Chapter 2
Review of Socio-Economic Development Pathway Scenarios for Climate Change Adaptation in Indonesia: Disaster Risk Reduction Perspective

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Abstract The work of Intergovernmental Panel on Climate Change (IPCC) on a Special Report on Emission Scenarios has pioneered the methods for greenhouse gas emission scenario associated with socio-economic development pathways in the coming century, followed by other models such as the Shared Socio-economic Pathways (SSPs) in climate change and disaster risk. This scenario is useful to understand how human society develops the future assessment of climate change and to provide possible mitigation and response strategies. This chapter is aimed to review the current status of socio-economic scenario on climate change and disaster and risk reduction effort in scholarly literatures and to identify gaps and opportunities for future research and decision-making based on the reflection of existing Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) theories and emblematic case studies. We have conducted a semi-structured literature review and content analysis. The result of our analysis revealed that there is still a dearth of study on the application of different models of socio-economic forecasting scenarios to understand how would each pathway affect the vulnerability of certain type of disaster and its potential as a decision-making tool in Indonesia. However, there are opportunities to expand the methods and define socio-economic variables that go beyond the economic indicators (i.e. GDP), such as of welfare, health, education, social

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capital human development, participation and technology. Challenges are also identified, including the limitation of methodology, availability of data, lack of synergy between CCA and DRR, lack of interdisciplinarity, space for science–policy interface and political support. Future research on SSPs should pay attention to the aspect of multi-hazard approaches to climate change impact, emerging technology and its adverse impacts. We argued that projection is a highly important tool; however, largely reliable at the global scale rather than regional or national scale. To understand that climate variability and change is high, it is important to raise self-awareness on adaptation to future disasters.

Keywords Disaster risk reduction · Climate change impact · Socio-economic scenario · Indonesia

Introduction

Real-Life Problem and Existing Global Policies

Climate change is responsible for the increasing number and intensity of disaster, especially of hydro-meteorological causes (CRED and UNISDR 2016). There are growing evidence that certain typology of disasters such as floods, storms, fires and droughts are increasing due to climate variability and change. The latest WMO report on the State of Global Climate stated that in 2018, nearly 63 million people were affected by extreme weather associated with climate change leaving 2 million people displaced (WMO 2018). This shows that climate variability and change affect both fast- and slow-onset disaster and are responsible for the loss of lives, livelihoods, culture and heritage.

One of the latest deadly disaster events is the Cyclone Idai that ripped into Southern Africa in March 2019. With totalities of more than 1000 human loss and more than 1$ billion US economic loss, the Cyclone Idai event has laid an evidence of how climate change affects the intensity of tropical storms. It demonstrates the vulnerability and exposure of low-lying cities and also the disruption of normal weather patterns due to climate change impact (UNDRR 2019).

In terms of climate change mitigation, the issue of clean energy and emerging innovation are the core focus of the effort to decarbonize development. There is an issue of tradeoffs between mitigation and adaptation, and between reducing disaster risk in the short term and adapting to a long-term climate change impact. For example, in terms of land use prioritization and policy for conserving resources and ecosystem, improving health, well-being of communities, while at the same time also promote the use of clean energy and promoting innovation. These are hard choices to be made and would require thinking to anticipate the impact of anthropological activities and disruptive technology, which could increase the risk of adverse climate change impact and disaster.

In the global policy arena, the year of 2015 marked a very important year for disaster risk reduction, climate change actions and sustainable development. The Sendai Framework for Disaster Risk Reduction adopted in March 2015 (UNISDR 2015) and Paris Agreement in December 2015 (UNFCCC 2015) and the SDGs were agreed by 193 countries (UNGA 2015). The interlinkages among these three frameworks are crucial to ensure orchestrated efforts to achieve sustainable development.

The Sendai Framework for Disaster Risk Reduction focuses on 4 priorities for actions, namely understanding of risk, governance, investment and the building back better for resilience. The latest UNFCCC Conference of the Parties 24 (COP24) in Katowice, Poland, has produced a rulebook which clearly mentioned that parties should advance their effort and consider future climate risk in implementing their plans and strategies to reduce disaster risk:

> 10(b) To take into consideration future climate risks when developing and implementing their relevant national plans and strategies that seek to avert, minimize and address loss and damage and reduce disaster risks, as appropriate. (UNFCCC, 2018a, Draft decision -/CP.24 para 10.b)

The Katowice rulebook is also further calling out for more transparency of countries in terms of reporting mechanism and accountability of their climate actions.

The SDG 13 focuses on taking urgent action to combat climate change and its impacts. This particular SDG will be reviewed in the High-Level Political Forum 2019 on climate change at later this year. More efforts to ensure synergy is anticipated.

These global policy processes have strongly encouraged countries to prepare, adapt and mitigate the unknowable adverse impact of climate change in the future, which could lead to increasing number and intensity of disasters, jeopardizing the efforts to achieve the sustainable development goals. It is, therefore, crucial for science to contribute to understanding disaster risk and to unpack the connection between climate change adaptation and disaster risk reduction. This includes the understanding of socio-economic factors and variables affecting the future pathways in climate change adaptation and mitigation efforts.

Theoretical Reflections

We selected four main theories or concepts relevant to the disaster risk reduction and climate change research, including the resilience and vulnerability theories, theory of societal change and transformation and adaptive governance.

The resilience and vulnerability theories are most often referred in disaster risk reduction and climate change research. The resilience concept has been around for about 5 decades since Holling's groundbreaking paper (1973). The definitions of resilience, however, is not easy to grasp and often times are confusing (see Walker et al. 2004). The general definition of resilience has been laid out by many scholars, indicating the capacity of a system to retain to original function within critical

threshold after experiencing shocks or changes (see Walker et al. 2004; Folke et al. 2010; Folke 2006; Olsson et al. 2006; Voss 2008).

According to Folke et al. (2010), the component of adaptability and transformability are considered as crucial to build resilience. While adaptability ensures stability throughout development trajectory when experiencing changing external drivers such as climate change impacts and disaster risk, transformability ensures crossing threshold to a new, better development trajectory (Folke et al. 2010). While transformation is crucial, the preparation for changes is at most important to guide transformability. Walker et al. (2004) has also argued that transformability as the last, crucial phase of resilience, where a stability of a new system is created. Olsson et al. (2006) argued that the component of building knowledge, networking and leaderships are the key factors for preparing changes in the socio-ecological systems. Using the case study of Everglades, a new novel system configuration and windows of opportunity are found through building knowledge and network, where actors manage to suspend extant beliefs, question perceptions and contrast possible futures (Olsson et al. 2006: 18).

The vulnerability theory on the other hand focuses on both environmental and social condition. It emphasizes the complex mixture and dynamics of variables which affects the vulnerability of such systems. Environmental system consists of physical and biophysical factors such as land, climate, ecosystem and its functions. The factor of social condition includes diverse aspects such as capital distribution, institution, economic and political system, as well as technology and the impact of emerging technology to society (see Voss 2008: 49). Voss (2008) also argued that vulnerability could not be only seen from the perspective of physical aspect, and that of social aspect is often overlooked. Using the case study of Indonesia, they highlighted an example of the importance of social aspect in defining the level of vulnerability. The research discovered that the existing customary rule such as "adat" could shape society and affect the level of vulnerability of certain community groups. It constructs the way people understand reality and the value of their lives in the local environment, including on how they perceive certain event as a disaster as a threat or not.

In the context of environmental and climate change policy, the theory of societal change ABC (Attitude-Behaviour—and choice) is believed to be a suitable entry point for social scientists to contribute to the discourse (see Shove 2010: 1273). The ABC theory argued that the responsibility for responding to climate change lies on individuals whose behavioural choices will make the difference (Shove 2010: 1283; Wilson and Chatterton 2011).

Park et al. (2012), extends the transformative concept into decision-making tools by designing adaptation action cycles. The cycle consists of four phases including (1) problem structuring and establishing the adaptation arena; (2) developing the adaptation agenda, vision and pathway; (3) implementing adaptation actions; and (4) evaluation, monitoring and learning. These phases are tested through a case study of the wine industry in Australia and their incremental adaptation and transformative adaptation. The incremental adaptation actions are defined as short term by nature, meanwhile the research revealed that transformative adaptation helped to ensure long-term changes and enable learning. The research also concluded that the

contemporary challenges in transformative adaptation are the lack of understanding of socio-economic environmental conditions in the present time and the future.

Lastly, the concept of adaptive capacity and adaptive governance further highlights the need of new thinking in good governance when it comes to finding the best mechanism on how to respond to global environmental change, including climate change and disaster risk (see Smit and Wandel 2006; Pahl-Wostl 2007; Tompkins and Adger 2004; Adger et al. 2005a, b; Djalante et al. 2011). Adaptive governance emphasized factors such as co-learning (Pahl-Wostl 2007; Djalante et al. 2011), co-management, participation, and collective action (Tompkins and Adger 2004; Djalante et al. 2011), polycentric and multilayered institutions, and self-organization and network (Djalante et al. 2011). Tompkins and Adger (2004) further argued that the social elements are strongly influencing the present and future vulnerabilities as both are a function of adaptive capacity, which is in turn dependent on social capital, institutions, and resources distributions. In addition, an adaptive governance also emphasizes the improvement of the capacity of institutions to better coordinate relief operations, public awareness and risk reduction policy in case of disasters, by encouraging learning from experience (Bakkour et al. 2015).

The review on existing theories revealed that resilience bounds mitigation and adaptation in regards to climate change and disaster risk reduction. There is an increasing focus on societal change and transformation to ensure resilience. And at the same time also serves as perquisite variables to increase adaptive capacity and adaptive governance for climate change adaptation and disaster risk reduction. We discovered that learning and building knowledge is a catalytic element to enable resilience and transformation for successful adaptation and mitigation of climate change impact and disaster risk in the future. The knowledge of socio-economics and environmental conditions is identified as detrimental to the process of adaptive transformation and resilience.

The Objective

Against these backgrounds (i.e. real-life problem, global policy status and theoretical reflections), there are four objectives of this paper. *First*, to highlight the current status of socio-economic scenario on climate change, both in existing theory and empirical case studies, and the impact to different disasters and risk reduction effort in scholarly literatures. *Second* to assess the challenges and opportunity for upscaling existing shared climate and socio-economic projection models for policy design and implementation. *Third* is to identify gaps and opportunities of the socio-economic scenarios for better policy-making at the national level. And finally, *fourth*, to reflect on the broader implication towards CCA theories and future research needs.

Structure of This Chapter

This chapter has introduced the real-life problem, existing global policies related to climate change and disaster risk reduction, theoretical reflections and objectives. Section "Methods" describes the methods used in this chapter. Section "Literature Review" presents the results from the literature review on SSPs and socio-economic impacts and future pathways and scenario of CC and DRR. Section "Results: Indonesian Case Studies" elaborates the context of Indonesia based on the review of existing literature and policy documents. Section "Discussion" discusses the opportunities and challenges on using SSPs and other models of socio-economic scenarios to help as decision-making tools in DRR. Section "Conclusion" finally provides a general conclusion of this chapter.

Methods

We have selected a semi-structure method for the literature review. Scopus scientific databases are used to list the past research on this topic with two sets of keywords. In addition, the Google scholars are used to allow authors to find prominent literatures and sources which are not listed in International journals or databases.

There are five sets of keywords used to generate an inventory of resources. Four sets are operated in Scopus database:

(1) For worldwide-general case, keywords selected are (TITLE-ABS-KEY ((climate PRE/0 change AND disaster AND projection OR scenario)) AND (socioeconomic OR socio-economic), depicts the general scholarly literatures in climate change and disaster with 136 results;
(2) For Worldwide-Shared Socioeconomic Pathways (SSPs), keywords selected are TITLE-ABS-KEY ((climate PRE/0 change AND disaster AND projection OR scenario)) AND (socioeconomic OR socio-economic) AND SSPs;
(3) For Indonesia-general case, keywords selected are TITLE-ABS-KEY ((climate PRE/0 change AND disaster AND projection OR scenario))) AND ((socioeconomic OR socio-economic)) AND (Indonesia), resulted into 16 scholarly literatures specifically on Indonesian case studies;
(4) For Indonesia-SSPs, keywords selected are TITLE-ABS-KEY ((climate PRE/0 change AND disaster AND projection OR scenario))) AND ((socioeconomic OR socio-economic)) AND (Indonesia) AND SSPs.

In addition, one set of keywords is operated with Google search (SRES scenario, disaster, Indonesia) which are later filtered and selected based on relevancy to the topic and intended purpose of this research.

In addition to the literature review, we also conducted analysis on policy documents. We have selected the policy documents relevant to climate change policy especially at the national level in the form of regulations, laws, and policy paper. For

Indonesia, four documents are analyzed including (1) Country National Communication document submitted to the UNFCCC (1st, 2nd and 3rd); (2) Nationally Determined Contribution (NDC) Country Report of Indonesia (Republic of Indonesia 2016); and (3) Other relevant documents (e.g. disaster, land use and forest management policy).

Literature Review

Introduction to SSPs

The Special Report on Emission Scenario (Nakicenovic et al. 2000) provides four storylines of development with regard to the way world population, economies and political structure may evolve over the next few decades (see also Adger et al. 2005a, b). There are four storylines included in the SRES, including A1, A2, BI and B2. Each is characterized by different conditions in regards to economic growth, population, the use of technology and scale focus in development. There is also a distinction in regards to the technological emphasis on the use of energy sources such as fossil, non-fossil and a more balanced source (For detail storylines, see Nakicenovic et al. 2000; pp. 4–5).

The pathways have been evolved since first published in 2000. The Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) are established as an expansion of the earlier pathways (see Fig. 2.1). The pathways include differentiations and consideration of the factors of socio-economic challenges for mitigation as well as adaptation. SSPs served as an methodological approach for reference, elaborated by narratives and quantitative model and pathways, and when combined quantitatively with Climate RCPs model, it became a scenario (see O'Neill et al. 2014 and Van Vuuren et al. 2013). However, scholars argued that there is still a problem of the combinatorics between climate and socio-economic models in the new RCPs and SSPs model (see Van Vuuren et al. 2011).

The SSPs' pathways combined nine socio-economic categories, including demographics, economic development, welfare, environmental and ecological factors, resources, institutions and governance, technological development, broader societal factors and policies (see O'neill et al. 2014; pp. 396).

The SRES scenario outlines the four pathways (i.e. A1, A2, B1 and B2) (Nakicenovic et al. 2000). Some of them are still relevant in the new SSPs illustrations. SSP1, identified as low challenges for mitigation and adaptation happened when sustainable development was proceeding at a high pace with low inequalities and more environmentally friendly technology which would increase the productivity of land. Meanwhile, in the other extreme, high challenges for mitigation and adaptation will be experienced when the rate of emissions are high and unmitigated due to moderate economic growth and growing population, which led to high inequality and slow technological change in the energy sectors, with low adaptation. In between

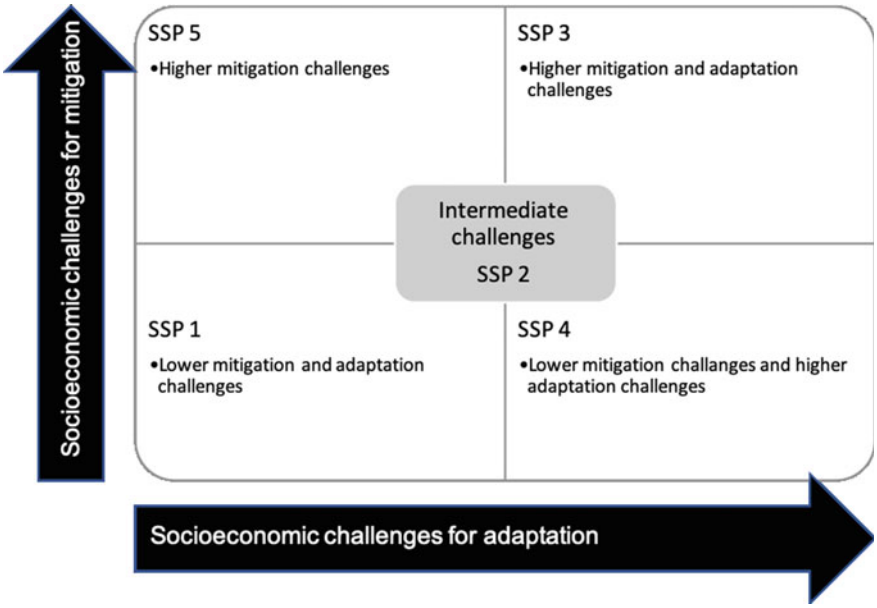

Fig. 2.1 SSPs model. Adopted from O'neill et al. (2014)

these extremes there are SSP4 and SSP 5 with an analogue that high challenges on adaptation happened when there is inequality, but rapid technology on clean technology. Whereas the high challenges on mitigation are experienced when there is a lack of alternative energy technology, but a more improved human capital with less vulnerability. Based on the two models, it is clear that there is an existing storyline and illustration on narratives of how socio-economic trajectory develop and would help to understand better action according to each challenge faced.

Review from the Worldwide Case Studies on Socio-Economic Impacts and Future Pathways and Scenario of CC and DRR

The result from the database query shows that there is an increasing number of scholarly research on the use of climate change scenarios for measuring impact in terms of disaster (see Fig. 2.2). However, in the case of Indonesia, there is still a dearth of study published in the international publication on the socio-economic scenario to climate change impact in Indonesia and its policy usage and/or implementation.

This section will review the query results on socio-economic impacts/variables of CC and Disaster. However, it will be mainly focussing and referring to the models of socio-economic scenarios pathways and implications on disaster risk and vulnerabilities (Nakicenovic et al. 2000; Birkmann et al. 2013). Based on the review, we

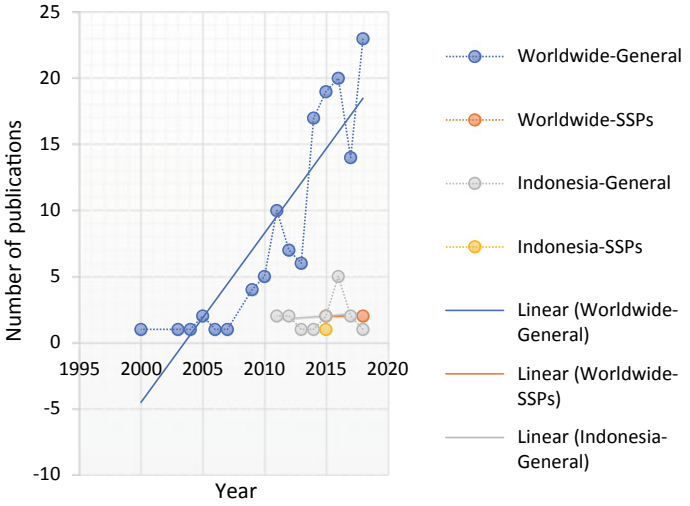

Fig. 2.2 Result of literature review analysis. *Source* Scopus database analysis

discovered that there is still strong domination of physical scenarios on climate change projections and impact rather than socio-economic-related scenario. Out of the 136 results from worldwide case, only four results showed the direct and specific usage of SSPs (Mochizuki et al. 2018; Chen et al. 2018; Birkmann et al. 2015; Cuaresma and Lutz 2016).

In the case of Indonesia, only one result shows the direct usage of SSPs out of the 16 results, (case of flooding in Jakarta) (Birkmann et al. 2015), meanwhile other publications mentioned or referred to another type of future climate scenario. The usage of SSP is still limited to the impact of climate change on a very limited type of disaster (in this case flooding in urban and coastal areas). Review on the existing emblematic case studies around the world using the models of socio-economic scenarios to understand the implication of each pathway to disaster vulnerabilities from the scholarly literature are listed as below.

Chen et al. (2018) conducted studies on the population exposure to droughts in China under the 1.5 °C global warming target proposed by the Paris Agreement (UNFCCC 2015). It uses the Standardized Precipitation Evapotranspiration Index (SPEI) to calculate drought frequencies in the period of 1986–2005 and 1.5 °C global warming scenario (2020–2039 in RCP 2.6). The research revealed a specific outcome that population are more exposed to drought in the East China rather than the west. However, generally the total drought frequency will be decreasing if the 1.5 °C global mean temperature target is achieved. Finally, it suggested that reaching the 1.5 °C target is a potential way for mitigating the impact of climate change on both drought hazard and population exposure (Chen et al. 2018).

Melkonyan (2014) also presented the case of drought in Armenia. Armenia has experienced different types of water-related disasters, such as droughts, floods, and

storms, which have a direct influence on economy and are expected to occur more frequently in terms of climate change, raising the need to estimate economic vulnerability especially in agricultural sector. One of the most important sectors in Armenia, which possess 21% share in the GDP is the agricultural sector. The agricultural resources are vulnerable to the current and future climate change impact. The study assesses the economic loss of the crop production due to the climate variability and elements, including temperature, radiation, precipitation and wind field. Future climate projections in the region are used for the time period of 2011–2040. The research revealed that temperature increase causes a significant shift, and predicted that the economic loss in the drier condition in the future climate within the period 2011–2040 will be more than doubled.

Another study conducted in the field of flood disaster insurance in Austria (Mochizuki et al. 2018) uses the SSPs scenario to calculate the public cost of demography and expenditures in climate-related events. The study concluded that in the SSP2 scenario or intermediate scenario (see Fig. 2.1), the population in Austria will be increasing from 8.6 million in 2015 to 9.2 million in 2050 with increasing flood risk due to socio-economic development and climate change. It revealed that this will cause increasing public debt and insufficient current budgetary arrangement to deal with the rising risk of extreme floods in the future.

The analysis in Patt et al. (2010) suggests that climatic disaster risk (as measured by the number of persons affected by a climate disaster) is highest in the countries with Human Development Index (HDI) levels of around 0.5, after controlling for other determinants of vulnerability. The number of affected individuals starts to decline only after countries reach this level of development (Cuaresma and Lutz 2016). Through a set of 50-year scenarios of human losses due to climate change in Mozambique, which later extended to a sample of 23 least-developed countries, Patt et al. (2010) suggested the relationship between an increase in income and adaptive capacity. The results of their research suggested that in the second quarter of the century, the effects of socio-economic development trends may begin to offset rising climate exposure. This implies that vulnerability will be increasing rapidly in the period between now and then, which will be desperately in need of international assistance to finance adaptation.

In terms of the interlinkages between mitigation and adaptation, the concept and case studies of Ecosystem function have served as co-benefits. McVittie et al. (2018) in their paper on EbA for DRR and CCA, particularly in Europe emphasized the need for lessons learnt from implementing EbA across a range of land uses. The research evidence indicates that adaptation and DRR are achievable, cost-effective and would attract acceptability and funding when these co-benefits are demonstrated clearly. In Asia, a study regarding the application of EbA for DRR and CCA has been conducted in Indonesia (Triyanti et al. 2017). They conclude that the key to the success of EbA is the involvement and participation of stakeholders. However, the gaps in the EbA for DRR and adaptation are still existing, especially in terms of knowledge of the biophysical and economic benefits, or negative impacts of EbA.

The review revealed that the approach which considers both potential changes in countries' exposure to climatic extreme events and socio-economic development

trends that influence countries' own adaptive capacities is lagging. This is potentially caused largely by the absence of data and reliability, especially due to extreme dynamics and complexity of socio-economic development (Freire et al. 2016; Hoeppe 2016).

Results: Indonesian Case Studies

Country Status on Climate Change

Climate variability and change has impacted different sectors in Indonesia, including agriculture, water, and increasing risk of disaster. In terms of agriculture, climate change alters precipitation, evaporation, run-off water and soil moisture. This will severely affect the production of main crops and threaten food security (see World Bank 2011). In the water sector, climate change has affected the water quantity and quality. The shortage of water during the dry season is estimated in 2009, particularly in the urban area, which will cause 2% total economic loss annually, due to limited access to water and sanitation. Another water problem is including poor water quality affecting the spread of diseases and raising vulnerability of people. Furthermore, industries continue to use the groundwater causing land subsidence and increasing the risk of seawater intrusion and flooding (World Bank nd). This is shown in the case of big low-lying coastal cities in Indonesia including Jakarta and Semarang (see Marfai and King 2008; Marfai et al. 2015).

In terms of risk of disaster, a study conducted by IPCC (2018) revealed that by the end of the twenty-first century, it is very likely that sea level will rise in more than about 95% of the ocean area, and about 70% of the coastlines worldwide are projected to experience a sea-level change within ±20% of the global mean. This condition will increase the vulnerability of the community to climate-related natural hazards and disaster including, flood, drought, storm and hurricane (IPCC 2018).

In terms of contribution to mitigate and adapt to climate change, based on the NDCs submitted to the UNFCCC, Indonesia has voluntarily committed to reduce unconditionally 29% of its greenhouse gasses emissions against the business as usual scenario by the year of 2030 (Climate Watch Data 2019). Indonesia could increase its contribution up to 41% reduction of emissions by 2030, subject to availability of international support for finance, technology transfer and development and capacity building. Meanwhile based on the target found in the Decree 62/2013 regarding a Managing Agency for the Reduction of Emission (sic) from Deforestation and Degradation of Forest and Peat lands, there will be 26% cut in GHG emissions, 41% cut in GHG emissions with international assistance by 2020 (Climate Watch Data 2019).

Indonesian current effort is highly insufficient, with the projection that warming could reach 3 to 4 degrees, far from the 2 and 1.5 degrees (Climate Action Tracker 2018). Indonesia has been increasing emission at a faster rate and might be doubled

in 2030 compared to 2014 values if the policy does not change due to extensive use of coal (Climate Action Tracker 2018).

In terms of adaptation, Indonesia identified eight sectors including Agriculture, Coastal Zone, Cross-Cutting Area, Disaster Risk Management (DRM), Education, Energy, Environment and Health.

Policy progress and country commitment in the latest COP24 in Katowice submitted by the Indonesian government could be a good start for transforming policy to support more ambitious climate action. As an outcome of this conference, Indonesia supported the National Adaptation Communication and also transparency and compliance, with consideration of the case of force majeure in the face of challenges to natural hazard prone countries to implement the NDCs (UNFCCC 2018a, b).

Review on the Contemporary Use of SSPs in Climate Change and Disaster Risk in Indonesia

Review of the Scholarly Literatures

Our literature review shows that the emission scenario and projection are abundant in terms of methodology; however, there is still a lack of understanding on how these physical projections affect the socio-economic condition, now and in the future (Wilby et al. 2009).

The number of populations is a crucial factor. General population growth projection in the coastal area (Neumann et al. 2015), Indonesia and other four Asian countries, including China, India, Bangladesh and Vietnam accounted for more than half of the global low elevation coastal zone population in 2000 and will continue growing vastly under the future scenarios.

In terms of the relation to disaster, several cases such as the case of Jakarta (Birkmann et al. 2015) shows the exposure and susceptibility due to increasing population due to floods, cyclones, droughts and sea-level rise.

The sea-level rise is identified as a major threat and increases risk of flooding in Asian Countries, including the Maldives, Vietnam, Bangladesh, India, China, Thailand, Indonesia, Philippines and Myanmar.

Through quantitative analysis using the World Risk Index and participatory analysis in Jakarta, Birkmann et al. (2015) suggests that adaptation under B1 SRES scenario will reduce the number of people affected by flooding by 136 million people in 2100. Main socio-economic parameters in the case of disaster vulnerability are migration, poverty, social security, labour, energy use and governance (Birkmann et al. 2015).

Review of the Policy Document

The NCs submitted by the government of Indonesia to some extent has utilized the scenario projection. The second NC utilized the SRES scenario. It suggests that under the scenario of SRES A2, where GHG emission is increasing, most of the models are suggesting that in 2025, there will be increasing wet seasonal rainfall in several regions in Indonesia (i.e. Java, Bali, NTB, NTT and Papua), and other regions will decrease. Moreover, it is predicted that by 2050 and 2080, Indonesian regions will mostly experience higher rainfall, with exceptions in the northern parts of Sumatra and Kalimantan. Meanwhile, for dry season rainfall, especially in West Java and South Sumatra, it might be decreasing in 2025, increasing in 2050, and decreasing by 2080. If it achieves the low emission scenario (SRESB1), the dynamics will be lower (see Republic of Indonesia 2010; pp. IV-4). Following the first NC (Republic of Indonesia nd), the third NC (Republic of Indonesia 2017) uses the RCPs (i.e. temperatures, sea-level rise, seasonal rainfall among others), while the socio-economic as drivers and impact is still centred around the GDP (Republic of Indonesia 2017). Despite the apparent use of the scenario, however, there is no detail elaboration in the third NC on the SSPs method and its values for future policy design. Based on our analysis, although there is an increasing effort to mainstream climate change into different sectors, it is still perceived in singularity. There is an opportunity for future research agenda to test implementation across governing actors and jurisdictions.

Discussion

Opportunities and Challenges on Using SSPs and Other Models of Socio-Economic Scenarios to Help as Decision-Making Tools in DRR

Opportunities

The advanced list of elements derived from worldwide case study reviews on socio-economic impacts of climate change and disaster (see Table 2.1) shows that there is a huge opportunity to use the SSP for future projection. Socio-economic variables relevant for determining pathways and scenario for CC in disaster perspective are more or less similar with the SSPs determined variables, with a strong focus on risk component (e.g. socio-economic vulnerability of certain category of population, the susceptibility, coping capacity and adaptive institutions determinants such as preparedness, social capital, institutional settings and policies). Furthermore, the current focus on socio-economic drivers and impact for future pathways and scenarios on CCA-DRR in Indonesia is still too general and mainly focusing on economic variables (i.e. GDP) instead of other important variables such as loss and damage factors (i.e. both economic and social assets), environment (i.e. ecosystem approach for DRR, CCA

Table 2.1 Potential socio-economic parameters in DRR and CCA case

Socio-economic categories	Elements of the scenario (O'neill et al. 2014)	Interpreted elements in DRR and CCA case
Demographics	• Population including total and age structure	• Population by age (Cuaresma and Lutz 2016) • Vulnerable population (Birkmann et al. 2015) • Migration (Birkmann et al. 2015)
	• Urban versus rural populations and forms	• Ibid (Preston 2013)
	• Other specified geographical locations (e.g. coastal versus inland)	• Vulnerability of coastal areas (Neumann et al. 2015)
Economic development	• Global and regional GDP or productivity trends	• GDP (Birkmann et al. 2015; Cuaresma and Lutz 2016)
		• Economic losses (Preston 2013)
	• Regional, national, and sub-national distribution of GDP (i.e. economic development of developing countries)	• Insurance for CC and DRR
	• Specific sectoral structure of national economies (i.e. the share of agriculture, and land productivity)	• International aid
	• Share of population in extreme poverty	
	• Nature of international trade	
Welfare	• Human development	• Ibid (Cuaresma and Lutz 2016)
	• Educational attainment	• Ibid (see Cuaresma and Lutz 2016)
	• Health including access to public health and health care infrastructure	
Environmental and ecological factors	• Air, water, soil quality	
	• The function of ecosystem	• Ecosystem function to reduce disaster risk (McVittie et al. 2018)
Resources	• Fossil fuel resources and renewable energy potentials	• Energy and potential disruption (Fan et al. 2014)
	• Other key resources, such as phosphates, freshwater, etc	

(continued)

Table 2.1 (continued)

Socio-economic categories	Elements of the scenario (O'neill et al. 2014)	Interpreted elements in DRR and CCA case
Institutions and governance	• Existence, type and effectiveness of national/regional/global institutions	• Ibid
	• Degree of participation	• Community engagement (Opitz-Stapleton and MacClune 2012)
	• Rule of law	Ibid
		• Corruptions (Birkmann et al. 2015)
Technological development	• Type (e.g. slow, rapid, transformational) and direction (e.g. environmental, efficiency, productivity improving) of technological progress	• Early Warning System (EWS)
	• Diffusion of innovation in particular sectors, e.g. energy supply, distribution and demand, industry, transport, agriculture	
Broader societal factors	• Attitudes and world views to environment/sustainability/equity	• Preparedness
	• Lifestyles (i.e. diets)	• Social capital
	• Societal tension and conflict levels	
Policies	• Non-climate policies (i.e. policies on development, technology policies, urban planning, transportation, energy security, environmental policies to protect air, soil and water quality) and policy objectives (e.g. welfare improvement)	• Relevant policies regarding CC and DRR

and CCM), socio-cultural aspects (i.e. welfare, health, education, social capital and human development), technology (i.e. technology in early warning systems) and political complexity and dynamics (i.e. participation, inclusiveness in DRR governance) among others (see Table 2.1). Finally, there is a need for disaggregation and thorough socio-economic studies which would be helpful for future assessment such as through integrated assessment modelling (IAM).

Challenges

Based on the review, there are several challenges identified: (1) Methodological limitations on the extension of SRES, SSPs and combination with climate RCPs.

Although there are existing references and study which elaborate methods and socio-economic variables, there is difficulties in terms of mismatch of scales between natural and social systems. Socio-economic aspect of human development is very dynamic and complex in nature, therefore oftentimes intangible; (2) Availability, inconsistencies and reliability of the data; (3) Lack of synergy of CC and DRR due to sectoral and policy segregation, as well as gaps on terminology and understanding of the scope of disaster risk, climate change adaptation and mitigation; (4) Lack of interdisciplinarity and continuous and monitored space for advancing science–policy interface; and (5) Lack of political support. There are still challenges in communication between scientists and policy-makers, which affect the implementation of CCA and DRR research. Furthermore, lack of coordination among governmental sector and complex bureaucracy oftentimes also hindered the effectiveness of CCA and DRR efforts.

Conclusion

This section highlights the contribution of the finding towards CCA and DRR theories, gaps and opportunities and future research direction, both apply to global and national level using the case of Indonesia. We concluded that vulnerability and resilience are largely controlled by human dynamics. Transformation and adaptive capacity to governed interlinked issues such as climate change and disaster risk reduction are dependent on socio-economic conditions. Therefore, there is an urgent need of building knowledge and increasing understanding of the future based on the socio-economic factors that increase vulnerability of disaster, exacerbated by climate change. Interdisciplinary and holistic research is needed for the short and long term. There is a new development in terms of future climate change and socio-economic scenarios (RCPs and SSPs) which is based on the SRES scenario. However, the new combination of RCPs and SSPs is still daunting (Nakicenovic et al. 2014; Van Vuuren et al. 2011), therefore, for future research, it would be useful to unpack the SRES SSPs to develop new insights through robust empirical research.

In the context of Indonesia, there is a need of a stronger emphasis on climate mitigation and adaptation and disaster risk reduction and adjustment of socio-economic variables that goes beyond the economic indicators (i.e. GDP) such as of welfare, health, education, social capital human development, participation and the role of disruptive technology. It is also crucial to include the aspect of multi-hazard approach to climate change impact, emerging technology and its adverse impact, and research related to process and mechanism of inclusive development and sustainable impact of research to community-based programme. It is therefore important to promote interdisciplinary research collaboration for a new generation of RCPs and SSPs through available methods, including the integrated assessment modelling (IAM), and leveraging the role of social science and governance studies in future climate change research.

A more advance strategy is needed in science communication and dissemination of future climate modelling and uptake of valuable finding to inform policy and community. This will be particularly useful to serve as a basis for monitoring and evaluation of Paris Agreement transparency mechanism and SDGs targets and indicators implementation.

We argued that projection is one of the highly important tools; however, largely reliable at the global scale rather than regional or national scale. To leverage understanding of high climate variability and change, it is important to raise self-awareness on adaptation to its impact, including future disasters.

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