Vulnerability Analysis to Climate Change in Lembeh Island, North Sulawesi

Endang Retnowati, Safran Yusri, Idris, Mikael Prastowo Sesotyo Widodo and Fakhrurrozi
Yayasan TERANGI, Jl. Asyibaniah no 105-106 Depok 16438, West Java, Indonesia

Corresponding author: endang.retnowati58@gmail.com

Abstract. The local community in Lembeh Island, North Sulawesi depend on natural resources that is affected by climate change, such as fisheries and agriculture, and therefore their vulnerability to climate change needed to be assessed. A vulnerability and resilience survey was done in three villages in Lembeh Island, which were Kareko, Pintu Kota, and Pasir Panjang. Questionnaires survey with parameters of the sensitivity, exposure, and adaptive capacity were done to 90 households. Results showed that the most vulnerable village is Pintu Kota. This is due to the decline of the fisheries outcomes that affected by extreme weathers as the result of the climate change itself. Aside from that, the local community in Pintu Kota Village was lack of information and knowledge about the mitigation and adaptation strategy to the natural disaster and climate change effect. On the other side, the most resilient village is Pasir Panjang, this is due to most households there usually have members with several alternative livelihoods, so that the local community of Pasir Panjang have the ability and skill to survive toward the impact of the ecological disaster and climate change. Since Lembeh Island experienced a high exposure to climate change, the local community need to cope with and adapt to it. Therefore, this study output addressed the government and other related institutions to promote better mitigation and adaptation strategy towards ecological disaster and climate change impacts.

1. Introduction
Indonesia is an archipelago country that situated in the coral triangle [1]. As the planet’s climate changes so too will communities and ecosystems, with intense consequences for fisheries change [2]. Currently climate change give significant impact to fisheries and agriculture and these sectors need to adapt to the risk of climate change [3]. Coastal community is potentially affected by the ecological disaster and climate change [4]. Aside that, Indonesia has maritime climate and tropical climate that worsen the impact of the climate change itself. Vulnerability is defined as a combination of the extrinsic exposure of groups or individuals or ecological systems to a hazard, such as climate change, their intrinsic sensitivity to the hazard, and their lack of capacity to modify exposure, absorb, and recover from the hazard, and to improve the process of adaptation [5]; [6]; [7]. Three villages in North Sulawesi became the location of vulnerability assessment to the ecological disaster related to climate change. Those three villages were Kareko, Pintu Kota, and Pasir Panjang. The survey locations were chosen because these villages were located in the coastal area of North Sulawesi which is considered to be prone to the impact of climate change, ecological disaster on fisheries and agriculture sectors.

Climate variability has a range of human and ecological impact; climate and weather have profound effect on economies, and the food security and livelihood of community [4]. Marine area in North Sulawesi is known for its marine biodiversity. Lembeh Strait is affected by two seasons, which are north season that promotes rain and south season that is relatively dry with strong wind [8].
Coastal communities are prone to the risk of climate change and ecological disaster, such as extreme weather, high wave, and strong current that can increase the risk of damage to the buildings, furthermore these can promote lost of lives [9]. Currently, the vulnerability assessment to climate change in the community is not a priority, as the community is susceptible to climate change and ecological hazards, they have an active role in adaptation and mitigation [10]. Therefore, Yayasan TERANG (Terumbu Karang Indonesia) tried to increase the resilience of the coastal community of Lembeh Island with the proper adaptation and mitigation strategic to cope with and adapt to the climate change and ecological disaster. This study also addressed the policy makers that urgently require information and analysis to guide investments and initiatives in climate change mitigation and adaptation.

2. Methodology
The area of study is Lembeh Island (1° 26’ N and 125° 14’ E), and situated off the north east coast of North Sulawesi, Indonesia (Figure 1). Vulnerability assessment of climate change was done in three villages, which are Kareko, Pintu Kota, and Pasir Panjang from 5 – 15th of October 2018, using quantitative and qualitative assessment in the form of questionnaire interview and in-depth interview. The questionnaire survey was done to 90 respondents in 3 villages in Bitung City with data sampling unit of the survey was household in the village scale. The respondents were chosen randomly in every island. Secondary information were gathered from publicly available online data.

In the questionnaires, vulnerability to climate change were assessed using three key elements: exposure (E) to physical effect of climate change, the degree of intrinsic sensitivity (S) of the natural resource system or dependence of the economy upon social and economic returns from that sector, and the extent to which adaptive capacity (AC) enables these potential impacts to be offset [11]; [12]. There is no objective, independently derived measures of exposure, sensitivity, or adaptive capacity, and so their relevance and interpretation depend on the scale of analysis, the particular sector under consideration and data availability [13]; [14].

As this study focused on the variable of three elements to assess the vulnerability of the community in coastal area, so based on those variables, the indicators were chosen are derived as below:
2.1 Exposure (E)
IPCC defined exposure as how far the climate change affected the system. The system here defined as the ecological or the life form and the livelihood of the community [15]. The indicators of exposure are the tendencies of the climate and the phenomena that were promoted by climate conditions [3]. This study analyzed how far the impact of climate change towards the decline of fish catch and also focused on how far the community that lives in the coastal area was affected by the impact of climate change and ecological disasters. In the questionnaire form, indicators used include: the effect of the disaster to family members of the household, the frequency of the disaster occurrence, how long the disaster happened, and how far the area scope of the disaster itself. These are in line with the various condition promoted by different geographical areas as well as different frequency and intensity that can influence the exposure of the disaster and climate change that affected the community [16].

2.2 Sensitivity (S)
Sensitivity is defined as the intrinsic degree to which biophysical, social and economic conditions are likely to be influenced by extrinsic stresses or hazards [12]. Representation of the economic aspect, we focused on how the disaster affected the livelihood of the household, whether it affected the amount of income of the family or affected the kind of the livelihood in the household. Contribution of the fisheries on the employment is important to analyze the sensitivity index because this sectors support the livelihood and the food security for the household of the coastal community. This element of the assessment not only focused on the economic activities but also on the impact of the climate change and ecological disaster to other food production sectors that affect people’s livelihoods and food security [17], and impacts on aspects of people’s lives unrelated to their economic activities, such as damage to their homes [9]; [18]; [19].

2.3 Adaptive Capacity (AC)
Adaptive capacity comprises elements such as levels of social infrastructures, human resources and the effectiveness of governance structures [20]; [21]; [22]; [23]. Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity. Numerous definitions of adaptation are found in climate change literature, mostly variations on a common theme. [24] describes adaptation as ‘adjustments in a system’s behavior and characteristics that enhance its ability to cope with external stress’. [25] in the climate change context, refer to adaptations as ‘adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts’. [26] also in the climate context, defines adaptations as the ‘adjustments in individual groups and institutional behavior in order to reduce society’s vulnerability to climate’. Based on their timing, adaptations can be anticipatory or reactive, and depending on their degree of spontaneity they can be autonomous or planned [27]; [28].

2.4 Construction of Vulnerability Index
The data collected from the respondent in 3 villages through questionnaire interview and in-depth interview were being normalized and standardized [15]. The calculation of vulnerability index (Vi) may be seen as a relational function of exposure or sensitivity, which may be modified by adaptive capacity, such that Vi = (Ei + Si) - ACi. Implicit in this framework is that any vulnerability score is weighted one per amount of indicators included to adaptive capacity and one per amount of indicators included to exposure and sensitivity. The weighting of index for each element we used is ranged from 0 – 1 with the minimum index score is 0 (zero) and the maximum index score is 1 (one). With assumption, the lower the index score means it is less vulnerable, and the higher the index score means it is more vulnerable.

\[ Vi = (Ei + Si) - ACi \]

Where Vi is the vulnerability index, Ei is the exposure index, Si is the Sensitivity index, and ACi is the Adaptive Capacity index [15].
3. Results
Based on the results, the village with the highest vulnerability index is Pintu Kota 0.301 followed with Kareko 0.271 and Pasir Panjang 0.262. It is showed that Pintu Kota is the most vulnerable village with the vulnerability index due to the respondents in this area experienced more disaster than other villages. This is showed in Table 2. While Pasir Panjang, is the least vulnerable to the ecological disaster and climate change with the vulnerability index is 0.262 due to the high score of adaptive capacity of the respondent which they have various kind of livelihoods in facing the worst possibility of disaster impact so that they can survive to protect their food stocks or to gain income from many sources [3]. While in Kareko, with the vulnerability index is 0.271, experienced disaster such as drought, high waves and tidal floods because the villages are relatively near the coastal area, but uniquely the study found that this village is prone to the landslide because mostly all area of these villages are situated near steep slopes [29].

The vulnerability index calculated based on the elements of sensitivity index, exposure index, and adaptive capacity index. The highest sensitivity index is in Kareko 1.79 while the lowest is in Pasir Panjang 1.56. The range of exposure indices is from 1.41 in Pintu Kota to 0.96 in Kareko. The highest adaptive capacity index is in Pintu Kota 1.79 followed by Kareko 1.68. The adaptive capacity index depends on the indicator such as the availability of the evacuation route, the dissemination of the disaster warning message, the availability of the shelter, attitude towards the hazard situation of the disaster, coordination among the community facing the hazard situation, the leader in village that being trusted by community in coping with the threat of disaster, campaign and training about mitigation and adaptation strategy towards climate change and ecological disaster, the variation of the livelihoods in case to adapt with the impact of the disaster to food security and economic condition of the household. All of the above information can be seen in Table 1.

Table 1. Vulnerability index to climate change and ecological disaster in 3 villages.

| Village     | Vulnerability Index | Vulnerability Element | Exposure | Sensitivity | Adaptive Capacity |
|-------------|---------------------|-----------------------|----------|-------------|------------------|
| Kareko      | 0.271               | 0.96                  | 1.79     | 1.68        |
| Pintu Kota  | 0.301               | 1.41                  | 1.6      | 1.79        |
| Pasir Panjang | 0.262             | 1.19                  | 1.56     | 1.77        |

The villages in Lembeh Island had similar terrain but some villages are situated in the coastal area while some villages other are situated near the cliffs that are prone to land slide. Drought was also one of big issue for these villages that mostly affecting the agricultural sector. The result from the exposure index showed there are 9 kind of disasters, where the most often mentioned by respondent is drought 33% and it can be found in all villages. The second most often mentioned disaster by respondent is tidal floods 22% where it mostly can be found in Kareko and Pasir Panjang. The disaster with the widest impact is drought, while the second is tidal floods where both happened in most of the research area. To know all the disaster occurrences can be seen in Table 2.
Table 2. Frequency of disaster occurrences in 3 villages.

| No | Disaster          | Frequency         | Total per Disater |
|----|-------------------|-------------------|-------------------|
|    |                   | Kareko            | Pasir Panjang     | Pintu Kota       |
| 1  | Tidal floods      | 10                | 16                | 15               | 41  |
| 2  | Extreme weather   | 4                 | 9                 | 5                | 18  |
| 3  | High wave         | 15                | 10                | 2                | 27  |
| 4  | Drought           | 20                | 21                | 21               | 62  |
| 5  | Sea level rise    | 3                 | 2                 | 1                | 6   |
| 6  | Landslide         | 9                 | 1                 | 15               | 25  |
| 7  | Forest fire       | 0                 | 1                 | 0                | 1   |
| 8  | Abrasion & erosion| 0                 | 2                 | 0                | 2   |
| 9  | Floods            | 0                 | 0                 | 5                | 5   |
|    | Total per Village | 61                | 62                | 64               |      |

The sensitivity level of the community to climate change and ecological disaster can be seen based on their livelihoods such as fisherman, sailor, farmer, school teacher, civil servant, community chief, part timer, integrated mother and children care unit volunteers. The most mentioned livelihood are fishermen and farmers while the least mentioned are school teachers, part timers, community chiefs, sailors, civil servants, and integrated mother and children care unit volunteers. Aside from that, livelihood related to marine sector and fisheries employments are fishermen and sailors. Sailors can be in the form of boat owner, boat crew, and traditional fish seller. Village with the highest fisheries employment is in Kareko. The rest of the respondent profile showed that some female respondents did not have any income source for the household because they used to manage domestic life. Details on the livelihood of the respondents can be seen in Table 3.

Table 3. Frequency of livelihoods variety in 3 villages.

| Livelihoods                                             | Frequency         | Total |
|---------------------------------------------------------|-------------------|-------|
|                                                         | Kareko            | Pasir Panjang | Pintu Kota |     |
| School teachers                                         | 1                 | 0      | 1          | 2   |
| Part timers                                             | 2                 | 0      | 1          | 3   |
| Community chiefs                                        | 2                 | 0      | 1          | 3   |
| Fishermen                                               | 16                | 13     | 10         | 39  |
| Sailors                                                 | 3                 | 0      | 0          | 3   |
| Civil servants                                          | 1                 | 1      | 0          | 2   |
| Unemployed                                              | 3                 | 9      | 3          | 15  |
| Entrepreneurs                                           | 2                 | 3      | 5          | 10  |
| Integrated mother & children care unit volunteers        | 0                 | 1      | 0          | 1   |
| Farmers                                                 | 0                 | 3      | 8          | 11  |

Education level has significant influence to community attitude in coping with hazardous situation. A proper and higher level of education will lead to better mechanism and strategy of mitigation and adaptation as well as perception and attitude towards disaster and climate change [33]. The information on education level in all villages can be seen in table 4.
Table 4. Respondent’s education level in 3 villages.

| Education Level       | Frequency | Total |
|-----------------------|-----------|-------|
|                       | Pasir Panjang | Kareko | Pintu Kota |     |
| Elementary school     | 12         | 9     | 11         | 32  |
| Junior high school    | 11         | 10    | 9          | 30  |
| Senior high school    | 5          | 8     | 8          | 21  |
| University            | 1          | 3     | 2          | 6   |
| Uneducated            | 1          | 0     | 0          | 1   |

Related to the training and education program in mitigation and adaptation, it is showed that proportion of the respondent who get the dissemination of the disaster warning message is only 26% this means that the community is still lack of information that contain warning message so that they cannot properly prepare themselves to cope with and to adapt to the hazardous situation. This proportion of distribution in disaster warning message can be seen in Table 5.

Table 5. Frequency of disaster warning message dissemination in 3 villages.

| Message Dissemination | Frequency | Total |
|-----------------------|-----------|-------|
|                       | Kareko    | Pasir Panjang | Pintu Kota |     |
| Exposed               | 8         | 4     | 7          | 19  |
| Not exposed           | 22        | 26    | 23         | 71  |

4. Discussions

Lembeh Island has a complex topography [29]. Therefore, this area is prone to landslide, cyclones/hurricanes/typhoons, earthquakes, volcanic eruptions, extreme weather, and strong current that can increase the risk of damage to the buildings, these disasters can even took the lives of the residents [29]; [30]; [9]. On the other hand, marine condition can also promote disaster such as high wave and tidal floods. Community which live in small island like in Lembeh Island have to increase the capacity of adaptation towards hazardous natural disaster related to climate change with diversifying livelihoods and maintaining strong social resources and positive attitude towards such conditions [31]; [32].

Changes on climatic aspects also affected on the conditions of environmental surroundings hazards, this would also affect the frequency, intensity, and/or duration of various natural disasters [33]. The increasing frequency and intensity of severe rainfall events is a primary trigger of increase in the number of areas exposed to landslide risk [34]. Frequencies and intensities of extreme weather as the impact of climate change are expected to affect natural and human systems, more specifically the area affected by drought is likely to increase [35]. Sea level rise as an impact from the climate change will also worsen the vulnerability of coastal areas to physical process of storm waves or high waves [36]. Individuals should know how to prepare themselves to cope with and to adapt to natural disaster and climate change phenomenon, communities should have proper knowledge, awareness, and positive attitude to take precautions. Further training and education about mitigation and adaptation is needed to increase the knowledge [37].

Based on the education level of the respondent showed that mostly they had basic formal educations and only few of them had higher formal education such as senior high schools or university. The higher the education level, respondents tend to not work in the fisheries and agriculture sectors because, based on their opinion from in-depth interview, they gain better education for a better livelihood on land that is safer and generate more income. On the other side, the respondent with lower education had tendency to keep working on fisheries and agriculture sectors because of two possibilities, that whether they have no better option of professions or because they continue working on this sector with the other members of the family.
Based on this study, community in those villages already have enough livelihood varieties to survive and maintain their food stock, so the community already had awareness about food security in case facing the situation to compensate with the impact of the climate change and the ecological disaster affected their livelihood [38]. On the other side, the disaster might affect the fisheries employment that led to the decreasing of the income for the household or even they might lose their source of income. According to [3] this is good because they were not only depended on one source of income so that they could manage to survive in critical situations, they even managed to have food stock, such as seafood, stored in the ice box to survive for more days while they were striving to gain money from other sources. This means that the community have a relatively good concept of food security to support the household. In this context, the community have dependency to the fisheries employment to support their food security that indirectly affected by the disaster and climate change [3]. At the level of governance interventions, physical buildings that support the adaptation and mitigation in those 3 villages such as shelter and evacuation route were relatively not significant because the buildings were not available in the strategic places in the villages.

Commonly the three villages have nearly the same vulnerability index but Pintu Kota have the highest index among all. This is due to many respondents facing a lot of natural disasters related to climate change in the last 5 years. This fact of phenomena also found by [33] which many occurrence of natural disaster impacted by climate change phenomena and this is influenced by the human social structures, specifically vulnerable community and infrastructures [39];[40];[41]. In this study, the highest exposure faced by Kareko due to the lack of alternatives for livelihoods. Villages with less of livelihood variety have tendency to be more vulnerable to the climate change impacts. Various livelihoods, provides alternatives source of income and reduce the pressure on fisheries sectors, environmental degradation, thereby lessen the impact of climate shocks [42].

In other side, it is showed that there is still lack of information and knowledge come from training and education program about mitigation and or adaptation towards ecological disaster and climate change. Respondent with lower education level had tendency in lack of proper knowledge about how to cope with and adapt to threatening situation. On the contrary, respondent with higher education level, besides they have more knowledge to cope with the situation, they also have better attitude in facing such situation. However, government and other related institution still have less attention to this concern. Forms of adaptation including attitude towards the threat of disaster can give highest contribution to adaptive capacity index. One of the aspects that can help to promote positive attitude is education or capacity building program related to disasters [37]; [43]; [44].

The lowest frequency of adaptation form is education program related to training of mechanism and strategy to cope and to adapt with ecological disaster and climate change due to limited access to remote areas in Lembeh Island and the lack of awareness from the government and other related institution to build better mechanism of mitigation and adaptation program. This can be solved by focusing development target to education program and infrastructure and socio-economic aspect of the community because natural hazards can promote disaster specifically through involvement of those aspects that worsen the vulnerable populations [39];[40];[41]. Adaptive capacity covers elements such as levels of social infrastructures, human resources and the effectiveness of governance structures [20]; [21]; [22]; [23]. The adaptive capacity index in this study was a composite of three human development indices (education, governance and economy). Respondent with higher level of formal education had the ability to adapt better to the hazardous situation than the respondent with lower education. They also had skill and knowledge that was given from the formal or informal sources such as training of mitigation from the governance or from the group in the community itself that was driven by the figure of the key person who they trusted had the proper knowledge and skill on how to cope with the hazardous situation when the unpredictable phenomenon of climate change ecological disaster attacked because however better perception and knowledge would lead to better mitigation program [33].

5. Conclusions

Based on the analysis of the the three elements of vulnerability index within its indicators in the questionnaire form, this study can be concluded that the coastal community in these 3 villages in
Lembeh Island which are Pasir Panjang, Kareko, and Pintu Kota were relatively less vulnerable to the impact of climate change and ecological disaster. This is due the coastal community in these vilages had various sources of income to support their livelihood in time of crisis. Regardless this reason, the community were still had less proper knowledge and skill related to strategies to cope with and adapt to disasters and climate change. Most of the people in these villages had awareness about the impact of disasters and climate change. However, besides their awareness they had less proper knowledge and skill about how to cope with and adapt to the hazardous situation. The behaviour shown was based on their common sense to survive in critical situation. Therefore, this result addressed the government and its related institution to invest and formulate the policy that could support better mitigation and adaptation strategies for the coastal community in Lembeh Island specifically, and in other villages in North Sulawesi in general. The caveat of this study for other research project with same focus and issues is to expand the scope of the survey area so that the result of the analysis could indicate the wider and deeper analysis scope of the vulnerability assessment towards natural disaster and climate change impact.

Acknowledgement
The authors would like to thank Indonesia Climate Change Trust Fund, for funding the research. We also would like to thank the authorities of Bitung City, such as the Marine and Fisheries Office and Development Planning Agency at Sub-National Level, Village authorities in Lembeh Island, and the local community of Lembeh Island. The authors also would like to thank S. D. Arwida and Y. Herdiana for their input in this research, and Sea Soldier Manado Chapter and all staff and surveyors from Yayasan TERANGI (Terumbu Karang Indonesia).

References
[1] White AT, Aliño PM, Cros a, Fatan NA, Green AL, Teoh ST, Laroya L, Peterson N, Tan S, Tighe S, VenegasLi R, Walton A and Wen W 2014 Marine Protected Areas in the Coral Triangle: Progress, Issues, and Options, Coastal Management, 42(2): 87-106, DOI: 10.1080/08920753.2014.878177
[2] Edwards, M, Beaugrand, G, Reid, PC, Rowden, AA and Jones, MB 2002 Ocean climate anomalies and the ecology of the North Sea Marine Ecology Progress Series 239 pp 1–10
[3] Allison E, A Perry, M Badjeck, W Adger, K Brown, D Conway, A Halls, G Pilling, J Reynolds, N Andrew and N Dulvy 2009 Vulnerability of National Economies to The Impacts of Climate Changes on Fisheries Fish and Fisheries 10 pp 173–196
[4] Dunstan, PK 2017 Marine Policy http://dx.doi.org/10.1016/j.marpol.2017.09.033
[5] Adger, WN, Arnell, NW and Tompkins, EL 2005a Successful adaptation to climate change across scales Global Environmental Change 15 pp 77–86
[6] Brooks, N, Adger, WN and Kelly, MP 2005 The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation Global Environmental Change 15 pp 151–163
[7] Smit, B and Wandeland, J 2006 Adaptation, adaptive capacity and vulnerability Global Environmental Change 16 pp 282–292
[8] Kambong A, R Senduk, LI Rares, J Manengkey, Mudjiono, H Gandaria, M Ompy, A Y Sengke, Weno, JJ, JJ Saruan, N Tangkilisani, A Sukmara, F Maramis, SA Tighe, J Patlis, S Berhimpon 2005 Naskah Akademik Pengelolaan Terpadu Kawasan Pesisir Selat Lembeh dan Sekitarinya, Kota Bitung, Provinsi Sulawesi Utara Pemerintah Kota Bitung dan Mitra Pesisir-USAID Manado pp 160
[9] Kovats, RS, Hajat, S, Bouma, MJ, Worrall, E and Haines, A 2003 El Nin˜o and health Lancet 362, 1481–1489
[10] Tompkins E, R Few and K Brown 2008 Scenario-based stakeholder engagement: Incorporating stakeholders preferences into coastal planning for climate change Journal of Environmental Management 88 pp 1580–1592
[11] Adger, WN 2000 Social and ecological resilience: Are they related? Progress in Human Geography 24, 347–364
[12] IPCC 2001a Climate Change 2001 Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge

[13] Turner, BL, Kasperson, RE, Matson, PA 2003 A framework for vulnerability analysis in sustainability science Proceedings Of the National Academy Of Sciences Of The United States Of America 100 pp 8074–8079

[14] Sullivan, CA and Meigh, J 2007 Integration of the biophysical and social sciences using an indicator approach: Addressing water problems at different scales Water Resources Management 21 pp 111–128

[15] Siry HY, P R Siregar, S H E Sadtopo, F Nurhabni, R M Ismail, K Anggraini, K Praseno, G Wilisandy, B C Purba, I S Murthiari, D Siregar, Irwan, S Prasojo, E Kurniawan, E Sukesti, PD Wahyuni and D R Sukarno 2014 Bimbingan Teknis Perencanaan Mitigasi Bencana dan Adaptasi Perubahan Iklim: Buku 1 Penilaian Tingkat Kerentanan Desa Direktorat Jenderal Kelautan, Pesisir dan Pulau-Pulau Kecil, Jakarta pp 84

[16] Giordano F 2014 Climate change vulnerability and risk: key concepts Istituto Superiore per la Protezione e la Ricerca Ambientale Roma 24 pages

[17] Rosegrant, MW and Cline, SA 2003 Global food security: challenges and policies Science 302 pp 1917–1919

[18] Lafferty, KD, Porter, JW and Ford, SE 2004 Are diseases increasing in the ocean? Annual Review of Ecology, Evolution, and Systematics 35 pp 31–54

[19] Haines, A, Kovats, RS, Campbell-Lendrum, D and Corvalan, C 2006 Harben Lecture - Climate change and human health: impacts, vulnerability, and mitigation Lancet 367 pp 2101–2109

[20] Haddad, BM 2005 Ranking the adaptive capacity of nations to climate change when socio-political goals are explicit Global Environmental Change Part A 15 pp 165–176

[21] Yohe, G, Malone, E and Brenkert, A, et al 2006 A Synthetic Assessment of the Global Distribution of Vulnerability to Climate Change From the IPCC Perspective That Reflects Exposure and Adaptive Capacity CIESIN (Center for International Earth Science Information Network), Columbia University, Palisades http://ciesin/columbia.edu/data/climate/ Access date July 8, 2008

[22] Tol, RSJ and Yohe, GW 2007 The weakest link hypothesis for adaptive capacity: An empirical test Global Environmental Change-Human and Policy Dimensions 17 pp 218–227

[23] Vincent, K 2007 Uncertainty in adaptive capacity and the importance of scale Global Environmental Change-Human and Policy Dimensions 17 pp12–24

[24] Brooks, N 2003 Vulnerability, risk and adaptation: A conceptual framework Tyndall Centre for Climate Change Research Working Paper, 38(38), pp 1-16

[25] Smit, B, Burton, I, Klein, RJ and Wandel, J 2000 An anatomy of adaptation to climate change and variability In Societal adaptation to climate variability and change (pp 223-251) Springer, Dordrecht

[26] Pielke Jr, RA 1998 Rethinking the role of adaptation in climate Global environmental change 8(2) pp p1597170

[27] Fankhauser, S, Smith, JB and Tol, RS 1999 Weathering climate change: some simple rules to guide adaptation decisions Ecological economics, 30(1), pp67-78

[28] Smit B, Burton I, Klein RJ, Wandel J 2000 An anatomy of adaptation to climate change and variability Climatic Change 45 pp 223-251

[29] Yusri S, E Retnowati, M P S Widodo, Idris, Fakhurrozi 2019 Combining participatory mapping, cloud computing and machine learning for mapping climate induced landslide susceptibility in Lembeh Island, North Sulawesi IOP Conf. Ser.: Earth and Environmental Science

[30] Rampengan, Mercy Maggy Franky 2015 Impacts of multiple hazards on small island communities: perspectives from North Sulawesi, Indonesia PhD thesis, James Cook University

[31] Gaillard, JC, Clavé, E, Vibert, O, Azhari, Dedi, Denain, J-C, Efendi, Y, Grancher, D, Lianzon, C, Sari, D and Setiawan, R 2008 'Ethnic groups' response to the 26 December 2004
earthquake and tsunami in Aceh, Indonesia', *Natural Hazards*, 47(1) pp 17-38

[32] Gaillard, JC and Le Masson, V 2007 'Traditional societies' response to volcanic hazards in the Philippines', Mountain Research and Development, vol 27, no 4, pp 313-7

[33] Phillips, M C K, Cinderich, A B, Burrel, J L, Ruper, J L, Will, R G, and Sheridan, S C 2015 The effect of climate change on natural disasters: a college student perspective *Weather, Climate, and Society*, 7(1), 60-68 Doi:101175/wcas-d-13-000381

[34] Gariano, S L, and Guzzetti, F 2016 Landslides in a changing climate *Earth-Science Reviews*, 162 pp 227-252

[35] Arnell, NW 2008 Climate change and drought Drought Management: Scientific and Technological Innovations, *Options Méditerranéennes: Série A Séminaires Méditerranéens*, (80), pp 13-19

[36] Mori, N, Yasuda, T, Mase, H, Tom, T, and Oku, Y 2010 Projection of extreme wave climate change under global warming *Hydrological Research Letters*, 4(0), 15-19

[37] Gerdan S 2014 Determination of disaster awareness, attitude levels and individual priorities at Kocaeli University *Eurasian Journal of Educational Research*, 55 pp 159-176 http://dxdoiorg/ 4689/ejer20145510

[38] Adger, W N 2005 Social-ecological resilience to coastal disasters *Science*, 309(5737) pp 1036-1039

[39] Cannon, T 1994 *Vulnerability analysis and the explanation of ‘natural’ disasters* *Disasters, Development and Environment*, A Varley, Eds, John Wiley and Sons pp 13–30

[40] Chapman, D 1994 Natural Hazards Oxford University Press, 174 pp

[41] Mileti, D 1999 *Disasters by Design: A Reassessment of Natural Hazards in the United States* Joseph Henry Press, 351 pp

[42] Antwi, A 2013 *Climate change and food security: An overview about the issue* Friedrich Ebert Foundation, pp 13

[43] Ahayalimudinet al 2012 *BMC Public Health*, 12 (Suppl 2) pp A3

[44] W Fogo 2017 *Understanding factors related to surviving a disaster: The survival attitude scale* Proquest Dissertations and Theses, 146