

For the calculation of the damage, while DaLA presented implicitly three methods, ① depreciated value of lost assets (or "book value"), ② lost asset’s replacement cost that includes future disaster mitigation elements ③ replacement cost with the same characteristics as its original design. However, the PDNA guidelines unified the methods as "post-disaster price alterations and improvements associated with risk reduction and the concept of build back better". For sector classification, the PDNA guideline are based on the 17-sector classification of Table 2. For the 12 sectors with asterisks, individual sectoral guidance has been created as Volume B.

The PDNA guideline, as described above, defined the damage calculation as "replacement cost", and as detailed in Table 3, four items are presented as elements of the recovery requirement, (1) Infrastructure and physical assets reconstruction, (2) Service resumption, (3) Governance restoration and (4) Reducing risks.

However, the PDNA guidelines just describe a basic but not a detailed framework for calculation rules. Therefore, in major disaster events, sector teams (17 sectors as standard but customized in respective cases) would be organized by the affected governments and donors, and respective sector teams would calculate the damage and loss in respective sectors, and the aggregation of those would be the total damage and losses regardless of the methodological variation among the teams.

Table 4: Calculation guidance of "Reducing Risks"

（PDNA Guidelines）

Item	Calculation guidance
Cost of integrating risk reduction measures	- To address immediate risks; - Initiatives to reduce risks and vulnerabilities to future disasters such as safer infrastructure with considerations of spatial/territorial or land-use planning, hazard and risk maps, technical expertise, technologies and practices which build resilience; - Preparedness capacities of the various sectors to manage the impact of future disasters; - Provide equitable and affordable services to vulnerable groups; - Initiatives to promote resilience of individuals and communities.
Additional costs to Build Back Better (BBB) reducing risks and increasing preparedness	- Costs for addressing immediate risks; - Costs for upgrading preparedness measures in each sector; - Costs for further studies or assessments, technologies and practices, technical expertise, etc. required to facilitate implementation of building back better approaches; - Cost for specific measures to strengthen disaster risk reduction.

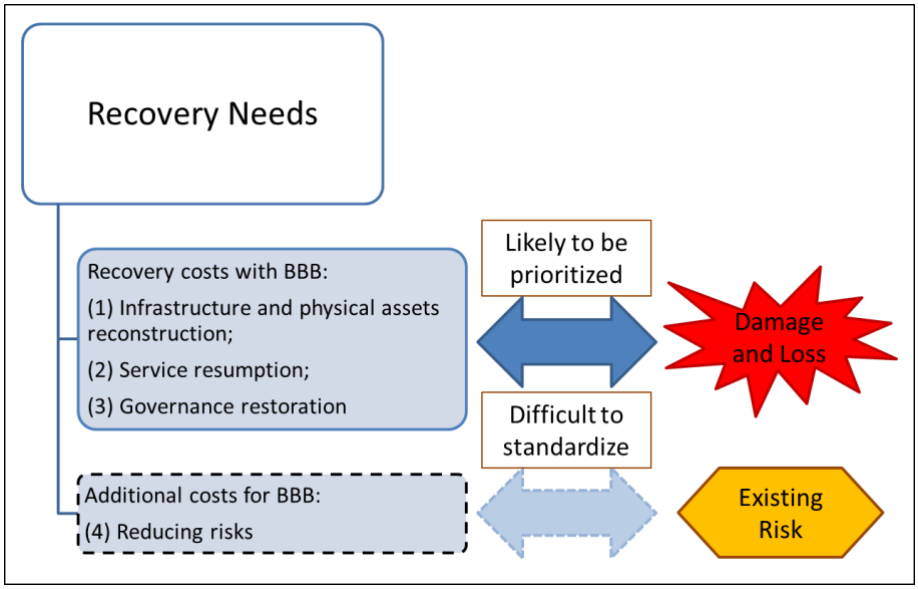

Figure 1： Current states of PDNA
(Written by author)

Moreover, recovery needs for (1) Infrastructure and physical assets reconstruction (2) Service resumption and (3) Governance restoration are rather straight forward since those can be calculated based on the damage and loss, but costs for (4) Reducing risks can't be simply factored. Although the PDNA guidelines are describing the calculation guidance as Table 4, the description is still remaining as conceptual abstract that should create a certain ambiguity. Consequently, recovery needs under PDNA are highly likely to focus on recovering what was damaged and lost but not to clarify what should be done for reducing risks as illustrated in the Figure 1.

3. Disaster risk and vulnerability index

A variety of attempts have been made to quantify the disaster risks and vulnerability at national level. If we can use these quantified risks and vulnerabilities as a tool to set up a benchmark for BBB, we may be able to improve the situation where the PDNA's estimation regarding the "reducing risks" is comparatively weak and not standardized in terms of BBB.

Table 5： Major national vulnerability index

Name or source document	Latest year	Institution	Disaster type	Calculation formula
Disaster Risk Index "Reducing Disaster	2004	United Nations Development	Earthquake Flood	$V = R/(H \times E)$ V： Vulnerability

Risk, a Challenge for Development”[15]		Program (UNDP)	Cyclone Draught	R: Annual average death tolls from 1980 to 2000 H: Hazard E: Exposure
Key Dimension 5: Resilience to water-related disasters “Asian Water Development Outlook 2016”[xv]	2016 (First publish in 2007, biannual)	Asian Development Bank (ADB)	Flood and Wind Draught Storm surge	$V = (E + V_B) \times (1 - C/C_{MAX})$ V: Vulnerability E: Exposure V_B: Basic Vulnerability C: Coping capacity
World Risk Index “World Risk Report 2016”[xvi]	2016 (First publish in 2011, annual)	Bündnis Entwicklung Hilft and UNU-EHS (Institute for Environment and Human Security)	Earthquake Wind Flood Draught Sea level rise	$V = 1/3 \times S + 1/3 \times C + 1/3 \times A$ V: Vulnerability S: Susceptibility C: Coping Capacity A: Adapting Capacity

Table 5 is a comparison by extracting the three typical vulnerability indices. This paper picks up three international disaster risk indices. The DRI (Disaster Risk Index)[xvii] came the earliest among the three, and it evaluated the disaster statistics from 1980 to 2000 (EM-DAT: Emergency Disasters Database[xviii]) focusing on the number of deaths. As a method of calculation, the aggregated death tolls for multiple type of disasters in the 21-year period were regarded as the disaster risks that is supposed to be equal a product of hazard, exposure and vulnerability, so we calculate the vulnerability from the expected hazard frequency and exposure population of each disaster type. In addition, it extracted the most significant indicator among the 24 indicators as the most explanatory variable for the vulnerability.

Although AWDO (Asian Water Development Outlook)[17] is only associated with the water induced disasters, it is characterized in that it evaluates the vulnerability directly using various indicators unlike DRI that disintegrates the disaster risk estimated from the actual past incident records into the vulnerability. Finally, WRI (World Risk Index)[18] also directly calculates vulnerability using more indicators than AWDO, then categorizing it into

susceptibility, coping capacity and adapting capacity. In this paper, we specifically focus on WRI among the three indices.

3.1 Modifying WRI to connect with PDNA

WRI are basically categorized into three spheres, susceptibility, coping capacity and adaptation capacity. But such outcome-oriented category is not compatible with the recovery needs estimated primarily under the basic 17 sectors of PDNA as in the Table 2. We have to consider a valid referable linkage between WRI and PDNA so that WRI can be utilized as a reference tool to properly identify the recovery priorities to reduce existing risks.

Since PDNA is consisting of sectoral categories, we can make a logical linkage between PDNA and WRI if WRI can be categorized into sectors. A referable categorization for the sectoral disaster vulnerability is described by J. Birkmann et al. (2013)[xix] as Table 6. Among these categories, cultural vulnerability is not dealt in this paper since obtaining measurable indicators among countries is difficult. Then, we decided to employ the disaster vulnerability sectoral dissolution method into five sectors, physical, social, economic, institutional and environmental.

In addition, since some indicators used in WRI are not generally accessible (e.g. insurance coverage) or are not constantly available every year (e.g. GINI index), WRI is not said to be generally highly usable or reproducible. For such problem, we tried to reinforce the set of indicators by complementing several useful indices used in DRI and AWDO. After reviewing alternative indicators, it was concluded to add five indicators, “the quality of overall infrastructure”, “the infant mortality rate/1000 births”, “Human Development Index (HDI)”, “% of arable land and permanent crops” and “% of agriculture's dependency for GDP”.

Table 6: Sectoral vulnerability category

(J. Birkmann et al. (2013) [19])

Sectoral Vulnerability	Description
Social dimension	Propensity for human well-being to be damaged by disruption to individual (mental and physical health) and collective (health, education services, etc.) social systems and their characteristics (e.g. gender, marginalization of social groups).
Economic dimension	Propensity for loss of economic value from damage to physical assets and/or disruption of productive capacity.
Physical dimension	Potential for damage to physical assets including built-up areas, infrastructure and open spaces.
Cultural dimension	Potential for damage to intangible values including meanings placed on artefacts, customs, habitual practices and natural or urban landscapes.
Environmental dimension	Potential for damage to all ecological and bio-physical systems and their different functions. This includes particular ecosystem functions and environmental services (see, e.g., Renaud 2006) but excludes cultural values that might be attributed.
Institutional dimension	Potential for damage to governance systems, organizational form and function as well as guiding formal/legal and informal/customary rules—any of which may be forced to change the following weaknesses exposed by disaster and response.

And data with low availability (if data are only available in 120 countries or less among the total 164 countries from 2011 to 2016) were excluded from the set of indicators. Such omitted indicators are "Percentage of population undernourished", "Extreme poverty ($1.25/1.90 a day (PPP))", "GINI Index", "Number of physicians per 10,000", "Number of hospital beds per 10,000", "Adult literacy rate" and "Ecosystem vitality: Forestry management". Moreover, the insurance coverage was to be removed because it is not generally available. Consequently, the total number of indicators used has become 20.

Table 7 shows the 23 indicators employed by WRI and 5 indicators additionally employed in this paper, which are categorized based on the sectoral vulnerability category in the Table 6. Although eight indicators from the 23 WRI indicators have been omitted and five indicators are added, the weight of each sectoral vulnerability in

the second row is not changed as the original WRI in the first row. Then, the weight of each indicator is simply divided by the number of indicators per sectoral vulnerability (equally distributed within the sectoral vulnerability).

For the calculation of the individual indicators, we followed the calculation methods by Bündnis Entwicklung Hilft and UNU-EHS (2016b)[xx] and T. Welle and J. Birkmann (2015)[xxi] for the fifteen indicators employed by WRI. And five indicators added referring to AWDO and DRI (P3, S7, S8, Ec3 and EC4) were converted into from 0 to 1 by the minimum maximum standardization and so on like in WRI.

Table 7: Selected indicators and alocated weights

	Weight WRI		Weight Modified WRI		#	Indicator	data process
Physical Vulnerability	4.76%	9.52%	3.17%	9.52%	P1*	Population with access to improved sanitation	raw data (%)/100
	4.76%		3.17%		P2*	Population with access to an improved water	raw data (%)/100
	(AWDO)		3.17%		P3*	Quality of overall infrastructure	standardize raw data from "0-7" to "0-1"
Social Vulnerability	4.76%	48.10%	Omitted	48.10%		Percentage of population undernourished	
	7.50%		Omitted			Number of physicians per 1,000	
	7.50%		Omitted			Number of hospital beds per 1,000	
	4.17%		Omitted			Adult literacy rate	
	4.17%		6.01%		S1*	Combined gross enrolment ratio	min-max standardize
	4.17%		6.01%		S2*	Gender parity in education	min-max standardize
	4.17%		6.01%		S3*	Women in national parliament	raw data (%)/100
	2.78%		6.01%		S4*	Life expectancy at birth	lagarithm min-max standardize
	3.33%		Omitted			Insurance coverage	
	2.78%		6.01%		S5*	Per capita government expenditure on health (PPP)	lagarithm min-max standardize
	2.78%		6.01%		S6	Per capita private expenditure on health (PPP)	lagarithm min-max standardize
	(AWDO, DRI)		6.01%		S7	Infant mortality rate/1,000 births	min-max standardize
	(DRI)		6.01%		S8*	Human Development Index (HDI)	raw data (0-1)
Econ	4.76%	19.05%	4.76%	19.05%	Ec1*	GDP per capita (PPP)	lagarithm min-max

							standardize
	4.76%		4.76%		Ec2	Dependency ratio	min-max standardize
	4.76%		Omitted			Extreme poverty ($1.90 a day (PPP))	
	4.76%		Omitted			GINI Index	
	(DRI)		4.76%		Ec3	% of arable land and permanent crops	min-max standardize
	(AWDO, DRI)		4.76%		Ec4	% of agriculture's dependency for GDP	min-max standardize
Institutional	7.50%	15.00%	7.50%	15.00%	In1*	Corruption Perception Index	convert "0-100" to "0-1"
	7.50%		7.50%		In2	Failed States Index	convert "0-120" to "0-1"
Environmental Vulneraability	2.08%	8.33%	2.78%	8.33%	En1*	Ecosystem vitality: Water quantity	convert "0-100" to "0-1"
	2.08%		2.78%		En2*	Ecosystem vitality: Biodiversity & Habitat	convert "0-100" to "0-1"
	2.08%		Omitted			Ecosystem vitality: Forestry management	
	2.08%		2.78%		En3*	Ecosystem vitality: Agriculture	convert "0-100" to "0-1"
Sum	100.00%	100.00%	100.00%	100.00%			

Note: Indicators with asterisks were deducted from one after converted to 0-1 (zero to one).

3.2 Sectoral breakdown of WRI's vulnerability value

Based on the above indicators and calculation methods, Figure 2 was drawn with the modified WRI's vulnerability compared with the original WRI 2016's vulnerability. The horizontal axis indicates logarithmically transformed per capita GNI (hereinafter referred to as "income level"). The values of original WRI 2016 are using Bündnis Entwicklung Hilft and UNU-EHS (2016c)[xxii].

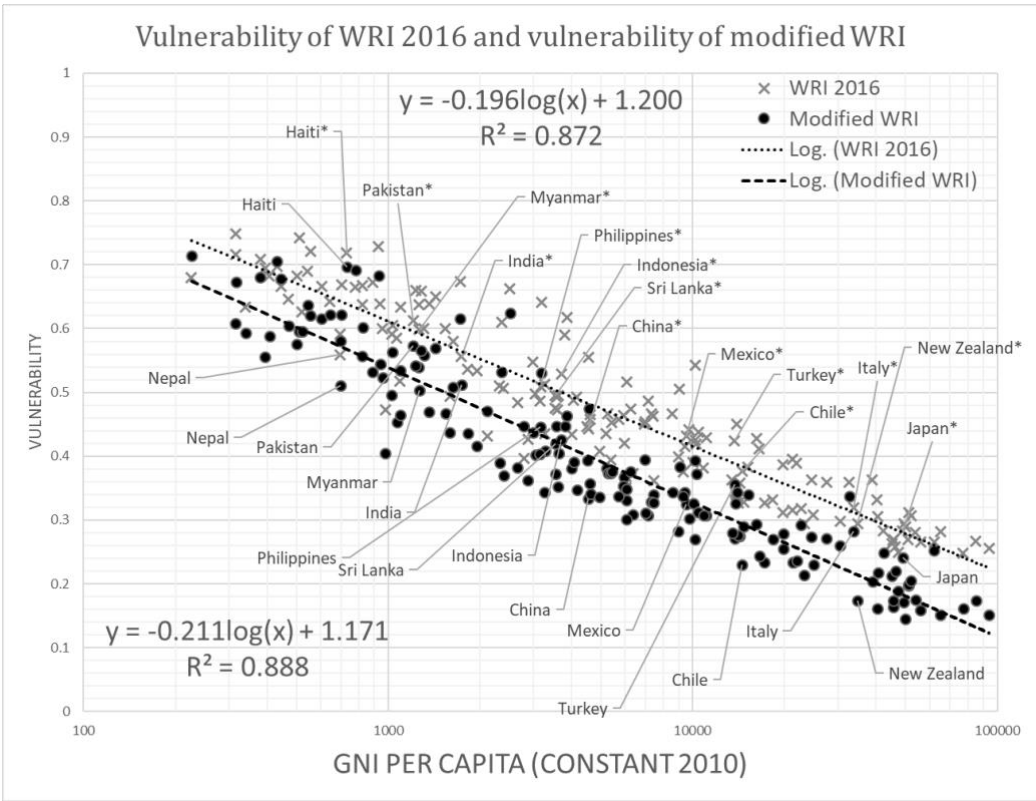

Figure 2 : Comparison between WRI and Modified WRI

We can know from this graph that both the modified WRI's vulnerability and that of the original WRI 2016's vulnerability has a soaring trend, and the slope and the determination coefficient (squared R) are almost the same. When looking at each country's value, the original WRI is about 0.04 higher than the modified WRI's vulnerability. In other words, the modified WRI's vulnerability has a tendency similar to the original WRI 2016's vulnerability, and it was found that the coefficient of determination is almost equal. This result indicates the modified WRI's vulnerability can be utilized as a substitute of the original WRI 2016 while increasing usability and reproducibility by using data more generally available with maintaining similar dependency on the income level.

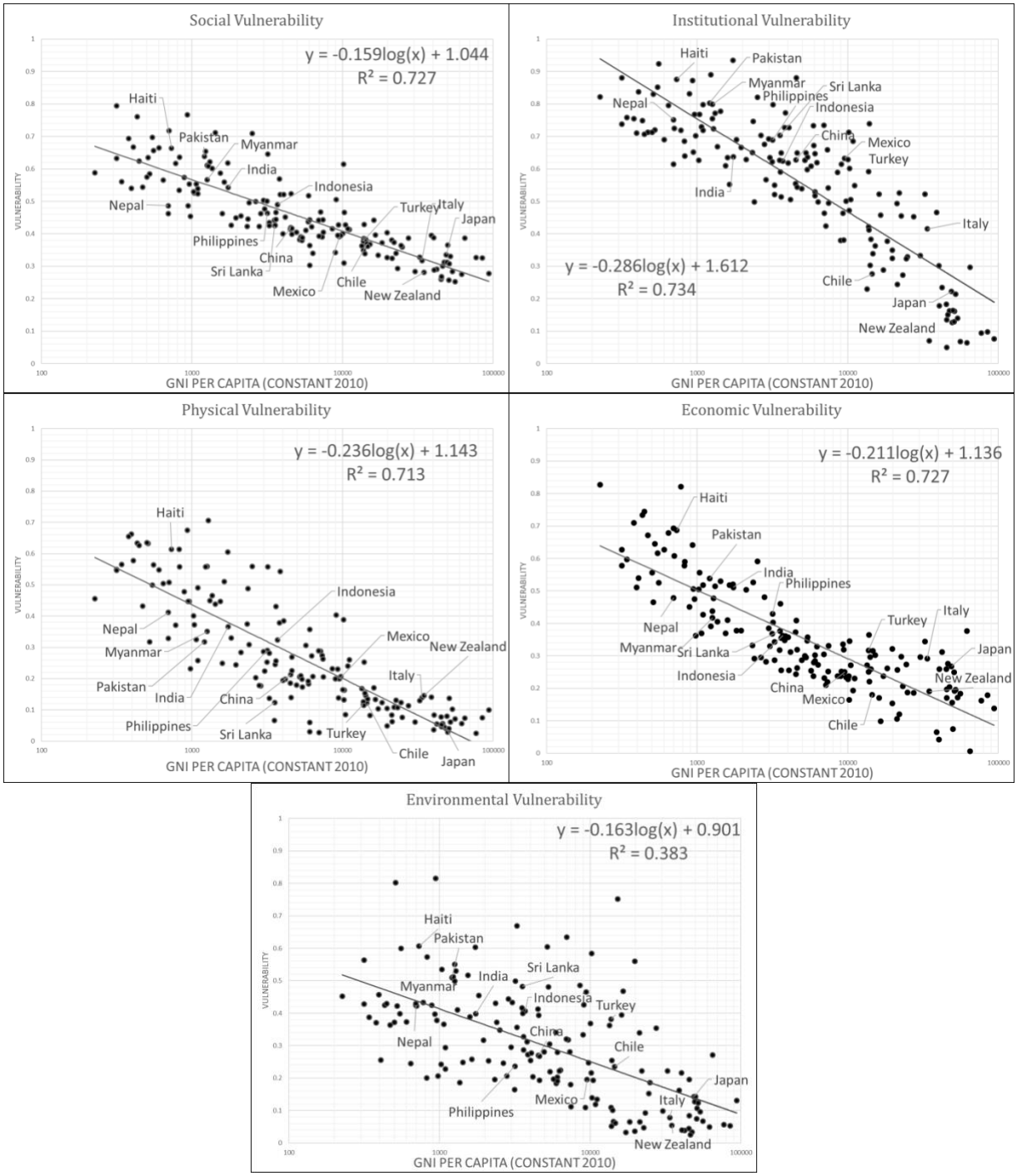

Figure 3：Sectoral Vulnerability and income level

The values of the vulnerability by this paper are divided into the five sectors based on the weighting in Table 7 and shown in Figure 3 scatter charts. In each graph, the approximation straight line represents the expected value of the vulnerability for the income level. In other words, these expected values are the standard vulnerability that could be attained with the income level of a country. If a country's vulnerability is higher than the approximation straight line, that country has higher vulnerability than normally expected for the income level. And conversely, the vulnerability is lower than the standard expectation if it is lower than the line.

Table 8 summarizes these scatter plots. Except for the environmental vulnerability, the correlations between the vulnerability and the income level were significant (the coefficient of determination was between 0.71 and 0.73). Conversely speaking, it was also clarified from this result that the determinants other than the income level are still existing with the coefficient level less than 0.27 to 0.29. This is to say the physical, economic, social and institutional vulnerabilities have 27% to 29% determinants other than the income level, while the environmental vulnerability is more dependent on those determinants at around 62%.

Table 8: Summary of sectoral vulnerability calculation results

Vulnerability	Regression equation (y: Expected vulnerability, x: Income level)	R^2: Determinant coefficient
Integrated Vulnerability (VI)	y = -0.211*log(x) + 1.171	0.888
Physical Vulnerability (VP)	y = -0.236*log(x) + 1.143	0.713
Economic Vulnerability (VEc)	y = -0.211*log(x) + 1.136	0.727
Social Vulnerability (VS)	y = -0.159*log(x) + 1.044	0.727
Institutional Vulnerability (VIn)	y = -0.286*log(x) + 1.612	0.734
Environmental Vulnerability (VEn)	y = -0.163*log(x) + 0.901	0.383

Also, looking at the regression coefficient, the absolute values of the inclinations are getting smaller in the order of institutional (-0.29), physical (-0.24), economic (-0.21), environmental (-0.16) and social (-0.16). This is to say that the increase in the income level would reduce the expected vulnerability, but the magnitude of decrease upon the income increase is different among the five sector vulnerabilities. In particular, the environmental and social vulnerabilities are less likely to decrease as the income level increases when compared with those of institutional and physical vulnerabilities.

In other words, compared with the integrated total vulnerability index, it has been confirmed that all the five sectoral vulnerabilities not only have the same downward tendency of declining as income level rises but also have a high correlation with the income level except the environmental vulnerability. On the other hand, since the regression coefficients for respective sectoral vulnerabilities were different, the respective sectoral vulnerabilities change differently as the income level changes.

As a result, by breaking down the integrated vulnerability index into five sectors, it was confirmed that a similar tendency obtained a different vulnerability index of the nature as a relation to the income level.

3.3 Connecting PDNA with the sectoral breakdown of WRI

The PDNA guidelines set the basic 17 sectors, and how to correlate these sectors with the five sectoral disaster vulnerability of the modified WRI should be considered. Table 9 shows that these two methods are different in terms of sectoral classification, and it proposes a tentative cross-reference scheme for classifying the 17 PDNA basic sectors into the sectoral vulnerability in this paper.

For example, "culture" is categorized in the social sector in PDNA, but the sectoral dissolution method in this paper categorizes it as "others" because the cultural vulnerability is not considered. In addition, "disaster risk reduction (DRR)" corresponds to a cross-cutting theme in PDNA, but the sectoral dissolution method classifies it as a physical vulnerability. However, we should be careful enough to categorize it also into the social vulnerability, if the DRR intends to also take the non-structural countermeasures such as disaster prevention education.

Table 9: Cross-reference between PDNA and WRI sectoral vulnerability

			Sectoral Vulnerability					Others
			VP	VEn	VS	VIn	VEn	
PDNA sectoral categorization	Social Sectors	Housing, land & settlements			●			
		Education			●			
		Health			●			
		Culture						●
		Nutrition			●			
	Infrastructure Sectors	Water, sanitation and hygiene	●					
		Community infrastructure	●					
		Energy and electricity	●					
		Transport and telecommunications	●					
	Productive Sectors	Agriculture, livestock, fisheries		●				
		Industry, Commerce and Trade		●				
		Tourism		●				
	Cross-cutting Themes	Governance				●		
		Disaster risk reduction	●					

		Environment					●	
		Employment and livelihoods		●				
		Gender			●			

3.4 Standardizing the sectoral breakdown value of WRI as a reference

Next, we will examine what should be set as the criteria to evaluate the sectoral disaster vulnerability index on whether it is high or low. Although WRI quantifies vulnerability, exposure and risk of the 168 countries, it is not clear how each country's vulnerability should be assessed in terms of their strengths and weaknesses while taking into account the economic and social disparity among the nations.

In Figure 4, we can see the sectoral vulnerability index of the total of 15 countries arranged in income level order getting higher from left to right. Certainly, the general and five sectoral vulnerabilities are showing the tendency to fall basically from left to right as income levels improve. However, for example in Haiti whose income level is almost the same as Nepal, while Haiti has more than 0.17 point higher integrated vulnerability than Nepal, and the same tendency can be seen in the five sectoral vulnerabilities as well. Similarly, in Italy and New Zealand, where the income level is almost the same, the institutional vulnerability is higher in Italy, but the environmental vulnerability is higher in New Zealand. In other words, even if the income level is comparable, the characteristics of the vulnerability vary among the country, and it is understood that the vulnerability of each country is affected by some determinants other than income level.

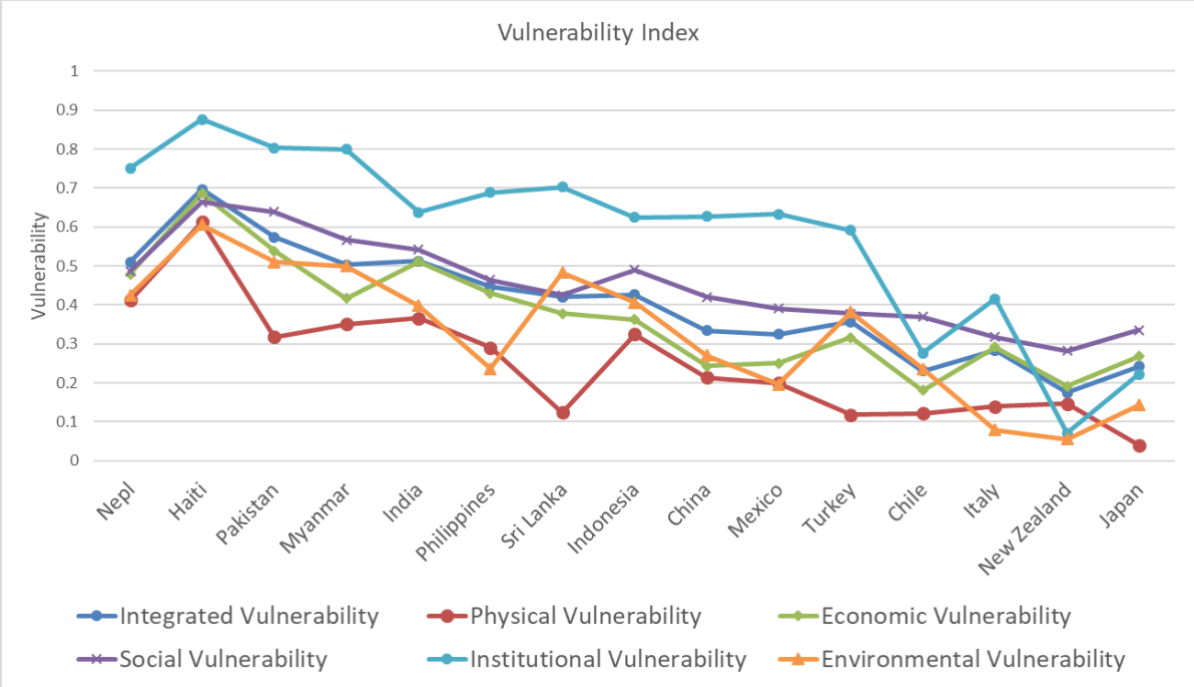

Figure 4：Vulnerability Index of selected 15 countries

Therefore, in order to exclude the effect of the difference in income level, we have to refer to the difference from the expected vulnerability by income level. With using the difference, it is possible to measure the influence given to the sectoral vulnerability by determinants other than the income level. And, by looking at whether the vulnerability index is greater or smaller than 0, we can know the direction of the influence. In a positive case, there would be some factors, apart from income level, in the country that could increase the vulnerability, which would be more susceptible to the disaster risk. In other words, the vulnerability will be reduced as the income level improves by a fairly high correlation, but there are still substantial parts that are affected by factors other than income level. It is understood that the difference from the expected vulnerability by the income level of each country is indicating the magnitude of vulnerability determinants other than income level.

Since the difference from the expected vulnerability by the income level is thought to be a standard to measure the vulnerability influencing factor other than the income level, in this paper, we use this difference as an evaluation criterion of the sectoral vulnerability. However, comparing the differences simply among the sectors might cause a significant misunderstanding in this situation. For example, if we compare a difference of 0.1 from the expected value in the environmental vulnerability whose distribution is biased to a lower level with the same 0.1 difference in the institutional vulnerability whose distribution is biased to a relatively high level, the implications should be more significant in the environmental vulnerability. Therefore, in this paper, it is decided to use the difference divided by the expected vulnerability to mitigate such misconceptions as Figure 5.

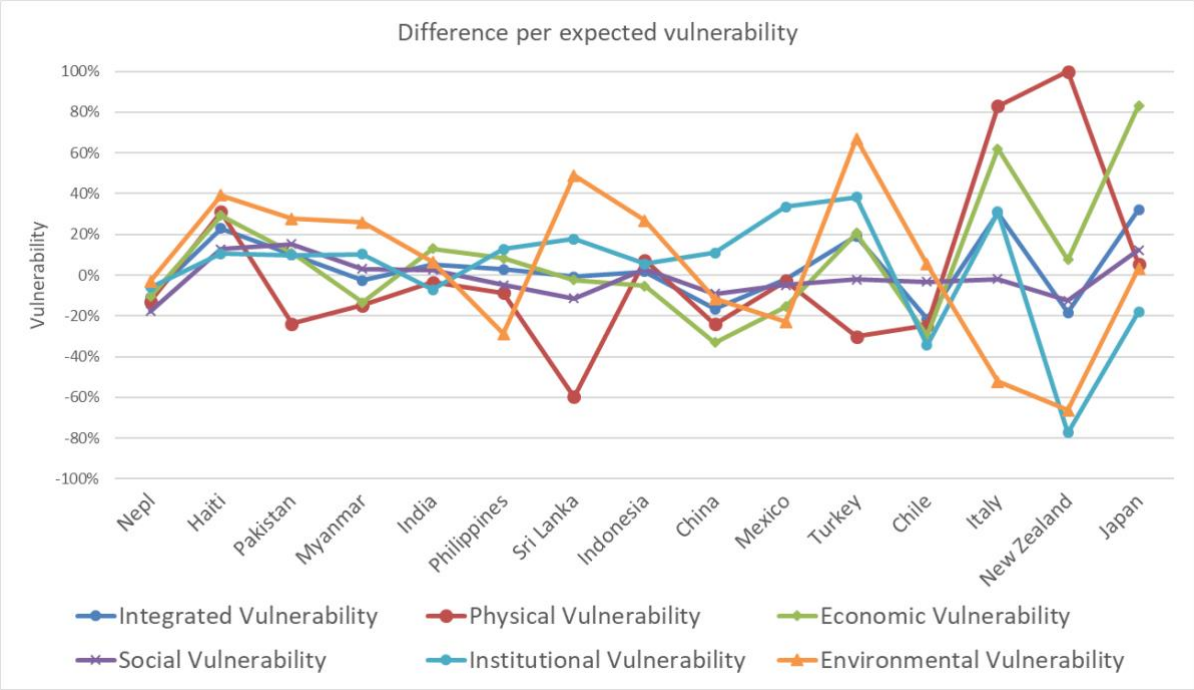

Figure 5： Difference per expected vulnerability of 15 countries

4. Verification of the sectoral breakdown of WRI with case studies

We would like to conduct case studies using the sectoral breakdown of WRI that has been investigated so far in this paper. The cases are three major disasters: the India Ocean Tsunami 2004 (Indonesia), the Great East Japan Earthquake 2011 (Japan) and the Nepal earthquake 2015 (Nepal). The sectoral breakdown of the WRI's vulnerability was calculated using 20 indicators of the exact or previous year of the event under an assumption that the country with those the 20 indicators existed in the year 2015.

Damage assessment and recovery needs estimate standards that were applied to those cases depend on the time of the disasters. In particular, the year 2003 when the ECLAC damage assessment method (DaLA) was revised, and the year 2013 when the PDNA guidelines were enacted are the specific boundaries of what kind of estimation and decision method was used. For the three major disasters dealt with in this paper, standards in Table 10 were employed to estimate the damage and the recovery needs.

This limitation resulted in that the verification with actual PDNA was possible only in the 2015 Nepal Earthquake. Moreover, as for the great East Japan earthquake, the ECLAC and PDNA have not been explicitly followed, and the damage assessment was made in a unique manner and the recovery needs were decided without any sectoral classification.

Nonetheless, even without PDNA, we can still verify the applicability of the sectoral breakdown of WRI with referring to either the recovery needs or actual expenditure. Although this paper is primarily focusing on the recovery needs estimation with PDNA, the sectoral breakdown of WRI could also be referred with the actual recovery spending in the same manner.

Table 10: Damage and recovery needs assessment for the 3 disasters

	Damage and loss assessment		Recovery needs assessment	
	Title of the results	Standard	Title of the results	Standard
Indian Ocean Tsunami	Preliminary Damage and Loss Assessment[xxiii] (Jan. 2005)	DaLA (ECLAC)	Master Plan for the Rehabilitation and Reconstruction of the Regions and Communities of the Province of Nanggroe Aceh Darussalam and the Islands of Nias, Province of North Sumatera[xxiv] (Apr. 2005)	None
Great East Japan Earthquake	Cabinet Office Assessment[xxv] (June 24th, 2011)	None	Basic recovery policy from GEJE (framework of 19 trillion yen)[xxvi] (July 29th, 2011)	None
Nepal Earthquake	Nepal Earthquake 2015 Post Disaster Needs Assessment[xxvii] (June 2015)	PDNA	Nepal Earthquake 2015 Post Disaster Needs Assessment[27] (June 2015)	PDNA

4.1 Case study on the 2004 Indian Ocean earthquake and tsunami

Calculation results of the standardized difference from the expected value of the sectoral breakdown of WRI based on the year 2004 are shown in Table 11. The difference between the expected sectoral vulnerability based on the income level divided by the expected value is used as an evaluation scale (percent), the plot on such scale is shown as Figure 6.

Table 11: Vulnerability indices of Indonesia as of 2004

	Raw value (RV)	Expected Value (EV)	Difference (Df)	Difference/EV (Df/EV)

	(A)	(B)	(C)=(A)-(B)	(D)=(C)/(B)
Integrated Vulnerability (VI)	0.4730	0.4624	0.0106	2.28%
Physical Vulnerability (VP)	0.4257	0.3507	0.0750	21.38%
Economic Vulnerability (VEc)	0.3682	0.5094	-0.0580	-13.61%
Social Vulnerability (VS)	0.5444	0.5094	0.0351	6.89%
Institutional Vulnerability (VIn)	0.7795	0.6503	0.1292	19.87%
Environmental Vulnerability (VEn)	0.4163	0.3543	0.0621	17.52%

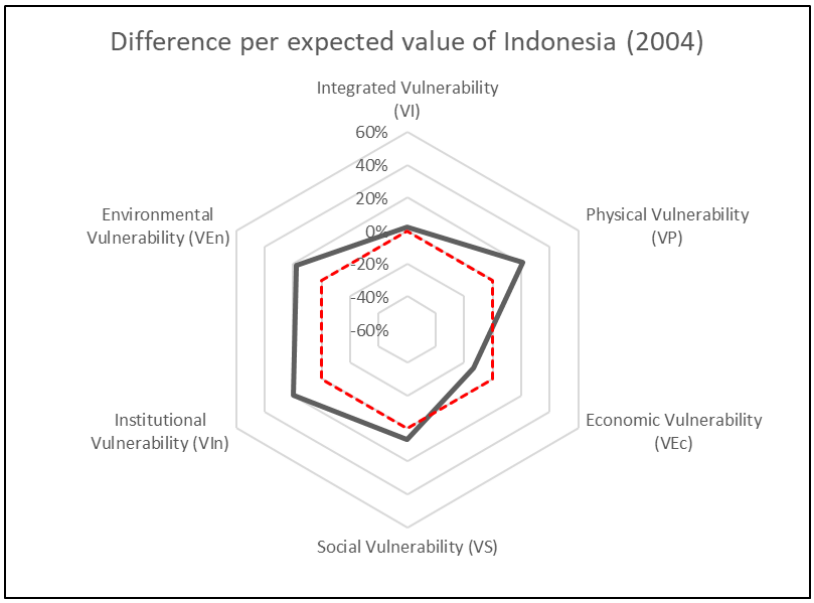

Figure 6: Difference per expected vulnerability Indonesia 2004

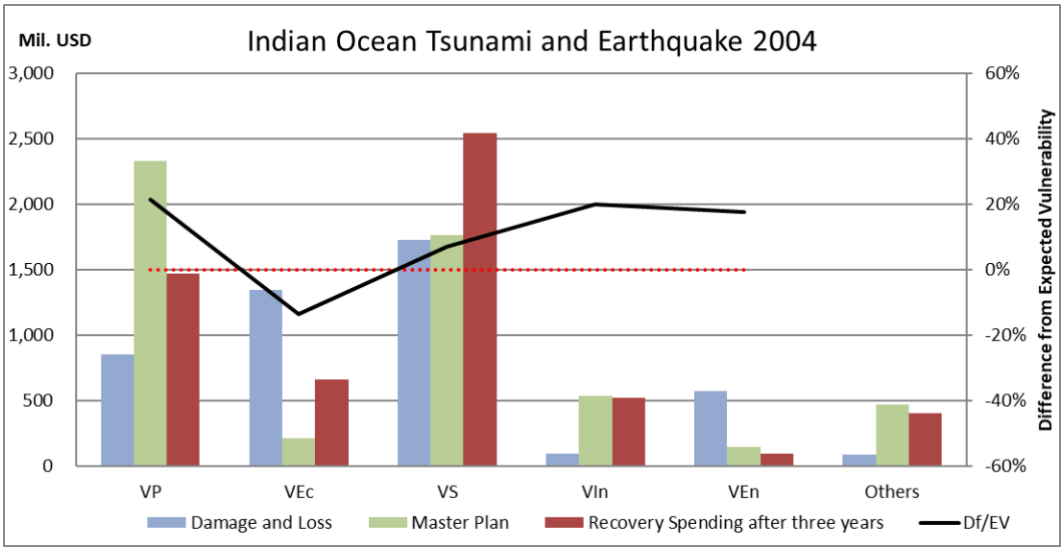

Figure 7: Actual recovery policy and implementation Indonesia

As can be seen from these graphs, it is possible to evaluate the sectoral vulnerability by displaying the difference. Positive differences indicate that the country's vulnerability level is greater than the expected value based on the income level.

Indonesia had positive differences from expected vulnerability in the four sectors except economic vulnerability as of 2004. Namely, physical, social, institutional and environmental vulnerability were all more than the expected values from the income level of the country. In particular, physical, institutional and environmental vulnerabilities are considerable exceeding approximately 20% from the expected values. On the contrary, economic vulnerability was low, and it was a strength of Indonesia. These sectoral vulnerabilities indicate that physical, social, institutional and environmental recovery needs should be considerably higher than the damage and loss incurred in those sectors to ensure BBB.

Figure 7 compares (1) Damage and loss, (2) Recovery needs (Master plan), (3) Actual recovery spending and (4) Sectoral WRI (difference). As of 2004, the PDNA guidelines had not yet been made public, so the damage and loss were estimated based on DaLA (ECLAC) one month after the disaster, and the recovery master plan was formulated estimating the recovery needs five months after the disaster. In the bar graph, we have tried to classify the amount of (1) Damage and loss, (2) Recovery needs (Master plan), (3) Actual recovery spending according to the five sectors in this paper. Also, the line graph displayed is the (4) Sectoral WRI (difference) per expected vulnerability as scaled in the second vertical axis on the right.

As set in the Master Plan, recovery needs in the social and environmental sectors are particularly deemed as insufficient, since recovery needs are not well taking into account the costs for “reducing existing risk” at least in the recovery needs assessment stage.

4.2 Case study on the 2011 Great East Japan Earthquake

Table 12 quantifies the vulnerability of Japan in 2010, one year before the Great East Japan Earthquake occurred. Figure 8 is a radar chart plotting integrated and five sectoral vulnerability differences in percentage of the respective expected values.

Japan had higher values in the physical, economic and social vulnerability among the five sectors than expected values from the income level as of 2010. In particular, economic vulnerability was around 57% higher than the expected value, and challenges were significant.

Table 12: Vulnerability indices of Japan as of 2010

	Raw value (RV)	Expected Value (EV)	Difference (Df)	Difference/EV (Df/EV)
	(A)	(B)	(C)=(A)-(B)	(D)=(C)/(B)
Integrated Vulnerability (VI)	0.2241	0.1890	0.0351	18.57%
Physical Vulnerability (VP)	0.0483	0.0452	0.0031	6.96%
Economic Vulnerability (VEc)	0.2390	0.3032	0.0866	56.85%
Social Vulnerability (VS)	0.3434	0.3032	0.0402	13.26%
Institutional Vulnerability (VIn)	0.1822	0.2791	-0.0969	-34.73%
Environmental Vulnerability (VEn)	0.1423	0.1434	-0.0012	-0.81%

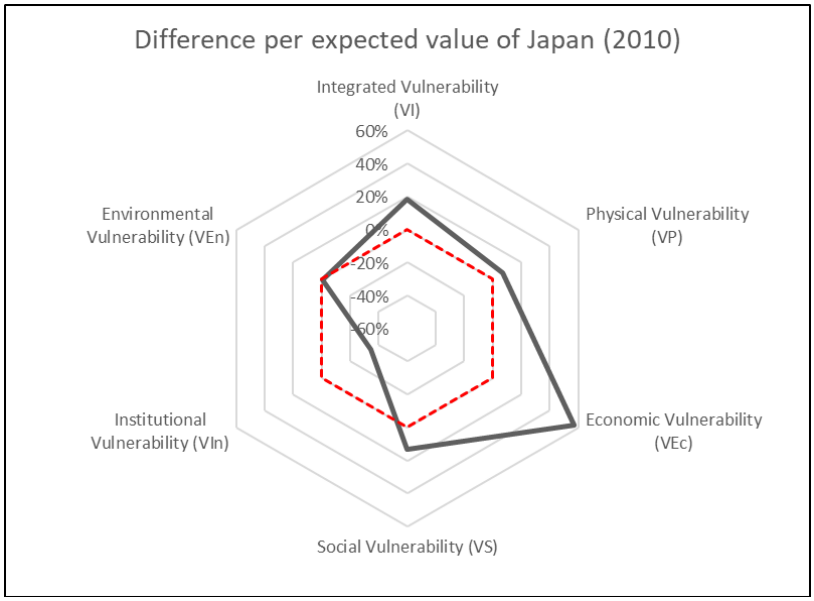

Figure 8： Difference per expected vulnerability Japan 2010

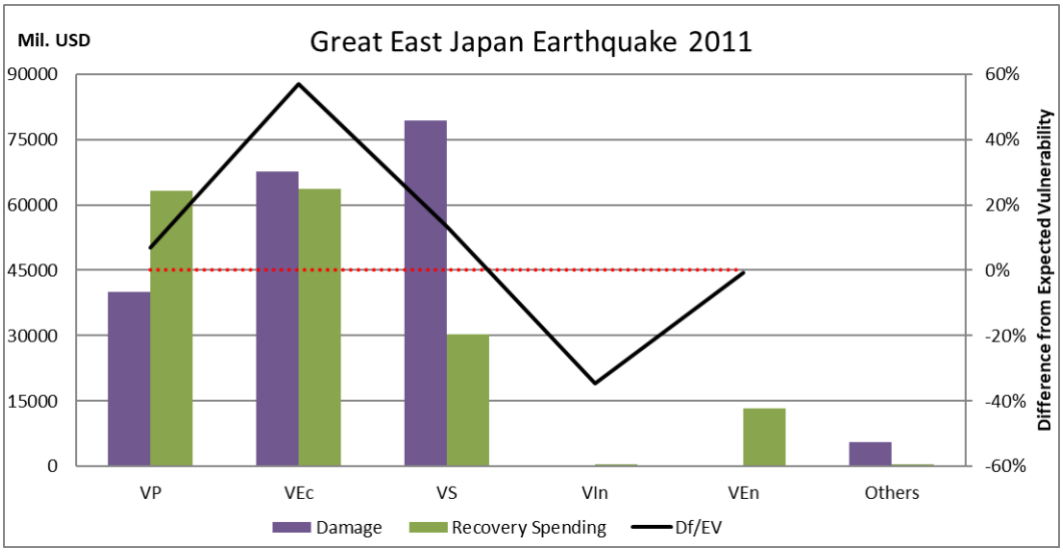

Figure 9 : Actual damage and recovery spending Japan

In such a backdrop, Figure 9 compares the damage, the actual recovery spending and the sectoral vulnerability. The damage estimate was done three months after the disaster, but this was not based on the PDNA guidelines and was only counting the direct damage. Four months after the disaster, the basic recovery policy and financial recovery needs of 19 trillion yen were set. However, the financial recovery needs were determined based on the proportion of the financial demand and damage in the Great Hanshin-Awaji Earthquake case, and the sector classification was not possible because a clear budget allocation policy was not presented. Within these limitations and contexts, the bar graph shows the damages and the recovery spending we have classified into the five sectors. Also, the line graph displayed is the difference per expected vulnerability in Figure 10 as scaled in the second vertical axis on the right.

The physical vulnerability is considered to have been properly tackled with as a sufficient level of expenditure compared to the amount of damage, while the recovery spending for the economic and social vulnerability was insufficient. In particular, despite the highest vulnerability in the economic sector among the five sectors, it was debatable that the spending in the economic sector was limited to same as the estimated damage. And, only half of the damage was spent for the social vulnerability that was also deemed as a weakness.

4.3 Case study on the 2015 Nepal Earthquake

Table 13 quantifies the vulnerability of Nepal in 2014, the year before the Nepal Earthquake occurred. Figure 10 is a radar chart plotting integrated and five sectoral vulnerability differences in percentage of the respective expected values.

Nepal had all negative differences in the five sectoral vulnerability that indicate Nepal has no deficiencies in the vulnerability referring to its income level as of the year 2014. Conversely, the income level is extremely low ($687 per capita (2010 USD)) and the biggest challenge was to raise the income level.

In such a backdrop, Figure 11 compares the damage, the actual recovery spending and the disaster vulnerability sectoral dissolution results. First, both the damage and recovery needs assessment based on the PDNA guidelines was carried out two months after the disaster. In addition, recovery needs were reviewed one year later as the Post Disaster Recovery Framework (PDRF). In the bar graphs, we have tried to classify the damage, the recovery needs and the recovery spending about two years later (as of July 2017) into the five sectors proposed in this paper. Also, the line graph displayed is the difference per expected vulnerability in Figure 11 as scaled in the second vertical axis on the right.

Table 13： Vulnerability indices of Nepal as of 2014

	Raw value (RV)	Expected Value (EV)	Difference (Df)	Difference/EV (Df/EV)
	(A)	(B)	(C)=(A)-(B)	(D)=(C)/(B)
Integrated Vulnerability (VI)	0.5057	0.5730	-0.0674	-11.76%
Physical Vulnerability (VP)	0.4107	0.4744	-0.0637	-13.42%
Economic Vulnerability (VEc)	0.4707	0.5928	-0.0664	-12.36%
Social Vulnerability (VS)	0.4920	0.5928	-0.1008	-17.01%
Institutional Vulnerability (VIn)	0.7441	0.8005	-0.0564	-7.05%
Environmental Vulnerability (VEn)	0.4181	0.4396	-0.0214	-4.88%

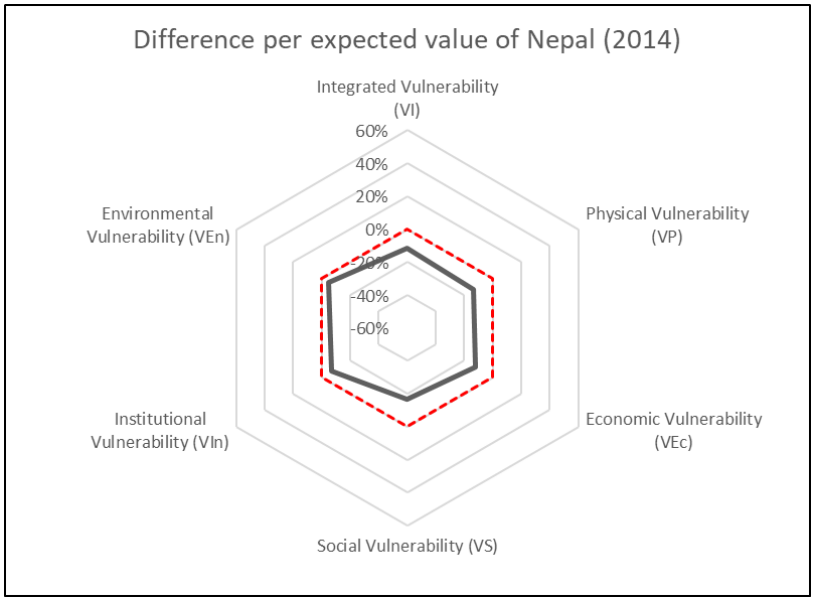

Figure 10: Difference per expected vulnerability Nepal 2014

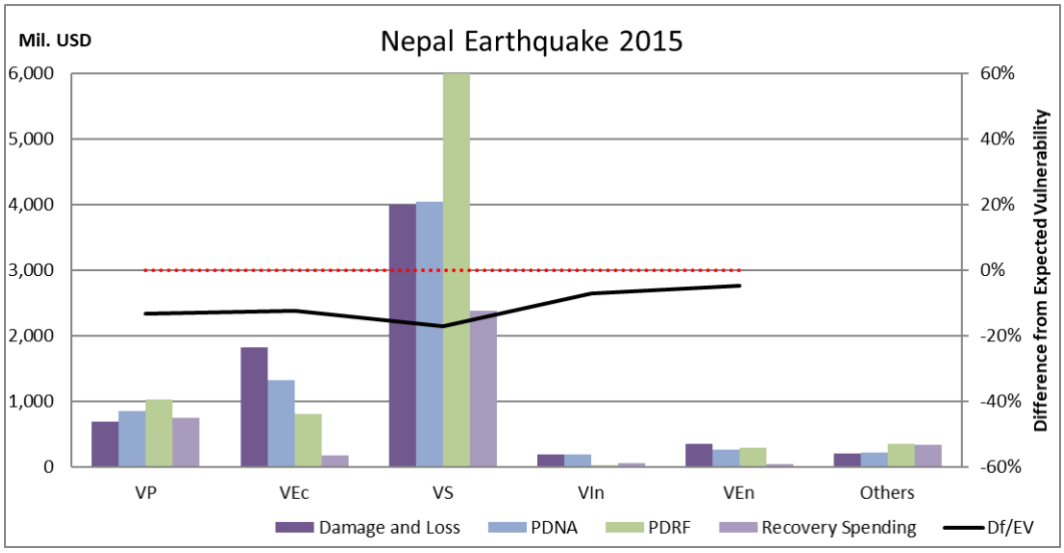

Figure 11: Actual recovery policy and implementation Nepal

Among the five sectors, both the recovery policy and the recovery spending were inadequate in terms of the economic vulnerability. Given the fact that Nepal is a low-income country, it is considered that the economic vulnerability should be given the highest priority for reducing the entire vulnerability of the nation. As for the social vulnerability and the institutional vulnerability, the recovery policy was properly setting up the recovery needs, but expenditure was not corresponding to it.

5. Limitations and discussions

As mentioned so far in this paper, we have verified the sectoral breakdown of WRI as a practical tool for linking with PDNA, but it is important to note that there are some limitations to this tool.

5.1 Limitations with the modified WRI

The deployed indicators, calculation method, weighting, etc. are based on WRI, but the optimization of these methods requires further verification. This paper is exhibiting a basic framework of the sectoral breakdown of WRI, and it is wished that further discussions and consensus buildings should be sought by decision makers, experts and academia of the world for the development of a more optimal method.

5.2 Limitations on the sectoral breakdown of WRI

In this paper, we have quantified the vulnerability of past years, but such calculation is made on an assumption that virtually that country of the year existed in 2015. However, the vulnerability index is basically not able to be evaluated across the years. In other words, the vulnerability figures for 2004 are determined by the indicators in 2004 and cannot be compared to the vulnerability figures of another year. In addition, the meaning of the difference as the evaluation criteria is conceiving a part that cannot be explained. The difference per the expected vulnerability is still not possible to set up absolute criteria.

5.3 Limitations of the case studies

In this paper, there was a limitation that the verification with actual PDNA was possible only in the 2015 Nepal Earthquake. Nonetheless, even without PDNA, we can still verify the applicability of the sectoral breakdown of WRI with referring to the sectoral damage assessment for either estimating the recovery needs or monitoring the actual expenditure. We could review the past disaster recovery cases whether recovery needs or actual expenditure were sufficiently accounted when considering the sectoral vulnerability. In the sectors that have higher vulnerability than the expected vulnerability for the country's income level, recovery needs should be considerably higher than the visible damage and loss. Since we could verify that all the three cases were showing the applicability of the sectoral breakdown of WRI for either estimating the recovery needs or monitoring the actual expenditure, we should be able to say that the sectoral breakdown of WRI can be applied to the earliest phase of the recovery needs estimation right after a future disaster occurrence.

5.4 Limitations of PDNA

This paper is focusing on how we can properly estimate the recovery needs under PDNA with applying the sectoral breakdown of WRI. And, we believe the recovery needs that are well taking into account the costs for "reducing risk" should be assuring BBB. However, in the reality, it may not be a case since the estimated recovery needs are not always needed to be strictly followed in the recovery process as we already saw in the cases in chapter 4. PDNA's primary purpose would be to quickly set up even a rough figure to call for the international assistance and the domestic budget requirement. Nonetheless, if recovery needs are estimated more properly in terms of "reducing existing risk" as in the BBB definition, we would be more likely to attain BBB in the total recovery process as keeping a benchmark to secure a necessary expenditure in the vulnerable sector.

6. Conclusions

In this paper, recognizing an issue that PDNA's recovery needs estimate is not properly addressing how to estimate the costs to reduce existing risk as required for BBB, we tried to exhibit a basic framework of the sectoral breakdown of WRI to support recovery needs estimate with PDNA to practically materialize BBB.

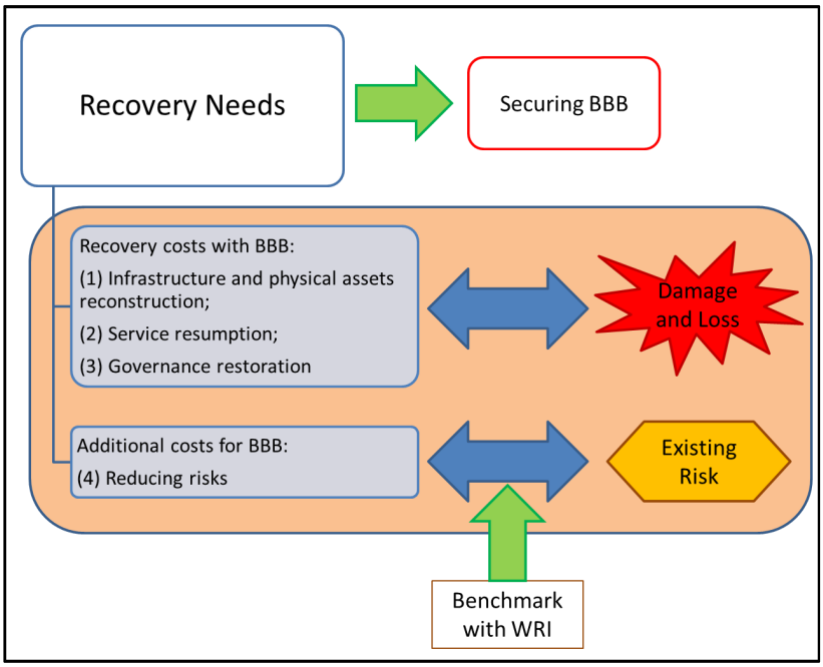

Figure 12: Securing BBB in PDNA with the sectoral breakdown of WRI

Although the framework in this paper still conceives a certain limitation, we could assure that benchmarking necessary "reducing existing risk" costs with sectoral breakdown of WRI is possible as figure 12

illustrates. In other words, we came to a conclusion that in the sectors that have higher vulnerability than the expected vulnerability for the country's income level, recovery needs should be considerably higher than the visible damage and loss.

References

[i] UNISDR (2016b)、Terminology related to disaster risk reduction: technical non-paper

http://www.preventionweb.net/documents/oiewg/Terminology%20related%20to%20disaster%20risk%20reduction%20-%20technical%20non-paper.pdf （2017 年 10 月 14 日）

[ii] UNISDR (2016c)、Terminology related to Disaster Risk Reduction updated technical non-paper

http://www.preventionweb.net/documents/oiewg/Terminology%20related%20to%20Disaster%20Risk%20Reduction%20-%20updated%20technical%20non-paper%2030%20September%202016.pdf （2017/10/14）

[iii] EU, UNDP and World Bank（2013）、POST-DISASTER NEEDS ASSESSMENTS Volume A GUIDELINES

http://www.undp.org/content/undp/en/home/librarypage/crisis-prevention-and-recovery/pdna.html （2017/10/8）

[iv] UNISDR (2015a)、Sendai Framework for Disaster Risk Reduction 2015 – 2030

http://www.unisdr.org/we/inform/publications/43291 （2017/10/14）

[v] UNISDR (2015c)、Working Background Text on Terminology for Disaster Risk Reduction

http://www.preventionweb.net/documents/framework/Working%20background%20text%20on%20DRR%20Terminology%202%20October%20reissued%20on%2023%20October.pdf （2017/10/14）

[vi] UNISDR (2004)、Terminology: Basic terms of disaster risk reduction

http://www.unisdr.org/files/7817_7819isdrterminology11.pdf （2017/10/14）

[vii] UNISDR (2009)、2009 UNISDR terminology on disaster risk reduction

http://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf （2017/10/14）

[viii] UNISDR (2015b)、Background Paper Proposed Updated Terminology on Disaster Risk Reduction: A Technical Review

http://www.preventionweb.net/files/45462_backgoundpaperonterminologyaugust20.pdf （2017/10/14）

[ix] UNISDR (2016a)、Working Text on Terminology Based on negotiations during the Second Session of the Open-ended Inter-governmental Expert Working Group on Indicators and Terminology relating to Disaster Risk Reduction

http://www.preventionweb.net/files/47136_workingtextonterminology.pdf （2017/10/14）

[x] UNISDR (2016d)、Report of the Chair of the Open-ended Intergovernmental Expert Working Group on Indicators and Terminology relating to Disaster Risk Reduction on Results of informal consultations from February to November 2016 on indicators and terminology relating to Disaster Risk Reduction

http://www.preventionweb.net/files/50683_reportofthechaironresultsofinformal.pdf （2017/10/14）

[xi] UNISDR (2017a)、official UNISDR terminology on disaster risk reduction

http://preventionweb.net/go/51750 （2017/10/14）

[xii] Yoshio Higuchi, Tomohiko Inui, Shigeru Sugiyama, Kouji Wakabayashi, Nobunori Kuga, Toshiaki Hosoi, Kengo Ikemoto, Isao Takabe, Yoshikazu Uematsu and Takeyori Arimitsu (2012)、Aftermath of the 3.11 Disaster: An Analytical Evaluation Using Official Statistics (published in Japanese)

http://www.esri.go.jp/jp/archive/e_dis/e_dis286/e_dis286.pdf (2019/1/14)

[xiii] ECLAC（2003）、Handbook for estimating the socio-economic and environmental effects of disasters

http://www.recoveryplatform.org/assets/tools_guidelines/Handbook_for_Estimating_Socioeconomic2003.pdf （2017/6/11）

[xiv] JICA (2007)、Japanese translation of the "Handbook for estimating the socio-economic and environmental effects of disasters" (published in Japanese)

http://open_jicareport.jica.go.jp/pdf/11862257.pdf （2018/1/3）

[xv] ADB（2016）、Asian Water Development Outlook 2016, Strengthening Water Security in Asia and the Pacific

https://www.adb.org/publications/asian-water-development-outlook-2016（2017/10/8）

[xvi] Bündnis Entwicklung Hilft and UNU-EHS（2016a）、World Risk Report 2016

http://weltrisikobericht.de/english/ （2017/10/8）

[xvii] UNDP（2004）、A Global Report, Reducing Disaster Risk, A Challenge for Development

http://www.undp.org/content/undp/en/home/librarypage/crisis-prevention-and-recovery/reducing-disaster-risk--a-challenge-for-development.html（2017/10/8）

[xviii] Emergency Events Database (EM-DAT)

http://www.emdat.be/（2017/10/30）

[xix] J. Birkmann, O. D. Cardona, M. L. Carreño, A. H. Barbat, M. Pelling, S. Schneiderbauer, S. Kienberger, M. Keiler, D. Alexander, P. Zeil and T. Welle (2013)、Framing vulnerability, risk and social responses: The MOVE frmework、Natural Hazards, Volume 67, Issue 2, pp 193–211

https://www.researchgate.net/profile/Joern_Birkmann2/publication/257632809_Framing_vulnerability_risk_and_societal_responses_The_MOVE_framework/links/5813036c08ae29942f3ea176/Framing-vulnerability-risk-and-societal-responses-The-MOVE-framework.pdf（2017/6/11）

[xx] Bündnis Entwicklung Hilft and UNU-EHS（2016b）、Overview of updated indicators for the WorldRiskIndex 2016 and indicator sheets with specific information regarding all indicators used

http://weltrisikobericht.de/wp-content/uploads/2016/09/Indicator-update-for-the-WorldRiskIndex_2016.pdf （2017/10/8）

[xxi] Torsten Welle and Joern Birkman (2015)、The World Risk Index – An Approach to Assess Risk and Vulnerability on a Global Scale 、 Journal of Extreme Events, Vol. 2, No. 1, (34 pages)

https://www.researchgate.net/profile/Torsten_Welle/publication/283087679_The_World_Risk_Index_-_An_Approach_to_Assess_Risk_and_Vulnerability_on_a_Global_Scale/links/5632128a08ae506cea68dc22/The-World-Risk-Index-An-Approach-to-Assess-Risk-and-Vulnerability-on-a-Global-Scale.pdf（2017/6/11）

[xxii] Bündnis Entwicklung Hilft and UNU-EHS（2016c）、WorldRiskIndex-2016_English

http://weltrisikobericht.de/wp-content/uploads/2016/09/WorldRiskIndex-2016_English.xlsx（2017/10/8）

[xxiii] The Consultative Group on Indonesia (CGI) (2005)、Indonesia: Preliminary Damage and Loss Assessment.

http://siteresources.worldbank.org/INTINDONESIA/Resources/Publication/280016-1106130305439/damage_assessment.pdf（2017/6/11）

[xxiv] Government of Indonesia （2005）、Master Plan for the Rehabilitation and Reconstruction of the Regions and Communities of the Province of Nanggroe Aceh Darussalam and the Islands of Nias, Province of North Sumatera

http://www.recoveryplatform.org/assets/submissions/200909020450_master_plan_for_reconstruction__government_of_indonesia__tsunami.pdf （2017/10/20）

[xxv] Cabinet Office （2011）、Damage estimate on the GEJE (published in Japanese)

http://www.bousai.go.jp/2011daishinsai/pdf/110624-1kisya.pdf （2017/10/8）

[xxvi] Reconstruction Headquarters in response to the Great East Japan Earthquake（2011）、"Basic Guidelines in response to the Great East Japan Earthquake" (published in Japanese)

https://www.reconstruction.go.jp/topics/doc/20110729houshin.pdf （2017/10/8）

[xxvii] NPC (2015a)、Nepal Earthquake 2015 Post Disaster Needs Assessment VOL. A: KEY FINDINGS.

http://www.npc.gov.np/images/category/PDNA_Volume_A.pdf （2017/10/8）