ANNEX F

ANNEX F: Past Research on Vulnerabilities and an Overview of Existing Literature on Climate Change Impacts in the Philippines

Our country is a leader in combating climate change. At the same time, our nation is one of those that has so far felt the harms of climate change most acutely and is at most risk. Despite increasing government investment in reducing climate change risks and managing disasters, the disastrous impacts of climate change are clearly beyond the capacity and resources of the people and our government to adapt to and address. The effects of climate change on workers, the poor, and other vulnerable people are exacerbating societal inequalities and threatening the full enjoyment of both human rights and the constitutional guarantees of health and a balanced and healthful ecology.

Situated in the so called "typhoon belt", the Philippines is exposed to multiple hydro-meteorological hazards, e.g. tropical cyclones, flooding, and even droughts. On average, the country is hit by 20 typhoons every year, just under half of which make landfall.[1] In particular, the eastern coast of the country is highly exposed to typhoons with wind speeds of 200 kilometers per hour. In many risk and vulnerability assessments the Philippines ranks among the most affected countries in terms of climate change impacts and extreme weather events.[2] Other studies further argue that the Philippines is one of the most disaster-prone countries in the world.[3] Researchers conducted a vulnerability mapping of 530 subnational areas in Southeast Asia. By overlaying maps for exposure to hazards, sensitivity, and adaptive capacity, they created a map of the vulnerability of Southeast Asia, with the Philippines exhibiting the highest levels of vulnerability (Figure 1).

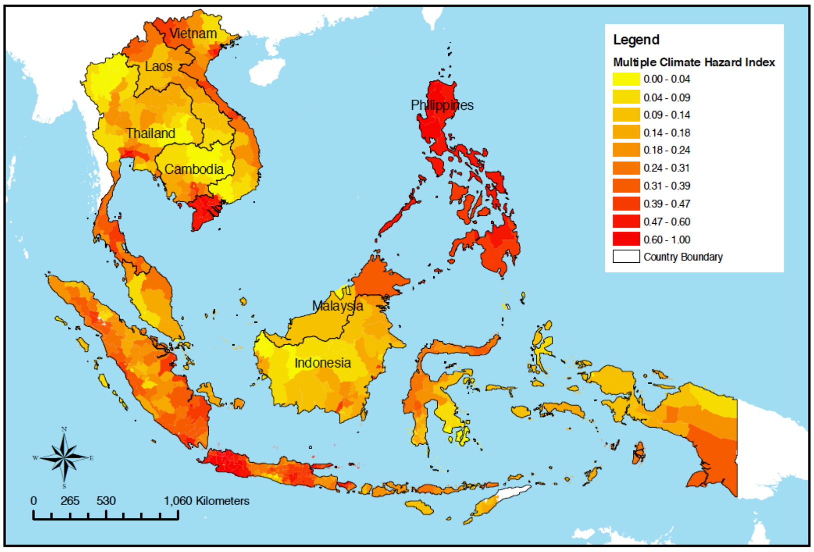
---

[1] Asian Development Bank, *The Economics of Climate Change in Southeast Asia: A Regional Review* (2009) at 28.

[2] N. Brooks & W.N. Adger, *Country Level Risk Measures of Climate-Related Natural Disasters and Implications for Adaptation to Climate Change*, 2003 TYNDALL CENTRE WORKING PAPERS. Available at http://www.tyndall.ac.uk/sites/default/files/wp26.pdf (last accessed June 17, 2015); J. Birkmann & D. Krause & N.J. Setiadi & W.T. Dora-Catalina & J. Wolfertz & R. Dickerhof & P. Mucke & K. Radtke, *World Risk Report 2011*, 2011 UNU-EHS REPORTS; S. Kreft & D. Eckstein & L. Junghans & C. Kerestan & U. Hagen, *Global Climate Risk Index 2015: Who Suffers Most fom Extreme Weather Events? Weather-related Loss Events in 2013 and 1994 to 2013*, 2014 GERMANWATCH.

[3] E. Porio, *Vulnerability, Adaptation, and Resilience to Floods and Climate Change-Related Risks among Marginal, Riverine Communities in Metro Manila*, 39(4) ASIAN JOURNAL OF SOCIAL SCIENCE 425 (2011); Y. GP Jr. & N.A. Cruz & N.t. Servando & C.B. Dimalanta, *Extreme Weather Events and Related Disasters in the Philippines, 2004-08: A Sign of What climate Change Will Mean?*, 35(2) DISASTERS 362 (2011).

Figure 1: Multiple Climate Hazard Map of Southeast Asia[4]



Experts have found that the country must spend a substantial portion of its annual budget to repair and rehabilitate devastated communities. The World Bank stated that the country spends 0.5% of its annual GDP responding to natural hazards.[5] Between 1998 and 2009, the Philippines was forced to deal with costs of up to US$24.3 billion (23.9% of GDP) resulting from storms that exposed 12.1 million people.[6]

Research has shown the resilience of the affected communities and individuals to be relatively high, due to their experience adapting to past disasters. However, hazards can exceed such coping capacities.[7] The 2013 super-typhoon Yolanda (Haiyan) illustrates the extent of the exposure and vulnerability of the country to these kinds of extreme events. Despite forecasts and warnings provided days in advance, the typhoon killed more than 6,000 people, affected millions of others, and devastated areas in central Leyte. Haiyan is stated to

---

[4] Yusuf, A. A., & Francisco, H. (2009). Climate Change Vulnerability Mapping for Southeast Asia. *East*, *181*(December), 1–19. doi:10.1158/1541-7786.MCR-07-0267, p.6.

[5] Ancheta, Christopher; Bojo, Jan; Dato, Victor; Heister, Johannes; Kariuki, Mukami; Morton, John; Trohanis, Zoe; Tuyor, Joe; Villaluz, Maya; Virtucio, Felizardo; Wedderburn, Sam; Zhang, Yabei. 2010. *A strategic approach to climate change in the Philippines*, at 1, Washington, DC: World Bank p. 6. Available at http://documents.worldbank.org/curated/en/2010/04/15198885/strategic-approach-climate-change-philippines [hereinafter World Bank].

[6] IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 688 pp., at 1638.

[7] G.P. Yumul Jr. & N.A. Cruz & C.B. Dimalanta & N.T. Servando & F.D. Hilario, *The 2007 Dry Spell in Luzon (Philippines): Its Cause, Impact and Corresponding Response Measures*, 100(3-4) CLIMATE CHANGE 663 (2010).

be the strongest cyclone that made landfall in the Philippines, including the storm surge it induced.[8]

According to the World Bank,[9] the EMDAT disaster database[10] shows that in the years 2000 to 2008 weather-related disasters accounted for 98% of all people affected and 78% of all people killed due to disasters in the Philippines. This is substantiated by the IPCC 4th assessment report, which states, with very high confidence that climate change currently contributes to the global burden of diseases and premature deaths. Further, the report determines with high confidence that an increased number of people are suffering from death, disease, and injury due to heat waves, floods, storms, and droughts.[11]

In 2005, the researchers from the klima Climate Change Center of the Manila Observatory, Ateneo de Manila University and Xavier University looked specifically at the climate change impacts on Philippine coastal communities.[12] Their findings are consistent with the observations of Petitioners from Alabat, Quezon, Verde Island Passage, and Batangas and include the following:

- Climate change-induced sea-level rise leads to tidal variation, increasted water depths, water movement alterations, and increased seawater intrusion into estuaries and rivers, which in turn affect the balance and harmony of the ecosystem.[13]

- Some low lying small islands of the Philippines will suffer from erosion and salt water intrusion, with a rise of 1.0m expected to inundate more than 5000 ha of land in 19 municipalities of Manila, Bulacan, and Cavite, and a 2.0m rise aggravating riverine flooding in the densely populated tributaries of Manila Bay (particularly the Pampanga and Pasig rivers).[14]

---

[8] World Meteorlogical Organization, Press Release No. 981: Provisional Statement on Status of Climate in 2013: Continuing High Temperatures Globally and Many Climate Extremes Worldwide (November 13, 2013), http://www.wmo.int/pages/mediacentre/press_releases/pr_981_EN.html (last accessed June 18, 2015).
[9] World Bank, supra note 5, at 5.
[10] D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.
[11] Confalonieri, U., B., Menne, R., Akhtar, K. L., Ebi, M., Hauengue, Kovats, R. S., … A.Woodward. (2007). Human Health. In *Climate Change 2007: Impacts, Adaptation and Vulnerability* (pp. 391–431); IPCC. (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, … L. L. White, Eds.) (p. 1132). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; IPCC. (2014b). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, … L. L. White, Eds.) (p. 696). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
[12] E. B. Capili, A. C. S. Ibay, & J.R.T Villarin, 2005. Climate Change Impacts and Adaptation on Philippine Coasts. Proceedings of the International Oceans 2005 Conference. 19-23 September 2005, Washington D.C., USA. Pp. 1-8. Available at http://info.worldbank.org/etools/docs/library/230308/Session%202/Session%202%20Reading%201.pdf
[13] *Id*. at 3.
[14] *Id*. at 2-5.

- Warmer waters will adversely affect certain species of plankton and fish, as well as sea grasses and corals, while possibly simultaneously enhancing the growth of some harmful algal species. The recurrence of toxic algal blooms in Manila Bay, especially the dominant alga, *Pyrodinium bahamense varcompressum*, has been attributed to the increased sea surface temperatures.[15]

- Temperature changes could also contribute to a redistribution of fish populations and disrupt migration patterns for pelagic fishes, which, combined with over-fishing and coral bleaching, may reinforce fishery collapse.[16]

- The disruption of salt and fresh water balance caused by warming may lead to a mismatch between the plankton blooms and juvenile fishes that depend on them for food, potentially leading in the long term to species shifts and impacts to commercial fisheries.[17]

- Warming alters the growth rates and physiological functions of sea grasses and changes their distribution and patterns of reproduction, affecting the many marine species that depend on them for food.[18]

- Other organisms like marine mammals, may also suffer from habitat destruction, fragmentation of population and disruption of their trophic dynamics.[19]

In another study, Peng, et al. (2004) found that higher night temperature due to climate change had already led to diminished rice yields, with irrigated field experiment data from 1992 to 2003, rice grain yield fell by 10% per degree centigrade increase in the minimum temperature during the dry season.

The preceding studies are now a decade old. As the IPCC AR5 does not add significantly to projections of change at a regional level, Greenpeace Southeast Asia commissioned its own study to give greater specificity and detail for the Philippines, insofar as that is possible. An independent researcher, Carsten Walther, authored an overview of existing literature (Table 1) on climate change impacts in the Philippines in his individual capacity as climate researcher for Greenpeace Southeast Asia. Mr. Walther is associated with the Potsdam Institute for Climate Impact Research (PIK).[20]

---

[15] *Id*. at 3.
[16] *Id*. at 4.
[17] *Id*. at 3.
[18] *Id*. at 3.
[19] *Id*. at 4.
[20] Walther. C. 2015. Literature review of studies related to climate change impacts in the Philippines. An internal document prepared for Greenpeace International and Greenpeace South East Asia. April, 2015.

Table 1: Vulnerability matrix – overview of relevant literature for the impact of climate change on the Philippines[21]

Climate Impact Vulnerable Sector	Climate Change in general	Weather extremes (WE)			Slow-onset changes: precipitation, temperature, SLR, salt water intrusion, SST
		WE general	Storms / Floods /Monsoon	Droughts / Heat / ENSO	
General, no specific sector	ADB (2009) Amadore et al. (2005) Balangue (2013) Brooks & Adger (2003) – 62 Cinco et al. (2013) Cruz et al. (2007) – 1531 DENR (1999) Garcia R.&Virtucio (2008) – 3 IPCC (2007) - 6646 IPCC (2013) - 13 IPCC (2014) – 42 Jabines & Inventor (2007) Murphy (2010) Villarin et al .(2008) – 5 UNU-EHS (2011) World Bank (2010) World Bank (2013a) World Bank (2013c) Yumul et al. (2011)	IFRC (2013) Jourdain et al. (2013) - 20 Meheux et al. (2006) – 42 Sillmann et al. (2013) - 100 Ueda & Hori (2006) – 1 Yumul et al. (2008) - 7 Yumul et al. (2011) - 22 Yusuf&Francisco (2009) - 145	Caron & Jones (2008) – 29 Chan (2006) Chan et al. (2009) Chang et al. (2005) – 103 Chang (2011) - 11 Cayanan et al. (2011) – 3 Elsner et al. (2008) – 461 Emanuel (2005) – 2309 Emanuel (2007) – 145 Emaanuel et al. (2008) – 410 Gaillard et al. (2007) – 46 Geng & Sugi (2003) - 142 Held & Zhao (2011) – 44 Huigen & Jens (2006) – 15 Hung & Yanai (2004) - 47 Murakami et al. (2011) – 62 Murakami et al. (2012) - 58 Loo et al. (2014) – 3 Mendelsohn et al. (2012) – 83 Park et al. (2014) - 2 Knutson et al. (2010) - 743 Kubota & Chan (2009) – 32 Sugi et al. (2009) - 67 Webster et al. (2005) – 2027 Zhao & Held (2012) - 33	Chang (2010) Endo et al. (2009) – 23 Hilario et al. (2009) - 2 Holden (2012) – 3 Jaranilla-S et al. (2011) - 22 Manton et al. (2001) Lyon et al. (2006) – 28 Lyon&Camargo (2009) – 32 Ropelewski&H. (1996) Sillmann et al. (2013) Taylor et al. (2012) – 6 Villafuerte II et al.(2014a) Villafuerte II et al.(2014b) Yumul et al. (2010) - 7	Akasaka (2010) - 4 Caesar et al. (2011) – 39 Chooprateep&McNeil (2015) Cinco et al. (2014) - 1 Cruz et al. (2012) – 6 Endo & Matsumoto (2010) Klein Tank et al. (2006) – 176 Manton et al.(2001) – 486 Perrette et al. (2014) - 21 Tangang et al. (2006) – 34 Yao et al. (2009) - 16 Villafuerte II et al. (2014)
Agriculture / Food / Water / Forestry	Amano et al. (2012) – 0 Buan et al. (1996) Bordey et al. (2013) Fuentes&Concepcion (2007) Garcia et al. (2013) – 3 Tolentino&Landicho (2013) - 0 UPLB (2011) Wassmann et al. (2009) - 125	Gibb&Veuthey (2011) - 0 Fuentes&Concep. (2007) - 2 Lansigan et al. (2000) - 48	Huigen and Jens (2006) - 15	Dawe et al. (2008) - 12 Warren (2013) - 0 PAGASA (2014)	Buan et al. (1996) – 61 Dasgupta et al. (2007) – 292 Jose et al. (1996) - 22 Jose & Cruz (1999) – 25 Lansigan et al. (2007) Peng et al. (2004) – 986 Peras et al. (2008) – 1 Rodolfo&Siringan (2012) - 64
Coastal Vulnerability (Ecosphere)	ADB (2014) Bayani-Arias et al.(2012) - 2 Boquiren et al. (2010) - 2 Brander et al. (2012) - 19 Burke et al. (2011) – 21 Capili et al. (2005) – 14 Carpenter et al. (2008) – 549 Combest-Fr. et al.(2012) – 14 Daw-as et al. (2010) – 0 De'ath et al. (2012) - 229 Ferguson&Gl. (2012) – 41 Giri et al. (2011) - 352 Gedan et al. (2011) - 132 Insigne & Kim (2010) – 0 Jacinto et al. (2010) – 0 Newton et al. (2007) – 181 Orencio & Fujii (2013) – 4 Perch-Nielsen (2010) – 36 Perez et al. (1999) – 22 Perez (2002) – 5 Praveena et al. (2012) – 1 Ranjan et al.(2009) – 21 Sale et al. (2014) – 4 Samonte-T. et al.(2007) - 36 Valiela et al. (2001) - 704 Walters (2003) - 63		Lapidez et al. (2014) Peduzzi et al., (2012) Villanoy et al. (2012) - 2 Zhang et al. (2004)		Arceo et al. (2001) – 44 Blankespoor et al. (2012) - 6 Gedan et al. (2010) Giri et al. (2011) McLeod et al. (2010a) – 27 McLeod et al. (2010b) – 20 Meissner et al. (2012) - 17 Orencio et al. (2013) Penaflor et al. (2009) - 36 Reyes&Blanco (2012) - 3 Sales (2008) Zhang et al. (2004) - 305
Society - Migration, Health, Gender ... (Anthropogenic sphere)	Acosta-Michlik (2005) - 21 Acosta-M.&Esp. (2008) - 61 ADB (2011) ADB (2012) Aquino et al.(2010) – 1 Brody et al. (2008) - 78 Dodman (2009) – 18 Khasnis&Nettleman (2005) - 192 Lasco & Boer (2006) Lee (2013) Lorenzo et al.(2011) Mias-Mamonong&F. (2010) Perch-Nielsen (2010) Peralta (2009) Satterthw. et al.(2007) - 344 Su (2008) – 31 Tatlonghari&Paris(2013) - 2 Tseng et al. (2008) – 19 Wilbanks & Fernandes (2012) WWF (2009)	Asuero et al. (2012) - 0 Hanson et al. (2011) Nicholls et al. (2008) - 289 Kreft et al. (2015) - 7	Balica et al. (2011) - 41 Bankoff (2003) - 76 Brecht et al. (2012) - 16 Dolhun (2013) - 0 IDMC (2013) Muto et al. (2010) - 6 Peduzzi et al. (2012) – 63) Porio (2011) - 10 Pulhin et al. (2006) - 6 Predo (2010) – 0 See et al. (2013 Uy et al. (2011) Yamada & Galat (2014) - 0 Zoleta-Nantes(2003) - 22	Tiangco et al. (2008)	Arnfield (2003) – 1032 Bravo et al. (2014) - 2 Dulay et al. (2013) - 1 Edillo & Madarieta (2012) - 2 Ferguson & Gleeson (2012) Hii et al. (2009) - 66 Khan et al. (2011) - 4 Oke (1982) – 1335 Picardal and Elnar (2012) - 1 Rudolfo and Siringan (2006)
Adaptation	ADPC (2013) Allen (2006) – 197 Butardo-T.&Tenef.(2011) CCC (2010) – 4 FAO (2013) Lasco et al. (2009) – 21 Lasco et al. (2011b) - 0 Lasco et al. (2012) - 6 NCCAP (2011) Perez et al. (2013) - 1 Smith Barry & O. (2001) - 907 Tanner (2010) - 13 Uy et al. (2011) - 13 Wassmann&D.(2007) - 25				Lasco et al. (2011a) - 12 Sales (2008) - 4 Sales (2009) - 19

His review is limited to peer-reviewed publications and yields the following major findings:

[21] Walther. C. 2015. Literature review of studies related to climate change impacts in the Philippines. An internal document prepared for Greenpeace International and Greenpeace South East Asia. April, 2015. p.27-28

- Temperature significantly increased in the past.[22] This warming trend will persist into the future, although with accelerating rates of increase. Increases in heat extremes have been confirmed for the past[23] and for the future.[24]

- Sea level rise (SLR) will be stronger in Southeast Asia than in the rest of the world.[25] This impact of climate change is related to the issue of land subsidence, which itself strongly depends on natural and anthropogenic factors. Groundwater extraction, which is anthropogenic, can further lead to saltwater intrusion into the freshwater storages.

- Observed changes in precipitation are hard to quantify due to the heterogeneous precipitation patterns in the country and the different methods used, data analyzed, time horizons employed, and indicators considered by the various publications. However, even contradictory statements given by various literatures[26] can be seen as relevant and correct under their specific assumptions. Projections of precipitation are also challenging, which is reflected in differences in the climate models. Total precipitation is expected to slightly increase. The IPCC stated that there is medium confidence of a moderate increase in rainfall in Southeast Asia. [27]

---

[22] F.T. Tangang & L. Juneng & S. Ahmad, *Trend and Interannual Variability of Temperature in Malaysia: 1961-2002*, 89(3-4) THEORETICAL AND APPLIED CLIMATOLOGY 127 (2007); Cruz, R. V., David, C. P., David, L., Espaldon, M. V., Lansigan, F., Lorenzo, F. M., … Uy, N. (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 469–506). Cambridge, UK; T.A. Cinco & R.G. de Guzman & F.D. Hilario & D.M. Wilson, *Long-term Trends and Extremes in Observed Daily Precipitation and Near Surface Air Temperature in the Philippines for the Period 1951-2010*, 145-146 ATMOSPHERIC RESEARCH 12 (2014); S. Chooprateep & N. McNeil, *Surface Air Temperature Changes from 1909 to 2008 in Southeast Asia Assessed by Factor Analysis*, 2015 THEORETICAL AND APPLIED CLIMATOLOGY.

[23] M.J. Manton & P.M. Della-Marta… & … D. Yee, *Trends in Extreme Daily Rainfall and Temperature in Southeast Asia and the South Paciic: 1961 – 1998*, 21 INT. J. CLIMATOL. 269 (2001).

[24] J. Sillmann & V.V. Kharin & F.W. Zwiers & X. Zhang & D. Bronaugh, *Climate Extreme Indices in the CMIP5 Multi-model Ensemble: Part 2: Future Climate Projections*, 2013 JOURNAL OF GEOPHYSICAL RESEARCH 1.

[25] M. Perette & F. Landerer & R. Riva & K. Frieler & M. Meinshausen, *A Scaling Approach to Project Regional Sea Level Rise and its Uncertainties*, 4 EARTH SYST. DYNAM. 11 (2013).

[26] Cruz, R. V., David, C. P., David, L., Espaldon, M. V., Lansigan, F., Lorenzo, F. M., … Uy, N. (2007). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 469–506). Cambridge, UK; Lyon, B., & Camargo, S. J. (2009). The seasonally-varying influence of ENSO on rainfall and tropical cyclone activity in the Philippines. *Climate Dynamics*, *32*(1), 125–141; Endo, N., Matsumoto, J., & Lwin, T. (2009). Trends in Precipitation Extremes over Southeast Asia. *SOLA*; Yao, C., Qian, W., Yang, S., & Lin, Z. (2009). Regional features of precipitation over Asia and summer extreme precipitation over Southeast Asia and their associations with atmospheric–oceanic conditions. *Meteorology and Atmospheric Physics*, *106*(1-2), 57–73. doi:10.1007/s00703-009-0052-5; Endo, N., & Matsumoto, J. (2010). Trends in Precipitation Extremes over Southeast Asia. In *Workshop on metrics and methodologies of estimation of extreme climate events*; Caesar, J., Alexander, L. V., Trewin, B., Tse-ring, K., Sorany, L., Vuniyayawa, V., … Sirabaha, S. (2011). Changes in temperature and precipitation extremes over the Indo-Pacific region from 1971 to 2005. *International Journal of Climatology*, *31*(6), 791–801; Cruz, F. T., Narisma, G. T., Villafuerte, M. Q., Cheng Chua, K. U., & Olaguera, L. M. (2012). A climatological analysis of the southwest monsoon rainfall in the Philippines. *Atmospheric Research*, *122*, 609–616; Villafuerte, M. Q., Matsumoto, J., Akasaka, I., Takahashi, H. G., Kubota, H., & Cinco, T. A. (2014). Long-term trends and variability of rainfall extremes in the Philippines. *Atmospheric Research*, *137*, 1–13.

[27] IPCC. (2014b). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, … L. L. White, Eds.) (p. 696). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

- Increasing trends of extreme precipitation were found for the past –in both intensity and frequency.[28] The importance of this type of precipitation for the whole water budget can be relatively high.

- Villafuerte et al. (2014) confirmed an extension of dry periods in the past.[29] Looking to the future, Taylor et al. (2012)[30] and Sillmann et al. (2013)[31] identify an increasing drought risk in Southeast Asia.

- With regard to major problems for the Philippines, such as tropical cyclones, the conclusions found in the literature are hard to generalize (similar to precipitation). Literature shows increasing intensity of storm events,[32] but no significant trends in their frequencies[33] in the past. Park et al. (2014) found different but insignificant trends for different data sets for the region.[34] The future changes in tropical cyclones are well summarized in Knutson et al. (2010).[35] The global average of intensity is increasing; simultaneously, models show a decreasing frequency for the future. A future rise in frequency is only expected for the most intense tropical cyclones[36]

---

[28] N. Endo & J. Matsumoto & T. Lwin, *Trends in Precipitation Extremes over Southeast Asia*, 5 SCIENTIIC ONLINE LETTERS ON THE ATMOSPHERE: SOLA 168 (2009).; C. Yao & Q. Weihong & S. Yang & Z. Lin, *Regional Features of Precipitation Over Asia and Summer Extreme Precipitation Over Southeast Asia and Their Associations with Atmospheric-Oceanic Conditions*, 106(1-2) METEOROLOGY AND ATMOSPHERIC PHYSICS 57 (2009); C.H. Chang, *Preparedness and Storm Hazards in a Global Warming World: Lessons from Southeast Asia*, 56(3) NATURAL HAZARDS 667 (2010); .A. Cinco & R.G. de Guzman & F.D. Hilario & D.M. Wilson, *Long-term Trends and Extremes in Observed Daily Precipitation and Near Surface Air Temperature in the Philippines for the Period 1951-2010*, 145-146 ATMOSPHERIC RESEARCH 12 (2014);. M.Q. Villafuerte & J. Matsumoto, *The Seasonal Role of ENSO and Monsoon on the Interannual Variations of Rainfall Extremes in the Philippines*, 49 GEOGRAPHICAL REPORTS OF TOKYO METROPOLITAN UNIVERSITY 23 (2014).

[29] M.Q. Villafuerte II & J. Matsumoto & I. Akasaka & H.G. Takahashi & H. Kubota & T.A. Cinco, *Long-term Trends and Variability of Rainfall Extremes in the Philippines*, 137 ATMOSPHERIC RESEARCH 1 (2014).

[30] I.H. Taylor & E. Bruke & L. McColl & P. Falloon & G.R. Harris & D. McNeall, 9(11) HYDROLOGY AND EARTH SYSTEM SCIENCES DISCUSSIONS 12613 (2012).

[31] J. Sillmann & V.V. Kharin & F.W. Zwiers & X. Zhang & D. Bronaugh, *Climate Extreme Indices in the CMIP5 Multi-model Ensemble: Part 2: Future Climate Projections*, 2013 JOURNAL OF GEOPHYSICAL RESEARCH 1.

[32] J.B. Elsner & J.P. Kossin & T.H. Jagger, *The Increasing Intensity of the Strongest Tropical Cyclones*, 455(7209) NATURE 92 (2008); P.J. Webster & G.J. Holland & J.A. Curry & H.-R. Chang, *Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment*, 309 (5742) SCIENCE 1844 (2005); T.R. Knutson & J.L. McBride…&…M. Sugi, *Tropical Cyclones and Climate Change*, 3 NATURE GEOSCIENCE 157 (2010).

[33] J.C.L. Chan & M. Xu, *Inter-annual and Inter-decadal Variations of Landfalling Tropical Cyclones in East Asia. Parti 1: Time Series Analysis*, 29(9) INTERNATINOAL JOURNAL OF CLIMATOLOGY 1285 (2009); H. Kubota & J.C.L. Chan, *Interdecadal Variability of Tropical Cyclone Landfall in the Philippines from 1902 to 2005*, 36(12) GEOPHYSICAL RESEARCH LETTERS (2009).

[34] D.-S.R. Park & C.-H. Ho & J.-H. Kim, *Growing Threat of Intense Tropical Cyclones to East Asia Over the Period 1977-2010*, 9(1) ENVIRON. RES. LETT. (2014). Available at http://stacks.iop.org/1748-9326/9/i=1/a=014008?key=crossref.1768076a048565351c334b902ac24053 (last accessed June 19, 2015).

[35] T.R. Knutson & J.L. McBride…&…M. Sugi, *Tropical Cyclones and Climate Change*, 3 NATURE GEOSCIENCE 157 (2010).

[36] M. Sugi & H. Murakami & J. Yoshimura, *A Reudction in Global Tropical Cyclone Frequency Due to Global Warming*, 5 SOLA 164 (2009); T.R. Knutson & J.L. McBride…&…M. Sugi, *Tropical Cyclones and Climate Change*, 3 NATURE GEOSCIENCE 157 (2010); I.M. Held & M. Zhao, *The Response of Tropical Cyclone Statistics to an Increase in C02 with Fixed Sea Surface Temperatures*, 24(20) JOURNAL OF CLIMATE 5353 (2011); H. Murakami & Y. Wang … & … &A. Kitoh, *Future Changes in Tropical Cyclone Activity Projectd by the New High-Resolution MRI-AGCM*, 25(9) JOURNAL OF CLIMATE CHANGE 3237 (2012).

Constrained by the dependency of the regional characteristics to sea surface temperature (SST) distributions in the future, this is also assumed for the region of SEA.[37] Model results also suggest an increase in storm-centered rainfall.[38]

- The importance of the El Niño Southern Oscillation (ENSO) phenomenon for the variability of tropical cyclones (TCs)[39] and precipitation[40] is large. But according to the IPCC, the confidence in projected changes for the future remains low.

- All the mentioned impacts of climate change represent a large burden for society and the natural diversity in the country. Many people depend on agriculture or aquaculture sectors that are strongly susceptible to climatic conditions. For agriculture, the literature lists many issues: droughts, saltwater intrusion, SLR, TCs, temperature (in particular nighttime temperature) increase, precipitation patterns, diseases, insects, and land degradation. SLR and saltwater intrusion only play a minor role, as most agriculture in the country does not take place in coastal areas.[41] It is not possible to judge which of the other stressors is most important. This depends on the region and the local conditions, e.g. type and variety of crops, distance to flood prone areas, etc. Droughts have already resulted in widespread impact on food supplies in the country. According to the literature they could be more frequent in the future[42] and their impact will be amplified by population growth. As these factors add pressure to agricultural yields that are already stressed, adequate adaptation measures should be taken. Unlike historical cases, famines today can be buffered with the national or global market, but

---

[37] M. Sugi & H. Murakami & J. Yoshimura, *A Reudction in Global Tropical Cyclone Frequency Due to Global Warming*, 5 SOLA 164 (2009).

[38] K. Emmanuel & R. Sundaranjan & J. Williams, *Hurricanes and global Warming: Results from Downscaling IPCC AR4 Simulations*, 89(3) BULL. AMER. METEOR. SOC. 347 (2008); T.R. Knutson & J.L. McBride…&…M. Sugi, *Tropical Cyclones and Climate Change*, 3 NATURE GEOSCIENCE 157 (2010).

[39] K. Emmanuel, *Environmental Factors Affecting Tropical Cyclone Power Dissipation*, 20(22) JOURNAL OF CLIMATE 5497, 5497; H. Kubota & J.C.L. Chan, *Interdecadal Variability of Tropical Cyclone Landfall in the Philippines from 1902 to 2005*, 36(12) GEOPHYSICAL RESEARCH LETTERS (2009).

[40] A.M. Jose & N.A. Cruz, *Climate Change Impacts and Responses in the Philippines: Water Resources*, 12(77-84) CLIMATE RESEARCH 77, 81 (1999); B. Lyon, H. Cristi, E.R. Verceles, F.D. Hilario, R. Abastillas, *Seasonal Reversal of the ENSO Rainfall Signal in the Philippines*, 33(24) GEOPHYSICAL RESEARCH LETTERS (2006); G.P. Yumul Jr. & N.T. Servando & C.B. Dimalanta & N.A. Cruz, *The Meteorologically Abnormal Year of 2006 and Natural Disasters in the Philippines*, 31(4) EPISODES 378 (2008); F. Hilario & R. de Guzman & D. Ortega & P. Hayman & B. Alexander, *El Niño Southern Oscillation in the Philippines: Impacts, Forecasts, and Risk Management*, XXXVI(66) PHILIPPINE JOURNAL OF DEVELOPMENT 10 (2009); P.A. Jaranilla-Sanchez & L. Wang & T. Koike, *Modeling the Hydrologic Responses of the Pampanga River Basin, Philippines: A quantitative Approach for Identifying Droughts*, 47(3) WATER RESOURCES JOURNAL (2011).

[41] Crepin, Christophe. 2013. *Getting a grip on climate change in the Philippines : executive report*. Public Expenditure Review (PER). Washington DC ; World Bank. http://documents.worldbank.org/curated/en/2013/06/17917169/getting-grip-climate-change-philippines-executive-report (last accessed June 19, 2015).

[42] I.H. Taylor & E. Burke & L. McColl & P.D. Falloon & G.R. Harris & D. McNeall, *Contributions to Uncertainty in Projections of Future Drought Under Climate Change Scenarios*, 9(11) HYDROLOGY AND EARTH SYSTEMS SCIENCES DISCUSSIONS 12613 (2012); J. Sillmann & V.V. Kharin & F.W. Zwiers & X. Zhang & D. Bronaugh, *Climate Extreme Indices in the CMIP5 Multi-model Ensemble: Part 2: Future Climate Projections*, 2013 JOURNAL OF GEOPHYSICAL RESEARCH 1. Available at http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50188/abstract (last accessed June 19, 2015); M.Q. Villafuerte II & J. Matsumoto & I. Akasaka & H.G. Takahashi & H. Kubota & T.A. Cinco, *Long-term Trends and Variability of Rainfall Extremes in the Philippines*, 137 ATMOSPHERIC RESEARCH 1 (2014).

only if infrastructures and logistics are available. Another interesting argument in the literature is that people have already demonstrated their ability to deal with a certain amount of climate variability, but in combination with more stressors this ability could be overextended.[43] Some further argue for using this indigenous knowledge for future adaptation strategies.

- The impacts related to the ocean (e.g. sea level rise, typhoons, floods, ocean acidification etc.) are of particular interest to the Philippines, as it is the country with the longest coastline in the world. The past and future developments in these issues have been addressed, but their influence on certain sectors will depend on more than just the pure exposure to the impacts. Most literature is pointing out that the impacts of climate change often are strongly interrelated with human activities and lead to a worsening of the particular problematic (e.g. human induced subsidence by groundwater extraction).[44] The example of the coral reefs is illuminating. De'ath et al. (2012) show that the corals are obviously able to cope with certain pressure of climatic changes, but only if additional pressure by human activities is omitted. [45]

- Independent of the future changes in cyclone activity, we must assume growth in the amount of damages as more and more people, assets, and economic power are situated in exposed areas. Only adequate infrastructure and adaptation measures can lower their vulnerability.[46] In particular, the fast growing urban settlements must tackle these problems. Climate related issues (e.g. UHI, SLR, floods…) can only be solved by meeting the challenges of the non-climatic stressors (e.g. high urbanization rate, migration, informal settlements, lack of important basic living standards…). Nonetheless, adaptation activities in some areas could relieve the burden of climate change. For instance, providing access to clean water and adequate sanitation (both under risk by storm activity and saltwater intrusion) strengthens people's coping capacity, especially with regard to infectious diseases. The literature has looked into relations between occurrence rate of infectious diseases and climatic conditions. Some

---

[43] R.U. Fuentes & R. Concepcion, *Implementation of Initiatives for Addressing Climate Change and Land Degradation: A Look at the Philippine Context* in M.V.K. Sivakumar % N. Ndiang'ui (Eds.), Climate and Land Degradation (2007) at 447; IPCC. (2014a). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, … L. L. White, Eds.) (p. 1132). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; IPCC. (2014b). *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, … L. L. White, Eds.) (p. 696). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

[44] K.S. Rodolfo & F.P. Siringan, *Global Sea-Level Rise is Recognised, but Flooding from Anthropogenic Land Subsidence is Ignored around Northern Manila Bay, Philippines*, 30(1) DISASTERS 118 (2006).

[45] G. De'ath & F.E. Katharina & H. Sweatman & M. Puotinen, *The 27-year Decline of Coral Cover on the Greater Barrier Reef and its Causes*, 109(4) PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA 17995 (2012).

[46] D. Dodman, *Urban Density and Climate Change*, 1 ANALYTICAL REVIEW OF THE INTERACTION BETWEEN URBAN GROWTH TRENDS AND ENVIRONMENT AL CHANGES 1 (2009).

studies found a relation to temperature and/or precipitation for dengue[47] but other results seemed to be neither consistent nor significant. This can be traced back to a large importance of non-climatic reasons for the spread of the illness[48] but also to the varying conditions in the country, in particular for the precipitation which is often discussed as a factor.

- Noting limited knowledge regarding the spatial distribution of vulnerability to climate change, most vulnerable areas found are drought prone areas housing populations strongly dependent on agricultural yields as food and income source. For regions further situated near the coast, additional risks contribute to an even higher vulnerability. All the coastal areas where coral reefs and mangroves are still present should be regarded as vulnerable. The same is true for the corresponding communities nearby. The possible disappearance of an ecotype seems to be of particular importance as the reversal is almost impossible. Much detailed knowledge regarding the spatial distribution can potentially be found in the listed case studies of Table 2 (next page).

---

[47] G.L.S. Su, *Correlation of Climatic Factors and Dengue Incidence in Metro Manila, Philippines*, 37(4) AMBIO 292; W.-C. Tseng & C.-C. Chen & C.-C. Chang & Y.-H. Chu, *Estimating the Economic Impacts of Climate Change on Infectious Diseases: a Case Study on Dengue Fever in Taiwan*, 92(1-2) CLIMATE CHANGE 123 (2009); Y.L. Hii & J. Rocklöv & N. Ng & C.S. Tang & F.Y. Pang & R. Sauerborn, *Climate Variability and Increase in Intensity and Magnitude of Dengue Incidence in Singapore*, 2(1) GLOB HEALTH ACTION (2009).

[48] A.A. Khasnis & M.D. Nettleman, *Global Warming and Infectious Disease*, 36(6) ARCHIVES OF MEDICAL RESEARCH 689 (2005).

Table 2: Overview of case studies related to climate change impacts or adaptation in the Philippines[49]

Author	Aim	Social group / sector	Where
Acosta et al. (2014)	Loss and Damage of floods and landslides	Communities	Philippines
Acosta-Michlik (2005)	Intervulnerability Assessment	Various study areas	Philippines
Acosta-Michlik et al. (2008)	Vulnerability assessment	Farming communities	Philippines
Amano et al. (2012)	DRR and CCA	Rainfed and agro-ecological zones	Buhi, Camarines Sur; Guinobatan, Albay; Gubat, Sorsogon
Asuero et al. (2012)	Social Characteristics	Disaster-prone communities	Infanta, Quezon
Balangue (2013)	Vulnerability Assessment	Different	Various regions
Bayani-Arias et al. (2012)	Economic vulnerability and adaptation options	Coastal erosion	San Fernando, La Union
Boquiren et al. (2010)	Vulnerability Assessment	Coastal Areas	Verde Island Passage
Butardo-Toribio (2011)	Assess Socio-economic Factors Influencing Community Adaptive Capacity	Communities	Bayawan City
Coral Cay Conservation (2013)	Assessing status of reefs under threat of Seastars	Coral Reefs	Napantao, San Francisco, Southern Leyte
FAO (2013)	Adapt to disasters in general	Agriculture	Bicol Region
Huigen and Jens (2006)	Socioeconomic Impact of Typhoon Harurot	Agriculture	San Mariano, Isabela
Lasco et al. (2010)	Assessing impacts, vulnerability and adaptation	Mostly agriculture and forestry	Pantabangan-Carranglan Watershed
Lasco et al. (2012)	Assessing Role of Governments for CCA	Climate hazards	PROVINCE OF ALBAY
Lee (2013)	COMMUNITY-BASED ADAPTATION	Urban Poor	Metro Manila
Mias-Mamonong& Flores (2010)	Vulnerability and resilience to climate change	General	Sorsogon City
Orencio and Fujii (2013)	Apply coastal community vulnerability index (CCVI)	Climate hazards	Municipality of Baler, Aurora
Palacio & Palacio (2014)	Perceptions of climate change potential for public health effects	Local health department	Albay
Perez et al. (2013)	Economic analysis of adaptation	Coastal areas	Honda Bay, Palawan and Batangas
Pulhin (2006)	Assess Vulnerability to climate variability and extremes	communities	Pantabangan–Carranglan Watershed
Predo (2010)	Adaptation to disasters (flooding and storm surge)	Communities and Households	Ormoc and Cabalian Bay
Reyes and Blanco (2012)	Assess coastal vulnerability to SLR	SLR	BOLINAO, PANGASINAN
Rodolfo and Siringan (2006)	Anthropogenic subsidence	Coastal area	Northern Manila Bay
Sales (2009); Sales (2008)	Adapt to climate variability and sea-level rise	CBA in coastal management	Cavite City
Samonte-Tan et al. (2007)	Economic Valuation	Coastal and Marine Resources	Bohol Marine Triangle
See et al. (2013)	Social Vulnerability of Urban Poor Households	Flooding	Metro Manila
Tatlonhari & Paris (2013)	Analyzing gendered adaptation strategies	Flooding events	Nueva, Ecija
Uy et al. (2011)	Micro-level enabling conditions for CCA	Coastal villages	Bacacay in the province of Albay
Zoleta-Nantes (2002)	DIFFERENTIAL IMPACTS	Different social groups	METRO MANILA

[49] Walther. C. 2015. Literature review of studies related to climate change impacts in the Philippines. An internal document prepared for Greenpeace International and Greenpeace South East Asia. April, 2015. p.29.