LAND SUBSIDENCE AS A SLEEPING DISASTER
Case studies from Indonesia

Erlis Saputra

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Land subsidence as a sleeping disaster

Case studies from Indonesia

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Case studies uit Indonesië
(met een samenvatting in het Nederlands)

Penurunan tanah sebagai sebuah bencana terselubung
Studi kasus dari Indonesia
(dengan ringkasan dalam Bahasa Indonesia)

Proefschrift

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door

Erlis Saputra

geboren op 1 oktober 1980
te Pekanbaru, Indonesië

Promotoren:

Prof. dr. E.B. Zoomers
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Erlis Saputra

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ABBREVIATIONS

ACCCRN	:	Asian Cities of Climate Change Resilience Network
APP	:	Asia Pulp and Paper
Bappeda	:	*Badan Perencanaan Pembangunan Daerah*/District Development Planning
Bappenas	:	*Badan Perencanaan Pembangunan Nasional*/State Ministry of National Development Planning
BBWS	:	*Balai Besar Wilayah Sungai*/Regional Office of River Basin Management
BGR	:	German Federal Institute for Geosciences and Natural Resources
BKB	:	*Banjir Kanal Barat*/West Floodway
BKT	:	*Banjir Kanal Timur*/East Floodway
BLH	:	*Badan Lingkungan Hidup*/Environmental Office
BNPB	:	*Badan Nasional Penanggulangan Bencana*/National Disaster Management Authority
BPBD	:	*Badan Penanggulangan Bencana Daerah*/Provincial or Regency Board for Disaster Management
BPP SIMA	:	*Badan Pengelola Polder SIMA*/Polder SIMA Management Board
BRG	:	*Badan Restorasi gambut*/Peatland Restoration Agency
CBFFM	:	Community-Based Forest Fire Management (CBFFM)
CSR	:	Corporate Social Responsibility
Dinas PSDA ESDM	:	Water Management-Energy and Mineral Agency
DKP	:	*Dinas Kelautan dan Perikanan Kota Semarang*/The Department of Marine and Fisheries of Semarang City
DPA	:	*Desa Peduli Api*/Fire Care Village
DRM	:	Disaster Risk Management
FEWS	:	Flood Early Warning Systems
FoE	:	Friends of the Earth
FRS	:	The Fire risk system
FGD	:	Focus Group Discussion
GWLP	:	Garang Watershed Leadership Program
HGU	:	*Hak Guna Usaha*/Cultivation rights on land
ICCSR	:	Indonesia Climate Change Sectoral Roadmap
IPPF	:	Indonesian Peatland Partnership Fund
JCDS	:	Jakarta Coastal Defence Strategy

JICA	:	Japan International Cooperation Agency
Jikalahari	:	*Jaringan Kerja Penyelamat Hutan Riau*
KKMKS	:	*Kelompok Kerja Mangrove Kota Semarang*/Mangrove Working Group of Semarang City
LSM	:	*Lembaga Swadaya Masyarakat*/Non Governmental Organization
MoAgr	:	Ministry of Agriculture of the Republic of Indonesia
MoEF	:	Ministry of Environment and Forestry of the Republic of Indonesia
MPA	:	*Masyarakat Peduli Api*/Fire care community
MPBI	:	*Masyarakat Penanggulangan Bencana Indonesia*/Indonesian Society for Disaster Management
NCICD	:	National Capital Integrated Coastal Development
NGO	:	Non Governmental Organization
PHU	:	Peatland Hydrological Unit/Satuan Hidrologi Gambut
PDAM	:	*Perusahaan Daerah Air Minum*/The government water company
RAD Karlahut	:	*Rencana Aksi Daerah Kebakaran Lahan dan Hutan*/Regional Action Plan for Land and Forest Fires
RAPP	:	Riau Andalan Pulp & Paper
RSPO	:	Roundtable for Sustainable Palm Oil
RTRWN	:	*Rencana Tata Ruang Wilayah Nasional*/National Spatial Planning
Satgas Karhutla	:	*Satuan Tugas Kebakaran Hutan dan Lahan*/Task Force for Forest and Land Fires
SPAM	:	*Sistem Penyediaan Air Minum*/Fresh Water Supply System
TRGD	:	*Tim Restorasi Gambut Daerah*/ Regional Peat Restoration Teams
WWF	:	World Wife Fund for Nature
YMI	:	*Yayasan Mitra Insani*
YPB	:	*Yayasan Pembangunan Berkelanjutan*/Foundation for Sustainable Development

Introduction

1

At the beginning of 2019, the president of the Republic of Indonesia announced a plan to move the capital of Indonesia from Jakarta to an area outside this metropolitan city. One of the main reasons behind this idea is the projection that most of the northern parts of Jakarta will be under water by 2050 (Takagi et al., 2017; Takagi et al., 2016). In addition, in the year 2100, more than one-fifth of Jakarta will be inundated, leading to damage amounting to €16.8 billion (Ward et al., 2011). Two other severe hazards—namely sea-level rise and flooding (Abidin et al., 2015; Chaussard et al., 2013; Deltares, 2015)—are also important reasons for moving the capital (Bappenas, 2019).

Land subsidence—that is, the gradual settling or sudden sinking of the earth's surface due to the movement of earth materials (Galloway et al., 1999)—is threatening various areas worldwide. In Indonesia, land subsidence is caused by the compaction or consolidation of inter-bedded layers of clay and silt within the aquifer system due to the intensive extraction of groundwater (Avilés and Pérez-Rocha, 2010; Changxing et al., 2007; Shi et al., 2008). The overexploitation of aquifers is generated by population growth, intensifying industry, and agricultural activities (Calderhead et al., 2011). Land subsidence in Indonesia is also a result of the decomposition and compression of peat volume (Evers et al., 2017; Grzywna, 2017; Hooijer et al., 2012; Thorburn and Kull, 2015; Wösten et al., 2008). The drainage of peatland to allow for the massive expansion of plantations accelerates the drying out and decomposition of the organic matter, which triggers peat subsidence (Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Kieft et al., 2016).

Land subsidence has severe consequences for people and both the built and the natural environment in various parts of Indonesia. In urban and coastal areas, it damages houses, other buildings, and infrastructures (Du et al., 2018; Marfai and King, 2007; Phien-Wej et al., 2006; Saputra et al., 2017) and widens the area that is subject to permanent inundation and coastal flooding (Andreas et al., 2018; Fiaschi and Wdowinski, 2017; Sarah and Soebowo, 2018). In peatland areas, subsidence triggers massive carbon emissions (Hooijer et al., 2012), increases the risk of flooding (Wösten et al., 2008), decreases the storage of freshwater due to saltwater intrusion (Laura et al., 2005), and increases the permanent loss of peatland (Evers et al., 2017). Because it has been happening for so long, subsidence has destroyed ecosystems in those areas, decreased the value of land, and damaged the source of income of the affected people (Abidin et al., 2015; Butler et al., 2016; Lixin et al., 2010; Yoo and Frederick, 2017).

In disaster literature, three concepts—namely awareness, response, and adaptive capacity—are considered crucial factors when dealing with disasters (Brooks, 2003; Pelling, 2010; Smit and Pilifosova, 2003). Awareness is an important factor, since it must be considered before making responses (Kapucu, 2008). It plays an essential role in determining responses to disasters since it increases the sense of urgency about the problems (Hartmann and Spit, 2014; Scolobig et al., 2012), which is followed by an increase in willingness to take measures (Thomalla and Schmuck, 2004). A better understanding of the risk leads to a more prepared response to future disasters (Grothmann and Reusswig, 2006; Miceli et al., 2008). In the end, it increases the number of responses and decreases maladaptation (Klein et al., 2003). At the

same time, knowledge of a potential disaster must be accompanied by adaptive capacity, since it is positively correlated with the degree of the response that can be made (Quarantelli, 2003; Shaw et al., 2013; Smit and Wandel, 2006).

Ample evidence concerning the importance of the awareness and responses of various actors in dealing with disasters has been provided by scholars in the context of rapid-onset or short-term disasters, for example, earthquakes, tsunamis, flooding, landslides, hurricanes, and volcanic eruptions (Heller et al., 2005; Miceli et al., 2008; Perry and Lindell, 2008; Rindrasih, 2018; Scolobig et al., 2012; Thomalla and Schmuck, 2004). In contrast, there has been limited discussion about these aspects regarding such long-term disasters as land subsidence. In the case of land subsidence, awareness, responses, and adaptive capacity are needed even more, since subsidence affects large areas and is always combined with other hazards (Abidin et al., 2015; Chaussard et al., 2013). In an area faced with complex problems, awareness is crucial to knowing how to separate hazards from one another, in order to not overlook a particular hazard and to be able to initiate the appropriate responses.

This dissertation uses examples from Indonesia to contribute to a broader understanding of the characteristics of land subsidence and the responses of affected people and various actors to subsidence.

Indonesia was selected as the case study to address the aims of this research because of the country's vulnerability to multiple hazards (Dilley et al., 2005). For decades, Indonesia has been one of the world's five countries that suffer the most disasters (Guha-Sapir et al., 2017). Another reason for selecting Indonesia is that different geographical areas of the country have been threatened by land subsidence for several decades (e.g., see Abidin et al., 2011; Hooijer et al., 2012; Marfai and King, 2007). Land subsidence is happening faster in Indonesia than in any other country in the world, and it has triggered severe physical environment and socioeconomic issues (e.g., see Abidin et al., 2015; Deltares, 2015; Hooijer et al., 2012; Marfai et al., 2008; Schrier-Uijl et al., 2013). Thus, the example from Indonesia can provide a complete picture of the land subsidence problem in one of the most severely affected areas and in different geographical settings. The third reason is that the research into land subsidence in Indonesia is dominated by efforts to understand land subsidence as a physical process, to explain the determinants of the process, and to design a map or to model techniques to understand the process and distribution. Evidence about the ways different actors to deal with the problems is scarce. Thus, this area can contribute to providing evidence for other developing countries by focusing on different localities.

All around the world, the roles of different actors are crucial in dealing with disasters (Djalante, 2012; Lassa, 2013). Indonesia's Disaster Management Law states that the central government and provincial and local governments are the main actors in managing disasters. The central government is obliged to draw up policies and plans, while provincial and local governments are responsible for designing, planning, and taking measures at lower levels, such as that of the local community. Since the disaster management policy reform in 2007, the management of disaster can be initiated not only by the formal institutions, but also by

informal bodies, such as civil society organizations and other non-state actors (Lassa, 2013). Therefore, Indonesia provides a good example of the importance of interventions by different actors from different levels, whose involvement is laid down in law.

In the case of a short-term disaster, preparations can be made before the disaster strikes, while the response is made after it has struck (Alexander, 2002). In responding to land subsidence, the time factor is important since subsidence happens continuously over an extended period of time (Abidin et al., 2011; Galloway et al., 1999; Hooijer et al., 2012). In this situation, actors might respond to the problem immediately after they recognize its existence, or they might decide to wait for a certain time before responding. To deal effectively with the problem, the actors must make appropriate responses. Thanks to its different time scales, the actors can determine whether the responses will take the form of adaptation or mitigation (Moser, 2012).

The present research contributes to a better understanding of the relationship between the response and the capacity of affected people to deal with the "sleeping disaster," namely land subsidence. What makes research into responses to land subsidence different from that into single-shock disasters, is that responses to land subsidence must be made continuously for an extended period of time and are aimed at a large scale of impacts. To support the responses, the economic capacity of the affected people and other actors is also needed for an extended period to guarantee that they will be able to deal with such long-lasting problems. Therefore, this dissertation will enhance the knowledge about such factors when dealing with long-term disasters.

The conceptualization of the aim of this dissertation is explicated in the remainder of this chapter, which consists of: a) theoretical perspectives, b) research aims and questions, c) research design (including case selection, research method, and data collection), and d) an outline of the dissertation.

1.1 THEORETICAL PERSPECTIVES

To better explain the response of actors to land subsidence, the terms "disaster awareness and preparedness," "disaster response and adaptive capacity," and "disaster governance" are defined below.

1.1.1 Disaster awareness and preparedness

Awareness of hazards is key to better preparedness and better responses. A high level of awareness leads people to admit that they are being threatened by a risk (Fielding, 2012). In responding to flooding, for instance, the perception of the risk is positively correlated with people's preparedness for future problems (Grothmann and Reusswig, 2006; Miceli et al., 2008). A high level of awareness of a risk increases the willingness to take measures to avert hazards (Neuwirth et al., 2000). On the contrary, a low level of awareness leads to a low level of preparedness and to inappropriate responses (Scolobig et al., 2012). Thus, awareness determines whether people will take preparedness measures (Perry et al., 2001).

Different actors and people can have different levels of awareness of disasters. The experience of the risk is one of the factors that build awareness (Ho et al., 2008). The level of awareness of people who have already experienced a disaster is higher than that of those who have not experienced one (Farley, 1998), and they are more aware of the risk and its severity in the surrounding area (Ho et al., 2008). For instance, people who have experienced a number of earthquakes and suffered severe damage and economic loss as a consequence, will take more robust preparedness measures (Heller et al., 2005; Nguyen et al., 2006; Perry and Lindell, 2008). At the same time, the experience of such actors as governments and non-governmental organizations (NGOs) of previous disasters increases their awareness of disasters, which enhances their ability to choose the appropriate measures (Thomalla and Schmuck, 2004). Therefore, the experience might lead people and different actors to be aware of and to better prepare to avert disasters (Becker et al., 2017).

Thus, awareness can be the basis for being able to decrease vulnerability to disasters. The absence of awareness leads to a low level of preparedness, which in turn leads to inadequate responses (Scolobig et al., 2012), resulting in the unresolved vulnerability status (Brooks, 2003; Pelling, 2010; Smit and Pilifosova, 2003).

1.1.2 Disaster response and adaptive capacity

The response to disasters in different geographical contexts can take the form of mitigation or adaptation (Moser, 2012). Mitigation is a measure to prevent hazard risk in the long term, while adaptation is an adjustment taken to deal with actual impacts or limit potential damage (Benson et al., 2001; Smit and Pilifosova, 2003). The two measures can be complementary, as both reflect the global and local benefits and different time-scale solutions (Dang et al., 2003; Moser, 2012). At the national and lower levels of government, and in the case of a long-term or short-term strategy, these two responses can be integrated (Moser, 2012).

In practice, the responses can depend on the type of disaster or the level of impacts. The affected people might reduce the impacts, repair the damage as a short-term solution, retreat from the affected areas, or do nothing (Loebach, 2016; Reuveny, 2007). Of these responses, moving away from the affected areas is the last choice, since it might damage people's economic and social relations (Harwitasari and van Ast, 2011; Koubi et al., 2016; Mortreux and Barnett, 2009). Not all adaptations can reduce the vulnerability of people: An adaptation is only useful if it can reduce impacts and exposure (Adger et al., 2005).

To be able to respond, people need enough adaptive capacity, that is, the ability to cope with or adjust to the current problem (Shaw et al., 2013; Smit et al., 2000). Adaptive capacity consists of various components, for example economic resources, technology, information and skills, infrastructure, institutions, legal and regulatory practices, and social networks (Brooks, 2003; Pelling, 2010; Smit and Pilifosova, 2003). A better socioeconomic status increases the ability to create various responses during the different time scales, which will directly decrease people's vulnerability (Adger, 1999; Blaikie et al., 2014; Cutter et al., 2003; Pelling, 2010; Yohe and Tol, 2002). The adaptive capacity is positively correlated with the degree of response (Shaw et

al., 2013; Smit and Wandel, 2006). Therefore, if the adaptive capacity is limited, the response that can be made will be minimal (Shaw et al., 2013; Smit and Wandel, 2006).

1.1.3 Disaster governance

The actions of an individual actor cannot solve disasters, since individuals have limited resources (Moser and Ekstrom, 2010). Interventions from different actors are needed to increase people's resilience by combining various social, political, and economic dimensions of responses (Douglass, 2016; Tierney, 2012). Different actors—namely the central and local governments, NGOs, and communities—play particular roles in mitigating and dealing with disasters (Douglass, 2016). Governments bear the most responsibility for guaranteeing citizens' safety (Kumar, 2018). The central government can create a national system and legal framework to manage risks and promote sustainable risk management, since it has enough human capital and financial resources (Bollin et al., 2003; Dobbs, 2016; Topno, 2018). At the same time, local governments have thorough knowledge of and the expertise to solve local problems (Dobbs, 2016). Furthermore, NGOs are in a good position to reduce the risk of disasters due to their strengths in community-based disaster management, mediation, and advocacy (Shaw, 2003). They can compensate for the weakness of governments at the local level, where the latter are mostly unwelcome (Agarwal, 2001; Benson et al., 2001). Through their specific abilities and experience, the initiatives by both actors might increase the ability to deal with disasters (King, 2007). The community can then also enhance the quality of responses, since they know precisely what the problem is and its consequences (Pandey and Okazaki, 2005). Therefore, to deal with complex problems like land subsidence at various levels, responses from different actors at different levels are needed.

1.2 RESEARCH OBJECTIVES AND QUESTIONS

The previous section showed that it is crucial that different kinds of actors from different levels have a high level of awareness and the appropriate capacity to respond to disasters, and that they respond and intervene in the appropriate way. However, those concepts are barely used in the land subsidence debate. Therefore, a study on awareness and responses to land subsidence is needed. Without a clear understanding of the characteristics of land subsidence, the awareness of land subsidence, and the response of actors to its consequences, it is challenging to design comprehensive interventions to deal with the problem.

The main research question is: *What exactly is the land subsidence problem and what kinds of measures can help to resolve it?*

To answer this question, three sub-questions are addressed in this dissertation:

1 What are the characteristics of land subsidence in different geographical settings? (SRQ-1)

The aim of answering this research question is to understand the importance of land subsidence in different geographical settings, with a focus on the characteristics of land subsidence, including rate, distribution, impacts, and interrelationships with other problems. The intention is not to provide a list of these variables, but to better understanding the characteristics of land subsidence in various geographical contexts and its relation to the activities and other hazards in such areas. This research question appears in all chapters as the base of the explanation of content analyses.

2 What kind of problems does land subsidence generate and how do people respond to those problems? (SRQ-2)

The aim of answering this research question is to reveal land subsidence's impacts on or consequences for the lives of affected people in the different areas and geographical settings. In urban, coastal, and peatland areas of Indonesia, land subsidence often occurs in combination with other hazards. As this complex problem has more significant consequences for people's economic status, the second aim is to reveal how big the consequences of land subsidence are for the economic status of affected people.

Some affected people react to the long-term problem because they want to be safe from the risks. In the areas that are prone to land subsidence, an understanding of the types of hazards that are interrelated with land subsidence and the ability to separate the hazards might be useful when considering the appropriate response. To be able to respond appropriately, it is crucial to be aware of the problem. Thus, the aim of answering this research question is also to understand how the affected people perceive land subsidence in areas with combined hazards, how they respond appropriately to the problems, or whether they respond inappropriately—which obviously is something that is not productive. This research question is answered in Chapters 2 and 3.

3 What kinds of measures have been taken by different actors from different levels to solve land subsidence problems and how successful are those measures? (SRQ-3)

The aim of answering this research question is to establish what measures the central and local governments, NGOs, and communities take in order to deal with land subsidence. The measures are divided into two types, namely mitigation and adaptation. These measures reflect the different time scales (Moser, 2012), which is important with regard to a long-term disaster. Establishing these measures allows an assessment of the effectiveness of actors' efforts to deal with land subsidence over different time scales. The land subsidence case can also be a complementary example to show whether it is necessary to integrate mitigation and adaptation measures. Finally, the case provides a clear example of the characteristics of the

effective solutions of various actors in various geographical settings, and how the relationships amongst the actors might be built. Chapters 4, 5, and 6 elaborate on this question.

The research questions concern the perspectives of the central and local governments, NGOs, and communities. Their perspectives are then introduced into different geographical areas to better understand the complexity of and the core problems caused by land subsidence. In this research, urban, coastal, and peatland areas represent different and complex geographical areas. The geographical variety is introduced assuming that: a) the core problems are different, b) the roles of the actors are diverse, c) different problems require particular solutions from different actors, and d) each actor might react in a different way if they identify different problems. Thus, by understanding the different context of awareness and response in different localities, the main issues of land subsidence can be explored.

A conceptual model has been developed to provide a clear understanding of this research (see Figure 1.1). In this model, after the characteristics of land subsidence are understood, the first layer of the land subsidence response is awareness. Awareness must be considered the main issue before ensuring preparedness or making responses. At the same time, the responses must be based on awareness and supported by the appropriate adaptive capacity. To optimize these responses, it is necessary to involve various actors and their interrelationships. This framework is based on the expectation that vulnerability to land subsidence can be decreased.

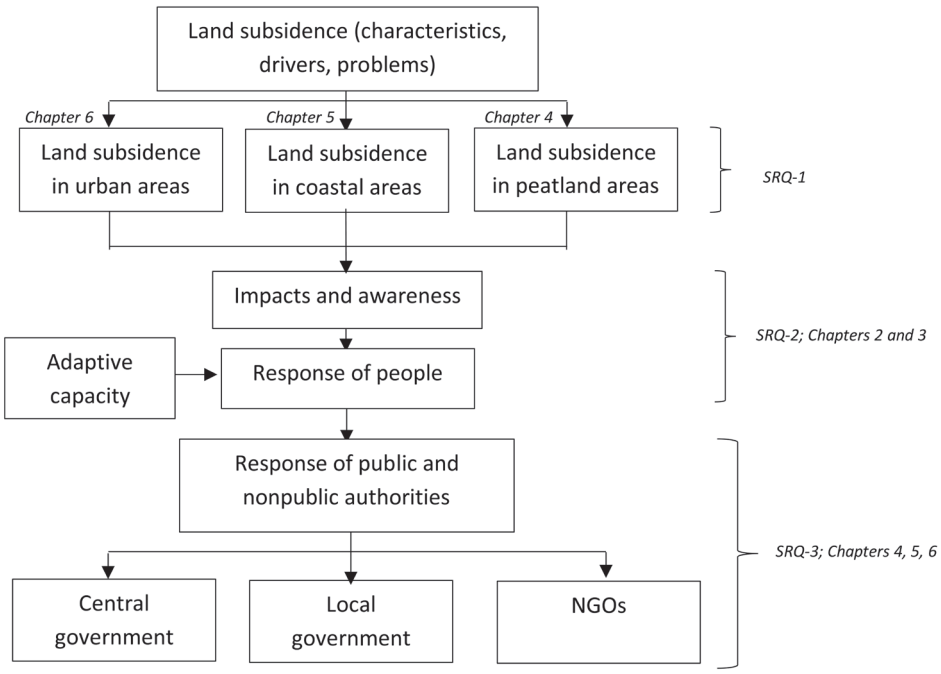

Figure 1.1 Conceptual model

1.3 RESEARCH DESIGN

1.3.1 Geographical context and research areas

The present research took the form of a multiple-case study. Case study research is necessary to understand the complexity of problems in the social sciences (Flyvbjerg, 2006). A researcher can use a multiple-case study to better understand the similarity or dissimilarity of the phenomena (Baxter and Jack, 2008). This research was conducted in three areas in Indonesia that represent urban, coastal, and peatland areas, respectively. In these areas, special attention was paid to the characteristics and impacts of land subsidence and the responses of various actors (i.e., the central and local governments, NGOs, and communities) to land subsidence.

Twelve subdistricts *(kecamatan)* in these three areas—namely Jakarta, Semarang City, and Riau Province—were selected for this research (see Figure 1.2). They were chosen for two main reasons: They experience the highest rate of subsidence and, compared with other areas in the same regions, they suffer from massive impacts. The detailed status of all case study areas is explained in Chapters 4, 5, and 6. However, the following few paragraphs briefly describe the areas.

Figure 1.2 Research locations

1 Jakarta

Jakarta is Indonesia's capital and its biggest city, covering an area of 662.33 km^2 on the island of Java. In 2016, the city's population amounted to approximately 10.27 million people and the population density was around 15,500 people/km^2 (BPS-Statistics of DKI Jakarta Province, 2017). Land subsidence in Jakarta was first detected in 1926. It is caused by the rapid growth of the population and the urban area, which leads to an increase in the construction load and the extraction of groundwater (Abidin et al., 2009). The groundwater exploitation by office buildings and large-scale settlements, which happens continuously, and the development of high-rise buildings, accelerates the subsidence (Kimmelman, 2017). The situation is

exacerbated by the lack of a piped water supply (see Bakker, 2007; Hall and Lobina, 2006). Thus, land subsidence seems likely to remain a problem for Jakarta.

2 Semarang City

Semarang City is in the north of Java. It is the capital of Central Java Province, which covers an area of 373.7 km^2 and has a 13.6 km coastline. In 2016, the population of Semarang was approximately 1.73 million people, and the annual population growth rate was about 1.66% (BPS Kota Semarang, 2017). Coastal areas of Semarang have been experiencing rapid land subsidence for more than a century (Abidin et al., 2013). Morphologically, Semarang is divided into the northern part, which is dominated by coastal plains and lowlands, and the southern part, which is a mostly hilly area. The northern part (the focus of this research) is the center of transportation and industrial activities, high-density settlement, and agriculture. As the center of population and economic activities, the pressure on the land in Semarang will increase, resulting in an increase in the area's vulnerability to coastal hazards, including land subsidence (Marfai et al., 2008).

3 Riau Province

Sumatra's Riau province was selected to represent peat subsidence. About one-fifth of all the peatland in Indonesia is in Riau (Warren et al., 2017). Of a total of 3.87 million ha of peatland, about 86.8% is categorized as deep or moderately deep peatland (Pemerintah Provinsi Riau, 2018). These two types of peatland are used for the massive production of food and non-food commodities.

For decades, Riau has seen the development oil palm, timber, and coconut estates, which has caused deforestation, peat and forest fires, massive carbon emissions, and peat subsidence (Hooijer et al., 2012; Lee et al., 2014; Miettinen and Liew, 2010). Peatland development will possibly trigger various further impacts, since the government has decided to increase the export and domestic use of biodiesel and to be the leading country in the pulp and paper industries (Harahap et al., 2017; MoFor, 2011). Thus, Riau—as the center of plantation activities—will continue to be exploited and consequently the peatland will continue to sink (Hooijer et al., 2012).

1.3.2 Research methods and data collection

The present research combined a qualitative and a quantitative approach. Data were collected using five methods: desk research, an introductory scoping study, focus group discussions, participatory mapping, and interviews.

1 Desk research

The desk research was carried out from January 2015 until July 2019. The aim was to collect sufficient data and information on various structural and non-structural measures and

interventions of different actors from literature, government regulations, official reports, government and NGO websites, and online and printed newspapers, and also to anticipate any change of policies and documents.

2 Introductory scoping study

An introductory scoping study was conducted to confirm and complete the information gathered during the desk research and the preliminary interviews with government officials. The areas that are most prone to subsidence and suffer the most from its consequences were chosen as study areas. All affected urban and coastal areas were surveyed, while in the peatland area, the affected areas that are inhabited and planted with commodity crops were prioritized to be surveyed. The studies were conducted to obtain a deep understanding of the precise distribution of land subsidence, its triggers, its impacts on the area and households, and the interventions of the different actors aimed at dealing with subsidence. A total of 12 surveys were carried out in all case study areas. They were conducted in two ways, that is, either individually (in seven cases) or in the company of government officials (in three cases) or community leaders (in two cases). One of the outputs of the study was the areas selected for in-depth interviews.

3 Focus group discussions

Focus group discussion (FGD) was essential in determining the exact areas that are the most prone to land subsidence, based on people's knowledge. This determination is important, since in all case study areas, land subsidence is not a single hazard, but is interrelated with other hazards. Therefore, determining the exact areas helped the FGD participants to distinguish the hazards. FGDs were held to discover problems of land subsidence at the local level and how the community responds to the issues. All FGDs were attended by representatives of the local community, who have advanced knowledge of land subsidence. They were representatives of various community groups, such as the local leaders, elders, fishermen groups, fire care community, women, youths, and religious groups or leaders. A total of around 20 to 30 group representatives were invited to every FGD. The FGDs, which were always facilitated by the principal investigator, were recorded and transcribed to ensure that no information was missed. Later, the FGDs—along with the area surveys—were used to select the areas for the in-depth interviews.

4 Participatory mapping

Participatory mapping was used to map land subsidence based on the knowledge of key actors, that is, the local community, the local government, and local NGOs. The participatory mapping processes were conducted both during and outside the FGDs. The base maps were produced from the literature study about the distribution of land subsidence in each case study area. In the absence of this information (e.g., in peatland areas), the land use map was

used. The maps produced during the FGDs showed the exact delineation of land subsidence based on the local leaders' interpretation, including the distribution, rate, and impacts. Along with the output of FGDs and area surveys, the outcome of the participatory mapping was also used to determine the households to be interviewed.

5 Interviews

Both semi-structured and in-depth interviews were conducted. The former were used to collect information from key actors from the central and local government institutions and NGOs. The interviews gathered the knowledge of the actors involved in land subsidence and their knowledge of its characteristics (i.e., triggers, rate, and impacts), and how the actors responded to subsidence, including the collaborative actions amongst the actors. In total, representatives of 14 government institutions (national and local-level institutions) and 18 environmental and developmental NGOs (national and local level) were interviewed.

The interviewees were selected in the basis of the following criteria: a) Their tasks were related to disaster, environment, urban, coastal, or peatland issues; b) they worked in one of the case study areas; and c) their office was located outside the case study areas but they regularly worked inside those areas. A standard guideline was used during the interviews. Some interviews were held more than once if there was a need to clarify information or a need for additional information. In some interviews, the actors were represented by one or more interviewees. Phone interviews were used for actors who could not be interviewed face to face due to distance or schedule constraints. On average, the interviews lasted 60–90 minutes.

The in-depth interviews were carried out in the 12 subdistricts over a three-month period in 2015. In these interviews, the analysis unit was the household, which at the same time was also the respondent. The respondents were selected in the case study areas that experience the highest rate of and suffer most from land subsidence, which was established through a literature study (Abidin et al., 2011; Lubis et al., 2011; Marfai and King, 2007; Saputra et al., 2017) and official reports from public authorities.

In total, in-depth interviews with 330 households were held (Table 1.1). The respondents were asked about their awareness of land subsidence, the consequences of land subsidence that must be dealt with, their responses to the impacts and the cost of those responses, and the longer term cost to them of land subsidence. The random sampling method was used to select households for interviews and completing the questionnaires. Due to the dynamics of the interaction with the interviewees, the average duration of each interview was 30–60 minutes.

Table 1.1 Number of respondents in each case study area (N=330)

Case study area	Sampling area (subdistrict)	Number of respondents
Jakarta (urban and coastal area)	Cengkareng, Penjaringan, Tanjung Priok	90
Semarang City (coastal area)	Genuk, Semarang Utara, Tanjung Mas, Tugu	124
Riau province (peatland area)	Enok, Tembilahan, Tembilahan Hulu, Batang Tuaka, Tempuling	116
Total (N)		330

1.4 OUTLINE OF THE DISSERTATION

This dissertation consists of seven chapters based on three published and two submitted articles, plus this introduction and the conclusions. Five articles on the interpretation of the characteristics, awareness, and responses of people and different actors from different geographical areas form the core of the dissertation.

This first chapter provides the background of the research, the central and sub-research questions, and the theoretical framework used. The case study areas and conceptual framework are briefly explained, followed by methods of conducting the research and the outline of the dissertation.

Chapter 2 addresses the debate on the impacts of land subsidence, as well as the awareness of local governments and affected people to land subsidence, including its rate and impacts. The discussion in this chapter shows that the difference in levels of awareness of land subsidence influences the degree of sense of urgency about the problems, which causes different actions. The chapter also shows that local governments' and affected people's awareness of land subsidence is low, and that land subsidence is not at the top of the agenda of local governments or, if land subsidence is mentioned in policy, the implementation of that policy is still limited.

Chapter 3 shows what kinds of problems land subsidence generates on the ground (i.e., the household perspective) and how the affected people respond to such problems. The chapter also shows that households are facing severe physical and socioeconomic problems due to land subsidence. They try to respond to the problems with various measures, but their lack of income resulting from an increase in expenditure and a decrease in earning capacity, means that many affected households cannot deal with the problems. Consequently, they remain vulnerable.

Chapters 4–6 provide an understanding of land subsidence in the three geographical settings (i.e., peatland, coastal, and urban areas). They also reveal the responses of different actors (the central and local governments, NGOs, and communities) to land subsidence in such different areas. It is important to understand these aspects, since a comprehensive understanding of the characteristics of land subsidence in different settings and the way different actors deal with the problems can help in the design of effective measures to deal with current problems and prevent the issues from reoccurring. Therefore, Chapter 4 discusses

land subsidence and the responses of the above three actors to peat subsidence. It shows that land subsidence in peatland areas is a complex problem that cannot be entirely solved by all actors. Chapter 5 explores land subsidence in coastal areas with an emphasis on the role of the central and local governments and NGOs in managing the problem. This example shows that land subsidence in the coastal area is a critical issue. The mentioned actors try to deal with it using their capacity and start working alongside each other, which creates various types of relationships between governments and NGOs. The response of individual actors and their combined solutions can slightly improve the situation. Chapter 6 presents an example from an urban area. It shows that governments from different tiers are needed to deal with land subsidence. However, there is a big gap between the solutions offered by the central government and by local governments, and none of them has a good solution. Thus, this chapter calls for solutions based on a coherent process and multilevel cooperation.

Finally, Chapter 7 discusses the main findings presented in the five articles. It contributes to a better understanding of the characteristics of land subsidence and the responses of people and various actors to land subsidence by presenting examples from three geographical settings in Indonesia.

Fighting the ignorance: Public authorities' and land users' responses to land subsidence in Indonesia

2

This chapter is an adapted version of the article: Saputra, E., Hartmann, T., Zoomers, A., & Spit, T. (2017). Fighting the ignorance: Public authorities' and land users' responses to land subsidence in Indonesia. *American Journal of Climate Change, 6*(1), 1-21.

ABSTRACT

Land subsidence can have a considerable impact on the socioeconomic viability of areas. In urban areas, land subsidence tends to damage buildings and infrastructures gradually, while in rural peatland it slowly destroys vegetation. The damage will worsen since climate change has further implications for the areas affected by land subsidence. In Indonesia, the response to land subsidence differs in different areas in terms of awareness, urgency, and action on the part of both public authorities and land users. This chapter systematically investigates these varied responses in urban and rural peatland areas. Interviews with experts and surveys of 330 land users in selected subdistricts were conducted and further supplemented by focus group discussions. We found that both the public authorities' and the land users' responses were considered of limited use to combat land subsidence. We suggest that the endorsement of land users' responses in governmental policies would make a significant difference in improving land subsidence management.

Keywords: Indonesia, Land Subsidence, Land Users, Public Authorities, Response

2.1 INTRODUCTION

Land subsidence is a gradual settling or sudden sinking of the earth's surface due to movement of earth materials (Galloway et al., 1999) or an abrupt depression of local ground surface (Tripathi et al., 2009). The relation between land subsidence and urban or rural areas is twofold: First, if land subsidence occurs on urban land, it can severely damage or lead to the collapse of buildings, bridges and other infrastructures; if it occurs on rural land, it can also damage plantations, homes and rural infrastructures. Second, the natural consolidation of sediments can be increased by the weight of construction on the land (Abidin et al., 2011; Chaussard et al., 2013). Agricultural expansion and a failure of the plantation system (i.e., the canal system and various technologies) might also worsen the subsidence. Therefore, land subsidence is directly linked with urban and rural development. Addressing this issue is crucial in these areas, particularly in delta and peatland areas.

The Indonesian urban areas of Jakarta and Semarang City suffer from a high level of land subsidence. They are densely settled areas and the effects of land subsidence are extreme. Some areas of Jakarta sink about 1–15 cm per year, while other areas sink by up to 20–28 cm per year (Abidin et al., 2011). In addition, the rapid population growth in Jakarta (i.e., about 136,000 people per year) triggers additional groundwater extraction, which in turn increases land subsidence (Abidin et al., 2011; Chaussard et al., 2013). Semarang City experiences land subsidence of about 8–11 cm per year (Lubis et al., 2011), caused by a combination of alluvium soil consolidation, massive groundwater extraction, and a heavy construction load (Abidin et al., 2013; Marfai and King, 2007). In both cases, the intensive growth of industrial areas, settlements, and population leads to an increased demand for clean water extracted from confined aquifers and accelerates land subsidence (Braadbaart and Braadbaart, 1997; Chaussard et al., 2013). In addition, the combination of land subsidence and sea level rise in the coastal area further increases the area's exposure to subsidence, since the rise of the sea level renders coastal areas more unstable. Besides the urban areas, the rural peatland of Indragiri Hilir also suffers from land subsidence at a rate of about 4–6 cm per year. The land subsidence in the peatland area is caused by desiccation, consolidation, water erosion, and biochemical oxidation (Deverel and Rojstaczer, 1996; Wosten et al., 1997). An intensive expansion of infrastructures and farming on the peatlands also accelerates the subsidence in Indragiri Hilir. The subsidence further worsens due to the intensive drainage of peatlands. The use of an intensive drainage system during agricultural activities has led to large carbon losses due to the oxidation of peat, which triggers subsidence (Jaenicke et al., 2008; Schipper and McLeod, 2002; Wosten et al., 1997). Population growth and the population's activities create a higher demand for space. Many environmental problems are caused by the population distribution (Ehrlich and Holdren, 1971). Since the capacity is limited and the population growth is constant, subsidence seems to be getting worse. These three cases illustrate the need to address land subsidence.

In order to reduce and prevent land subsidence, adaptation and mitigation are potential options for public authorities and land users. McGranahan et al. (2007) argue that, in order to reduce disaster risk related to climate, the approaches of adaptation and mitigation might be

combined. Similar to climate change, a long-term process of land subsidence might require a consideration of the actors involved. Hartmann and Spit (2014) argue that the understanding of climate problems might support the implementation of adaptation strategies. Since this is a process with a considerable time frame, the climate issue at its root receives too little attention from local decision makers. Appropriate adaptation should reduce the consequences of subsidence (Hallegatte and Corfee-Morlot, 2011). The public authorities should design policies that can alleviate problems, such as reducing groundwater extraction, artificially recharging aquifer systems, and introducing spatial zoning regulations to prevent future problems. Ye et al. (2015) showed that, by controlling groundwater withdrawal, land subsidence in Shanghai decreased to an average rate of 5.5 mm per year. Therefore, these detailed water-related policies must be accommodated in urban planning policies in order to increase the capacity of the adaptation (Kokx and Spit, 2012).

How do actors in urban and rural peatland areas address land subsidence? In this chapter, our main aim is to assess actors' responses to land subsidence. In particular, we focus on the responses of public authorities and affected land users in urban and rural peatland areas. Using the different characteristics of urban and rural peatland, allows us to explore and compare land subsidence management in these different areas. We assessed to what extent these actors are aware of the risk of land subsidence (awareness), to what extent they perceive it urgent to act (urgency), and what they actually do (action). This three-stage model of awareness, urgency, and action has previously been used to show indicators of changing environmental conditions, such as climate change (Hartmann and Spit, 2014). This scheme is used to depict the status of public policies with respect to land subsidence.

We start by describing the response in disaster risk management phases, analytical thinking and indicators used in assessing the response to land subsidence, and the status of land subsidence to show the importance of addressing the issue. In the following, we discuss the response of public authorities and land users to land subsidence in each case study area.

2.2 RESPONSE TO LAND SUBSIDENCE IN DISASTER RISK MANAGEMENT

Disaster risk management (DRM) refers to a framework for reducing disaster risk by including management perspectives that combine prevention and preparedness along with the response. Its purpose is to reduce possible risk factors and to prepare a response to them (Baas et al., 2008). It includes actions taken before (pre-disaster), during (disaster), and after a disaster (post-disaster) as a cycle.

Regarding land subsidence, most of the responses and efforts are made in a pre-disaster phase, while some of them happen in the post-disaster phase. The pre-disaster phase includes risk identification and mitigation as well as preparedness (Freeman et al., 2003). The aim in this phase is to strengthen households' capacity and resilience in protecting their livelihoods (Baas et al., 2008). The role of public authorities in this phase is to respond to and mitigate the risk. Political will and updated plans are required during this phase (Freeman et al., 2003). On the

other hand, households' capacity to protect themselves by avoiding and mitigating hazards must be increased, and strategies to cope with the problems must be realized (Baas et al., 2008). In the post-disaster phase, the focus is on recovery and rehabilitation of damages.

In land subsidence management, the response of actors, especially during risk identification, is crucial. Relevant actors must have knowledge about current and forthcoming conditions to respond to a disaster successfully (Seppänen and Virrantaus, 2015). The response should be pursued by public authorities and affected land users. The land users' ability to respond is important, since they are a prime component in the disaster mitigation process due to their knowledge of recent problems.

Response comprises three stages: awareness, urgency, and action (Hartmann and Spit, 2014). Awareness is the knowledge gathered from interactions between people and the environment, which must be updated for different situations. Awareness is crucial for success in disaster management (Chopra and Venkatesh, 2015), because it is used to assess the degree to which public authorities and land users recognize existing problems. It can be identified from a government's initiative to design subsidence-related plans (Stork and Sneed, 2002). There are four components that land users must be aware of: the riskiness of the area they live in, the status of the land subsidence, different ways to solve problems, and actions to prevent upcoming problems.

The land subsidence issue must be brought to the awareness of public authorities and land users with a sense of urgency to emphasize its importance and ensure that actions taken reach the policy level. To deal with disaster phenomena, Blaikie et al. (2005) argued that the phenomena must be included in the making of mainstream policy and practice. To reflect a sense of urgency, public authorities must include the phenomenon of land subsidence in their policies. Political limitations need to be modified to allow people who are not formal authorities to be involved in designing and implementing the policy.

Realizing action from awareness and urgency policies is challenging in land subsidence management, as it involves complex procedures. Tang et al. (2010) argued that any actions should consider a comprehensive awareness, complete an analysis, and adopt concrete action policies to reduce the problems. Gaillard and Mercer (2013) argued that the action must integrate an assessment of risk based on scientific and local knowledge, and must establish dialogue between external and internal actors. Action determined by multilevel actors and sectors will help increase resilience in a disaster (Djalante et al., 2011; Ha et al., 2015).

2.3 EMPIRICAL EVIDENCE FROM THREE CASE STUDY AREAS

This chapter explores three case study areas in Indonesia: the urban areas of Jakarta and Semarang City and the rural peatland of Indragiri Hilir (Figure 2.1). All three areas experience land subsidence issues, but public authorities (local governments) and land users respond to it differently. The responses differ in the measures taken by land users and in terms of policy actions.

In this research, several empirical research methods were combined. To reveal responses to land subsidence in the case study areas, governmental and non-governmental reports were analyzed and complemented by interviews with government officials and academics. To analyze land users' responses to land subsidence, surveys of 330 land users in 12 selected subdistricts *(kecamatan)* of affected areas were conducted; all this was further complemented by focus group discussions. Survey respondents were selected based on a combination of three considerations: highest rate of land subsidence, area characteristics (urban and peatland areas), and land use (settlements, industrial or plantation area). Focus group discussions were conducted with community leaders from affected and surrounding areas to determine the community's knowledge of land subsidence.

Figure 2.1 Location of case study area

2.4 ANALYTICAL THINKING AND INDICATORS

The awareness of land subsidence is linked to individual's personal experiences of the problem. These experiences cause individuals to perceive the problem in a different way and influence their perception of the urgency of the problem (Kotter, 2008). Problems that are perceived as a threat to daily life lead people to action. On the contrary, if the problems seem manageable, the affected people's concern tends to wane. Therefore, action is comprised of a combination of individual awareness and sense of urgency. There is no sense of urgency when people are unaware of the problem, and there is no action if the problem seems non-essential to solve. This concept will guide our analysis of public authorities' and land users' responses to land subsidence as found with the help of the above described research tools.

We assessed the response of public authorities and land users in different ways. The response of public authorities was assessed according to the response phases distinguished by Hartman and Spit (2014). The awareness of the public authorities includes knowledge of land subsidence, namely triggers, rate, and impacts. A number of legalized policies related to land subsidence—such as water usage, spatial and disaster management planning, and land

use information—indicate the urgency. Finally, the action is assessed by looking at adaptation and mitigation actions and their effectiveness. The land users' awareness is assessed in terms of their knowledge of the term, triggers, and rate of land subsidence on their land. We built an urgency indicator measured by the range of time taken to respond. We presume that the more time land users take to respond to land subsidence, the less urgent they perceive the problem to be. Finally, the action was assessed by examining the ways and means of self-adaptation and the mitigation of upcoming subsidence (see Table 2.1).

Table 2.1 Response indicators

Response level	Public authority	Land user
Awareness	Knowledge of land subsidence (term, trigger, and rate) Distribution and designed map identification	Knowledge of land subsidence (term, trigger, and rate)
Urgency	Water-related policies Spatial and disaster management plans Land-use information	Range of time to respond after awareness
Action	Adaptation Mitigation	Adaptation Mitigation

2.5 CAUSES AND IMPACTS OF LAND SUBSIDENCE

Land subsidence in the case study areas is not only naturally-induced, but also caused by human-induced processes. For instance, inappropriate policies and human activities in some of the areas stimulated the land subsidence. The land subsidence in the urban coastal area of Jakarta and Semarang City was also triggered by coastal reclamation, according to community representatives. The reclamation increased the surface material load and then accelerated the subsidence. In the rural peatlands, Indragiri Hilir suffers from land subsidence caused by the rapid expansion of coconut and oil palm plantations. Jaenicke et al. (2008) showed that the expansion of plantation areas has released large amounts of carbon into the atmosphere, which has triggered peat subsidence. If the oxidation happens constantly, it will also trigger peat fires and thus contribute to the process of global climate change (Page et al., 2002).

In addition to the direct impacts, such as damage to infrastructures and buildings (Abidin et al., 2013; Phien-Wej et al., 2006), land subsidence has other negative impacts, such as the salinization of coastal areas (Alam, 1996; Milliman and Haq, 1996), the degradation of groundwater, and changes to the water system (Van der Meij and Minnema, 1999). Land subsidence triggers direct economic loss and external costs incurred in the effort to rehabilitate damaged buildings, infrastructures, and farmland (Hu et al., 1997; Warren et al., 1975). Hu et al. (2013) revealed that land subsidence in coastal areas had caused a huge economic loss. In the peatlands, we found that land subsidence had damaged a traditional canal system, leading to the destruction of cultivated areas. If the damage continues to happen, it will cause a loss of economic activity and damage natural resources. If the government is not aware of the

impacts and approves the development of more plantations on peatland, this might trigger wider land subsidence. Therefore, land subsidence affects the environment in various ways.

Our surveys identified six physical environmental impacts of land subsidence in urban areas (see Table 2.2). The table shows the impact percentages, which are heavy impacts regarding damage to houses and infrastructures or facilities and the expansion of the flooding area. According to the table, the land subsidence predominantly affected houses, which comprise more than one third of the total impact in each area. The damage is predominantly in the form of subsided and skewed houses (see Figure 2.2). At the same time, combined with the rise of the sea level and climate change, the land subsidence in Semarang City has enlarged the flooded area, threatened coastal settlements, and triggered extensive damage to infrastructures. The Department of Marine and Fisheries of Semarang City stated that land subsidence stimulated coastal inundation to the extent of a strip between 0.738 km and 5.475 km wide. Along with the inundation, land subsidence initiated coastal erosion from 101 m to 2,540 m in length.

Table 2.2 Physical environmental impacts of land subsidence in urban areas

Impacts	Jakarta		Semarang City	
	Number of cases	Percentage	Number of cases	Percentage
Damage to infrastructures/facilities	54	29.8%	72	30.6%
Damage to houses	73	40.3%	87	37.0%
Cracks in permanent constructions	3	1.7%	17	7.2%
Expansion of flooding area	45	24.9%	56	23.8%
Lowered groundwater elevation	4	2.2%	0	0%
Increased inland seawater intrusion	2	1.1%	3	1.3%
Total	181	100%	235	100%

Source: questionnaire analysis (2016)

(a) (b) (c)

Figure 2.2 Physical environmental impacts of land subsidence in urban areas (2016). (a) Inundated settlement (Jakarta); (b) subsided school (Semarang City); (c) subsided house (Semarang City).

Land subsidence affects not only the urban areas, but also the rural peatland. Our surveys of peatland in Indragiri Hilir found that land subsidence had ruined houses and infrastructures

(see Table 2.3). The damage mostly took the form of leaning houses in capital cities and rural areas. The subsidence also destroyed plantations, such as coconut palm, oil palm, and timber (see Figure 2.3). Local farmers indicated that almost half of all coconut plantations were damaged. Another notable impact is the expansion of the flooded area. In a high rain season, such as December, sinking areas are exposed to a higher level of annual tidal inundation (local name: *pasang keling*). Along with the subsidence, this leads to further damage to houses, infrastructures, facilities, and coconut plantations.

Table 2.3 Physical environmental impacts of land subsidence in rural peatland

Impacts	**Indragiri Hilir**	
	Number of cases	**Percentage**
Damage to infrastructures/facilities	39	19.0%
Damage to houses	75	36.6%
Cracks in permanent constructions	1	0.5%
Expansion of flooding area	9	4.4%
Damage to coconut plantations	46	22.4%
Damage to timber plantations	6	2.9%
Damage to oil palm plantations	29	14.1%
Total	205	100%

Source: questionnaire analysis (2016)

(a) (b) (c)

Figure 2.3 Physical-environmental impacts of land subsidence in rural peatland (2016); (a) Damaged plantation (Indragiri Hilir); (b) flooded environment (Indragiri Hilir); (c) damaged infrastructure (Indragiri Hilir).

Since subsidence is a serious problem in several locations, the public authorities and land users need to be knowledgeable concerning causes and impacts. The awareness of public authorities is clearly important in designing appropriate policies. On the other hand, the land users' awareness is necessary for their own protection. Awareness of predictable hazards might effectively increase people's participation in disaster management (Qureshi et al., 2006)

and their safety (King, 2000). Thus, awareness in managing land subsidence will lead to a sense of urgency and action.

2.6 PUBLIC AUTHORITIES' RESPONSES TO LAND SUBSIDENCE

Public authorities' responses to land subsidence vary depending on their willingness and capacity to acknowledge problems and to respond to them. Appropriate actions are often not taken in urban and rural peatland areas because response types are too varied.

2.6.1 Jakarta

2.6.1.1 Awareness

The Jakarta government gathered information regarding the status of land subsidence from academics, researchers, and NGOs, as well as through self-measurement. As a part of this awareness promotion, the government designed and evaluated maps showing the distribution of land subsidence. The government's awareness was also reflected in Article 77 of the Spatial Master Plan Regulation, which contained information about the affected areas.

2.6.1.2 Urgency

Water-related policies and spatial planning are seen as indirect policies that can be used to manage land subsidence. Regarding water-related policies, the Jakarta government legalized DKI Jakarta Regulation No. 8/2007 and No. 17/2010. Regulation No. 8/2007, Article 23, Section 1 and Section 2, state that every extraction activity of groundwater and surface-water for commercial purposes must be based on governor permits. Moreover, regulation No. 17/2010 regulates a higher tax for groundwater usage in order to limit instances of exploitation. The government then launched the "zero deep well" program to limit groundwater usage by industry and households and move toward a piped water system.

The government also released DKI Jakarta Regulation No. 1/2012 about the Spatial Master Plan and No. 1/2014 about the Detailed Spatial Plan and Zoning Regulation. These policies indicate that all of the areas have already been shaped by certain activities and intensities. The Spatial Master Plan indicates that Jakarta will decrease its disaster risk through adaptation and mitigation activities (Article 6, Section 8). In Article 42, land subsidence is pointed out as a consideration that led to an effort to conserve water resources. Then, Article 77 details areas impacted by land subsidence. Section 4 of Article 44 regulates zero delta development and expanded dike development in areas prone to flooding. Zoning Regulations of Jakarta were designed based on the carrying capacity of the zones. Every zone is subject to regulations, such as an incentive mechanism, prohibited development areas, and prerequisites to develop the zones. However, this regulation still contains an ambiguous plan. For instance, Kamal Muara was designed as a metro area, but was also designated as a special area where resources to prevent inundation and flooding will be allocated.

2.6.1.3 Action

In order to adapt to land subsidence, the Jakarta government has launched programs to limit land users' vulnerability by maintaining drainage, raising houses and settlement infrastructures, and providing water pumps in inundated areas. The government seems more focused on mitigating: building giant sea walls, converting the use of groundwater into piped water for industries, constructing injection wells, monitoring the subsidence, and planting "biopori holes" (i.e., cylindrical holes that help storm water infiltrate into the ground). One of the mitigation efforts to deal with flooding due to land subsidence and the rise of sea levels is a mega project of the National Capital Integrated Coastal Development (NCICD). However, the government must consider that this project might increase the water level in drainage systems because of the boundaries in its downstream area. They must also consider possible rejection from people living in the coastal settlements, as the project widens the inundation areas.

To limit the use of groundwater, the government prevents industries from extracting water from unconfined aquifers of groundwater, but individuals are allowed to extract limited amounts of it. Regarding land utilization, zoning regulations are used to prevent activities that might accelerate subsidence in affected areas. The government collected people's needs and delivered plans using electronic or printed media, public discussion *(Musrenbang),* workshops, and focus group discussions. For land users, the government developed a website containing detailed spatial plans and zoning regulations that can be accessed by anyone. The government disseminates land allocation and development rules by revealing this information to the public.

2.6.2 Semarang City

2.6.2.1 Awareness

The Semarang City government has already determined the land subsidence status in affected areas and the related distribution, triggers, and impacts. Affected areas, such as the Tanjung Mas area, have already been prioritized in spatial planning as protected areas, especially those in the coastal areas that are influenced by daily tidal inundation.

2.6.2.2 Urgency

The Semarang City government has designed policies and planning documents based on the status of the land subsidence in certain areas. Regarding water-related policy, the government released Semarang City Regulation No. 8/2011, which decrees a 20% tax on groundwater extraction. The government also released Semarang City Regulation No. 2/2013 about Groundwater Management, which inventories and manages groundwater in the groundwater basin of Semarang City. Article 19 of this regulation states that groundwater conservation is controlled by monitoring and production of wells. Moreover, in Article 22, Section 4, the government bans people from extracting groundwater in critical zones, for recovery purposes. The government has also legalized Semarang City Regulation No. 14/2011

about the Spatial Master Plan, which lays down rules and allowed activities in both protected and previously-built areas. Section 4 of Article 7 requires the erection of coastal dikes and rehabilitation of coastal green areas to protect coastal and inundated settlements. However, in the same article, the government also designates the coastal areas as reclamation areas, which—according to the local community—caused subsidence due to the increased material load. This regulation also designates some strategic areas as areas for economic growth in the affected areas. However, it seems that land subsidence is not a strategic issue in planning policies since it is not a priority in any policies in Semarang City.

2.6.2.3 Action

Land subsidence is considered a part of coastal erosion and inundation problems. The government adapts to land subsidence by renovating damaged houses and streets, providing water pumps, and raising local streets. In 2014, order to reduce flooding, improve the drainage system, and deal with clean water problems, the government launched a national project called Integrated Water Resources and Flood Management Project for Semarang. In 2014, Semarang City prioritized projects such as rainwater harvesting and mangrove planting to increase the land users' resilience in the face of land subsidence and other environmental problems. It is expected that by providing clean water for those people, the amount of groundwater extraction could be reduced. However, the influence of these projects on reducing land subsidence is still both limited and debatable.

Preventative activities were also undertaken by the government, such as building dikes to prevent inundation, minimizing construction load by reconstructing damaged houses using lighter materials, conserving mangrove ecosystems, digging communal wells, and limiting groundwater extraction in affected areas. The government planted mangroves as a sea wall in 2002 that by 2014 had reclaimed half of the 1.96 square km of lost fishponds. In order to disseminate land-use information, the government uses electronic and printed media, as well as interactive education gaming to raise awareness and inform people of the government's plans.

2.6.3 Indragiri Hilir

2.6.3.1 Awareness

The government of Indragiri Hilir has only just begun to raise awareness since it is still in the process of establishing details related to land subsidence. Although the government is aware of the problem in general, it has not created distribution maps showing land subsidence.

2.6.3.2 Urgency

The government instated Indragiri Hilir Regency Regulation No. 21/2010, which imposes a 20 per cent tax on groundwater usage. However, because land subsidence in Indragiri Hilir is predominantly triggered by the natural consolidation of soil, construction load, and plantation

activities, this regulation does not really result in decreased land subsidence. People already prefer to use rainwater over groundwater for their daily needs, since the quality of groundwater in this area is poor.

Spatial planning policy in Indragiri Hilir depends on the spatial planning of Riau Province. Since the spatial planning of Riau Province has been postponed, we analyzed two spatially related policies: the detailed spatial plan of Tembilahan (capital city of Indragiri Hilir Regency) and the fast-growing strategic area plan. Article 14 of the Indragiri Hilir Regency Regulation No. 28/2005 about the Detailed Spatial Plan of Tembilahan establishes Tembilahan as an area for multi-activity development (i.e., for trading and service, government offices and settlement). In addition, Article 2 of the Indragiri Hilir Regent Regulation No. 55/2014 about the Fast-Growing Strategic Area of Indragiri Hilir declares some areas that are affected by land subsidence to be fast-growing strategic areas. Since the land subsidence in peatland area of Indragiri is also caused by the physical development, allocating the peatland as regional growth area seems problematic and might increase the subsidence.

2.6.3.3 Action

Even though the government has not yet legalized policies related to land subsidence, it has taken action to adapt to the problem, such as reconstructing damaged streets, but the changes are still limited. In order to prevent inundation (an indirect result of land subsidence), the government has built and rehabilitated gullies around settlements.

Comparing the responses of local governments is important in order to design or redesign appropriate policies based on the level of their responses. We found that local governments have already responded to land subsidence, but to varying degrees (see Table 2.4). The level of awareness on this issue is higher in urban areas than in rural peatland areas, which is understandable since urban areas are more planned regarding infrastructure and usually receive more attention in terms of improvements. Land subsidence is not the main concern of governments and is often perceived as a "sleeping disaster," which may explain some of the ignorance concerning this problem. We did not find a single policy released by governments that is solely focused on land subsidence. Ignoring land subsidence as a strategic issue in environmental policies has multiple impacts: Governments have less knowledge of land subsidence status, a lowered sense of urgency, and an unstructured action plan. Although they have already designed and regulated numerous policies and were supported by the people's involvement, the degree of response is still low and varied (see Figure 2.4).

Table 2.4 Level of local governments' responses to land subsidence

Local government	Awareness	Urgency	Action
Jakarta	++++	+++++	+++
Semarang City	++++	+++	++
Indragiri Hilir	+	+	+

Source: Data analyses (2016)

The difference in responses between Jakarta and Semarang City is also influenced by their different degrees of autonomy, even though they are in the same area (i.e., urban coastal). Jakarta, as a provincial government, has autonomy to legalize policies with the only possibility of intervention being from the central government; although Semarang City also has autonomy, it must consider the possibility of intervention by both the central and provincial governments. Even with the same level of autonomy, the response level between Semarang City and Indragiri Hilir is dissimilar because of such factors as different land utilization (urban and rural peatland) and the respective government's willingness to cope with the problem. In many situations, responding to land subsidence requires collaboration among different governmental bodies, which is unfortunately lacking. As a result, appropriate policies have not been designed or implemented correctly, or are not implemented at all.

2.7 LAND USERS' RESPONSES TO LAND SUBSIDENCE

The degree of awareness among land users regarding land subsidence in urban and rural peatland area is more or less similar (Figure 2.5). As shown in the figure below, more than 80 per cent of all land users could explain what land subsidence is. However, even though knowledge is increasing, we found that some of the land users do not ascribe much importance to land subsidence and its impacts. Knowledge about subsidence triggers and rates is not as prevalent as an understanding of the basic term "land subsidence." In Jakarta and Semarang City alike, land users are even less knowledgeable about the rate of subsidence than about the triggers, because they can usually observe the triggers during their daily activities but cannot measure the exact rate of land subsidence. Land users need to pay more attention to the triggers and subsidence rate as this knowledge will greatly affect how well they adapt to and mitigate the effects of land subsidence.

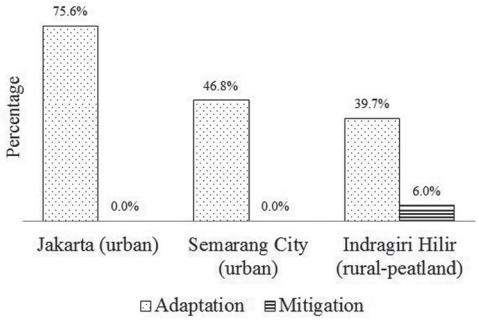

Figure 2.4 Land users' responses to land subsidence

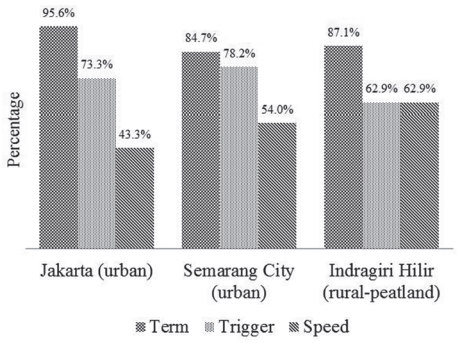

Figure 2.5 Land users' awareness of land subsidence

Figure 2.4 shows that the percentage of land users taking action regarding land subsidence in the case study areas is quite varied. As the figure shows, urban land users are better

adapted than land users in a rural peatland area, but are not necessarily better at mitigating the problems. More than three quarters in Jakarta and almost half of all affected land users in Jakarta and Semarang City have taken various steps toward adapting to land subsidence. Meanwhile, in Indragiri Hilir, only about one third of all affected land users have adapted to land subsidence in any way. Impacts in urban areas are greater in scale and intensity than they are in rural areas, and the way people tend to adapt to the problems are vastly different. However, only in rural areas have land users taken pre-emptive steps to mitigate impending problems, though this applies to only 6 per cent of them. Land users in the urban area have not taken such steps because the local governments have already taken some actions. The government in rural peatland areas has not yet sprang into action.

We also found that the affected land users could potentially contribute to and support local governments in solving the problem through self-adaptation and mitigation (see Table 2.5). The land users in several locations in the urban areas utilized light materials such as wood and battens to repair their damaged houses in order to reduce the weight—the same method used by governments. Even though the land users in Semarang City did not individually mitigate land subsidence, as a group they operate communal wells to restrict groundwater exploitation by land users. Land users in rural peatland areas must address some concerns because almost two thirds of them have not adapted to the problem. However, from a small group of the land users, we found best practices for mitigation methods. In peatland, the land users utilize wooden pillars in the house foundation to prevent the houses from leaning. They also built houses on stilts *(rumah panggung)* to prevent construction loads and cracked floors caused by land creep caused by subsidence. Almost all of the affected land users in urban and rural peatland areas were still focusing their efforts on adapting to current problems rather than trying to prevent future problems.

Table 2.5 Land users' responses to land subsidence

Case study area	Response	
	Adaptation	**Mitigation**
Jakarta	Raising houses, using water drainage pumps during inundations, and using light materials to repair damaged houses	Using communal wells and bathrooms (as a group)
Semarang City	Raising houses and streets, using water drainage pumps during inundations, and using light materials to repair damaged houses	Using communal wells and bathrooms, replanting mangroves, and constructing dikes (as a group)
Indragiri Hilir	Digging gullies around plantation areas to drain water from the land, repairing damaged houses and floors, and replanting damaged plantations	Building and repairing dikes, replanting mangroves, utilizing wooden pillars in house foundations, and using light materials to build houses

Source: Field surveys (2016)

As shown by the table, land users have adapted inappropriately to land subsidence. Some forms of adaptation might increase the problem if they strengthen the triggers. For instance, in the coastal areas of Jakarta and Semarang City, land users raise the floor of their houses to avoid one effect of subsidence, namely inundation. In the short term, this seems to solve the problem, but in fact the practice increases the load of surface materials, which leads to subsidence. Another example comes from land users in Indragiri Hilir who dig gullies around plantation areas; this could worsen subsidence due to loss of carbon dioxide from the drained gullies. Therefore, the land users must be given precise information regarding the status of land subsidence and appropriate ways to deal with the problems wisely.

2.8 MATCHING THE RESPONSES OF PUBLIC AUTHORITIES AND LAND USERS

The responses of the public authorities and land users must be consistent throughout the process from awareness to action. The heightened awareness must be followed up with appropriate and sufficient action. We found that each local government responded to land subsidence in a different manner (see Figure 2.6). These disparities could be remedied by learning from other areas with similar problems. The Semarang City government should adopt the Jakarta method of allocating zones in detailed spatial plans and of strengthening control over groundwater extraction by introducing disincentives for development, especially in the coastal area. These measures should be simple to adopt, since both cities are located in urban coastal areas. The Jakarta government must strengthen the implementation of zoning regulation to limit land subsidence triggers as well as select appropriate zones for economic growth, especially in critical areas. The Indragiri Hilir government must hurry to raise awareness of this problem by recognizing the status of land subsidence, recognizing the urgency of the problem, and letting this urgency inspire action. Although the characteristics of the area of Indragiri Hilir are different from the other two areas, some efforts to increase awareness can be adopted. However, the governments must also consider the response of land users to improve the governments' response.

Figure 2.6 also shows inconsistency among land users concerning taking action after acknowledging the problem and establishing its urgency. As shown by the figure, four fifths of land users are aware of the term "land subsidence." More than three quarters of land users recognized the triggers. However, in urban areas, less than three quarters of land users are familiar with the rate at which it can occur. The high degree of awareness is followed by a similarly high sense of urgency among land users in Semarang City, but not in Jakarta. In the rural peatland of Indragiri Hilir, although the rate of land subsidence is the slowest here and its effect on daily activities is less substantial than in urban areas, the sense of urgency is higher than in the other two locations. We found that the urgency is not related to either the rate of land subsidence in their neighborhood or to the effects of land subsidence on their daily activities. Regarding action, land users lack the means to mitigate land subsidence even though they recognize the triggers and rate of land subsidence in their environments. Downs

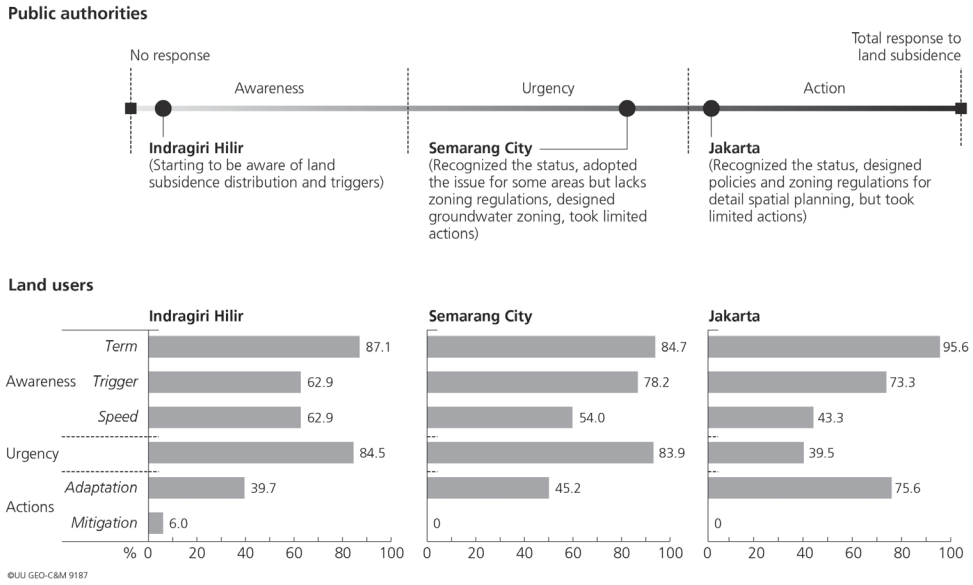

Figure 2.6 Responses of public authorities and land users to land subsidence

(1972) stated that the enormous and costly efforts required to solve the problems discouraged people from taking action, even though they understood that it was urgent.

Matching the responses of the public authorities with those of land users, we identified three types of responses to land subsidence: 1) high degree of response from public authorities, but low response from land users, 2) low response from public authorities, but high response from land users and 3) moderate response from both public authorities and land users. Since the degree of response between actors is dissimilar, it seems that the public authorities must provide the ability to increase land user's awareness (Kusumasari et al., 2010). The actors must also collaborate to solve land subsidence and prevent future problems by increasing the sense of urgency, improving policies and action, or boosting the self-initiative of affected land users. In urban areas, where land subsidence is mostly caused by groundwater extraction, the government could impose groundwater regulations on all groundwater users (Endo, 2011). In addition, in rural peatland areas, the public authorities must increase the response by increasing awareness, since land users have already started taking action. Based on these conditions, the actors should consider their readiness to respond to land subsidence by starting to pay attention to the problem.

2.9 CONCLUSION

In current disaster risk management, the response of actors in the disaster management cycle is crucial to reduce the impact of a disaster. Baas et al. (2008) and Kusumasari et al. (2010) show that response during pre-disaster periods will lead public authorities to design appropriate

policies and action, as well as increase people's awareness of potential problems and possible future losses. However, with regard to land subsidence management, the DRM cycle, which was designed for single-shock disasters, appeared a less suitable option. This is because land subsidence is characterized as a sleeping, or silent, disaster (Abidin et al., 2013) that happens continuously over a long period of time and beyond a single phase of disaster management. As the impacts of land subsidence are serious and will be worsened by climate change (Nicholls, 1995; Wang et al., 2012), the public authorities and land users must select appropriate means to increase their capacity to adapt to land subsidence.

In this chapter, we showed that the response of public authorities and land users to land subsidence varies widely, as is also shown by Holzer (1989) and Endo (2011). Our research found that this could be due to three issues: the government level, land use allocation, and actors' knowledge of this problem. For the first issue, we argued that the lower government level shows the lowest response to land subsidence, due to its lack of power to make decisions. Madan (2015) shows that this might be expected because of the lack of local government's authority to take immediate decisions on the complex structure of governments. The policy from lower level governments was mainly derived from the higher level government including disaster management, spatial planning, and zoning regulation, which highlighted the dependency of local governments in the Indonesian context (Hudalah and Woltjer, 2007; Kusumasari and Alam, 2012). The second aspect—the governments' response—seems to be influenced by the intensity of the development and activities, in both urban and rural peatland areas. The response is higher in areas that are more dynamic and have a higher population density. The different responses can be seen from international experiences (Frazier et al., 2013; Lall and Deichmann, 2012). The need of space for development has been forcing governments to allocate areas to meet fundamental needs such as housing, industry, and agriculture, but at the same time, also trying to minimize the impact of land subsidence. Similar governmental reactions can be found in Hu et al. (2004). The third aspect influencing governmental response to the land subsidence problem concerns their knowledge. We found that a profound lack of knowledge has caused a sort of "ignorance" of land subsidence problems in all case study areas. Land subsidence appears to not be a high priority for public authorities. Since subsidence is not prioritized, there are no programs and strategies to deal with its impact. Furthermore, we found that the adaptation and mitigation programs concerning land subsidence were not fully integrated with development policies. This is common, as literatures (Rodolfo and Siringan, 2006; Wang et al., 2012) show that in many cities, the government does not pay much attention to the land subsidence issue.

Based on our analysis of government responses, we argued that governments might benefit from more collaboration among the various levels of government. Yet, in their responses to land subsidence, governments could also benefit by involving land users in the government agenda to improve the hazard mitigation, as mentioned by Pearce (2003).

The typology mentioned requires different interventions and strategies for each type to successfully reduce the costs of land subsidence. It has many practical applications to create

effective forms of land subsidence management, in which both public authorities and land users collaborate. Researchers (Djalante et al., 2011; Kusumasari et al., 2010; Pearce, 2003) suggest integrating this into single forms of management, which can be translated into programs that accommodate all interests and diminish limitations. In addition, the quality of the programs will be improved if the involved actors are selected based on their capacities (Hartmann and Spit, 2015).

As land subsidence occurs continuously, the condition of the affected areas can only get worse. In the end, the longer governments and land users ignore land subsidence, the longer the area and the people will suffer from the problem, causing the areas to no longer be habitable.

Living in a bottomless pit: households' responses to land subsidence, an example from Indonesia

3

This chapter is an adapted version of the article: Saputra, E., Spit, T., & Zoomers, A. (2019). Living in a bottomless pit: Households' responses to land subsidence, an example from Indonesia. *Journal of Environmental Protection, 10*(1), 1-21.

Abstract

Land subsidence has severe physical and economic implications for both areas and people. Numerous scholars have shown that land subsidence has had massive impacts at global, national, and regional levels, and that the impacts were usually responded to by the government. However, little attention has been paid to what land subsidence means to people's daily lives and how much it costs them. To fill that gap, this chapter draws on empirical research carried out in three areas in Indonesia to provide a better understanding of what land subsidence means to households, and how they respond to the consequences and how much it costs them to do so. An analysis of a survey of 330 households shows that they have been suffering from various severities of impacts of land subsidence for an extended period. Whereas some of the households respond to the impacts by making small preparations or adapting to the damages, others can do nothing due to a lack of money and their continuously declining earning capacity. Thus, the affected households are effectively throwing money into a bottomless pit. We argue that these households must escape the vicious circle caused by land subsidence by increasing their income capacity or even abandoning the affected areas.

Keywords: Land Subsidence, Households, Impacts, Responses, Income Earning Capacity

3.1 INTRODUCTION

Land subsidence is a gradual settling or sudden sinking of the earth's surface due to the movement of earth materials (Galloway et al., 1999). It occurs gradually and has many impacts on both urban and rural areas. It destroys houses and facilities (Abidin et al., 2011; Marfai and King, 2007; Phien-Wej et al., 2006), damages plantations and their drainage infrastructure (Gambolati et al., 2006), and enlarges inundated areas (Chaussard et al., 2013; Wang et al., 2012). These impacts cause direct economic losses (Phien-Wej et al., 2006; Warren et al., 1975).

The reported economic cost of long-term land subsidence is enormous. For instance, Warren et al. (1975) showed that in just 30 years (1943-73), total land subsidence-related costs in Texas (USA) amounted to about US$ 113.6 million. In Tianjin (China), land subsidence in 2007 led to severe economic losses, amounting to as much as US$ 18.19 billion (Lixin et al., 2010). A recent assessment showed that in Arizona (USA), land subsidence had led to a fall in the prices of properties in affected areas (Yoo and Frederick, 2017). At the household level, land subsidence impacts both directly—in the form of damage to houses, buildings and infrastructures—and indirectly, namely on people's environmental, economic and social status, as the secondary consequences of land subsidence (Abidin et al., 2015).

As land subsidence is a massive problem, affected people should respond to it with all their capacity. People's ability to deal with the impacts is positively correlated with their responses and ability to adapt (Brooks, 2003; Smit and Pilifosova, 2003). The fact that land subsidence happens and affects people for an extended period of time necessitates an appropriate response and sufficient capacity to adapt. The question then is: Can affected households deal with the consequences of land subsidence? The answer to this question is particularly needed, since research on people's responses to and the impacts of land subsidence at the household level is limited. To date, most such assessments have been at a national and regional level or as part of physical impact analyses (e.g., see Abidin et al., 2015; Abidin et al., 2016; Carbognin and Tosi, 2002; Xu et al., 2016).

Therefore, this chapter presents a bottom-up assessment of what land subsidence means to households, how they respond to the consequences, and how much they spend on dealing with the impacts. Understanding the impact of land subsidence on the income of affected households is crucial, because a comprehensive analysis of the economic loss can help to improve risk mitigation and reduction or enhance pre-impact prediction (Kreibich et al., 2014; Lindell and Prater, 2003). Furthermore, understanding the responses of affected people will reveal their readiness to reduce impacts and their exposure (Adger et al., 2005). This chapter shows how widespread the problems are in three areas of Indonesia that have been suffering unceasingly from land subsidence due to numerous triggers, leading to severe physical and socioeconomic impacts on both the areas and their populations (Abidin et al., 2016; Chaussard et al., 2013; Erkens et al., 2015; Hooijer et al., 2012; Marfai and King, 2007; Marfai and King, 2008a; Saputra et al., 2017; Thorburn and Kull, 2015).

This chapter is structured as follows. The following subsection discusses the concepts of adaptation and adaptive capacity. Subsection 3.3 details the research location and research methods. The results are presented in Subsection 3.4. The chapter concludes with a discussion (Subsection 3.5) and the conclusion (Subsection 3.6).

3.2 ADAPTATION AND ADAPTIVE CAPACITY TO DISASTERS

People are socially vulnerable if they are exposed to natural hazards but cannot respond to or recover from them (Cutter and Finch, 2008, 2301). Their vulnerability is also influenced by their inability to cope with pressure on their livelihoods or wellbeing (Füssel, 2012). Thus, socioeconomic status is one of the leading factors affecting social vulnerability (Siagian et al., 2014): The less income affected people have, the more vulnerable they are (Adger, 1999).

The question is, how can such people deal with their vulnerable status? Brooks (2003) explains that vulnerability can be reduced through adaptation, which refers to changes in processes and practices to limit potential damage (Smit and Pilifosova, 2003). Reuveny (2007) argues that whereas some people adapt to problems by reducing impacts or repairing the damage as a short-term solution, others do nothing. Yet others respond to catastrophes by moving away (Loebach, 2016). However, for reasons related to economic and social relationships, most affected people are reluctant to move (Harwitasari and van Ast, 2011; Koubi et al., 2016). Thus, our research focus was on households that wanted or needed to stay in these areas and thus did not consider relocation.

The responses of affected people who remain in an affected area should be directed toward reducing their vulnerability. Adger et al. (2005) explain that an adaptation will be valuable if it reduces impacts and exposure. However, some affected households cannot minimize the impact of disasters because of their limited adaptive capacity, namely their limited ability to adapt to changes (Shaw et al., 2013). Smit and Wandel (2006) and Shaw et al. (2013) assert that the adaptive capacity of affected people influences their response. The socioeconomic status of affected people is one of the adaptive capacities that is positively correlated with their ability to decrease their vulnerability (Adger, 1999; Alwang et al., 2001; Cutter et al., 2003).

Without neglecting other factors, the focus of this chapter is on household income, as representing socioeconomic status. Income determines a household's ability to access money directly when it is needed. The availability of income increases the number of potential responses, which reduces a household's vulnerability (Blaikie et al., 2014; Pelling, 2010; Yohe and Tol, 2002). Even though other external resources (e.g., social capital from the extended family or neighbors) are needed, this income, as well as its sustainability, is crucial to covering the recurring costs because it can be accessed when required.

3.3 RESEARCH LOCATION AND METHODS

3.3.1 Study areas

Data were collected from urban, coastal, and peatland areas in Indonesia, namely Jakarta, Semarang City, and Indragiri Hilir, respectively (see Figure 3.1). Various urban, coastal, and peatland areas of Indonesia suffer from continuous land subsidence, which will become worse since the activities in these areas are increasing. These case study areas are the areas that experience the highest rate of and most damage from land subsidence, which was determined through a literature study (Abidin et al., 2011; Lubis et al., 2011; Marfai and King, 2007; Saputra et al., 2017), official reports from public authorities, and conversations with key persons from local government offices. The different characteristics of the areas promoted the understanding of the various consequences of land subsidence for households and their responses to those consequences.

Figure 3.1 The study areas: Jakarta, Semarang City, and Indragiri Hilir

Urban and coastal areas of Jakarta and Semarang City have long suffered from land subsidence (Chaussard et al., 2013; Lubis et al., 2011; Marfai and King, 2007). Groundwater exploitation and construction load due to rapid urban development have accelerated land subsidence and increased its impacts (Abidin et al., 2011; Marfai and King, 2007). The Indonesia Climate Change Sectoral Roadmap (ICCSR) report shows that due to land subsidence combined with sea level rise and higher tides, by 2100 most of the coastal areas in Jakarta and Semarang will be under 5 m of seawater, while the coastline will have receded by up to 10 km (Bappenas, 2010). Furthermore, rural peatland areas, such as Indragiri Hilir, are being overexploited for large-scale oil and coconut palm plantations, which lead to an influx of more people (Budidarsono et al., 2013). The peatland conversion for plantations, followed by drainage, has increased carbon dioxide emissions (Lee et al., 2014), which leads to peat subsidence (Hooijer et al., 2012; Saputra et al., 2017). Table 3.1 shows how severely these areas are affected by land subsidence.

Table 3.1 Land subsidence in the case study areas

Case study area	Characteristics	Sampling area (subdistricts)	No. of respondents	Land subsidence rate	Land subsidence triggers	Land subsidence impacts
Jakarta (urban and coastal area)	One of the world's megacities Population density: 15,052 people/km^2 Annual population growth: 1.11 %	Cengkareng, Penjaringan, Tanjung Priok	90	1–15 cm/year; in some areas 25–28 cm/year (Abidin et al., 2011)	Groundwater extraction, construction load, natural consolidation (Abidin et al., 2011)	Cracking of permanent infrastructure, expansion of inundated areas, increasing inland seawater intrusion (Abidin et al., 2011)
Semarang City (coastal area)	Located on an alluvial plain Population density: 4,373 people/km^2 Annual population growth: 1.71 %	Genuk, Semarang Utara, Tanjung Mas, Tugu	124	8–13.5 cm/year (Chaussard et al., 2013; Lubis et al., 2011)	Groundwater extraction, alluvium soil consolidation, construction load (Marfai and King, 2007)	Damage to urban infrastructures, coastal inundation (Marfai and King, 2007)
Indragiri Hilir (peatland area)	Intensive expansion of oil and coconut palms Population density: 60 people/km^2 Annual population growth: 1.92 %	Enok, Tembilahan, Tembilahan Hulu, Batang Tuaka, Tempuling	116	4–6 cm/year (Saputra et al., 2017)	Intensive agricultural activities – mainly oil and coconut palm (Hooijer et al., 2012)	Damage to houses, infrastructures and plantation areas (Saputra et al., 2017)

3.3.2 Data collection and presentation

This survey research combines a qualitative and a quantitative approach, known as mixed-method research (Tashakkori and Teddlie, 2010). In this method, the two approaches complement each other by minimizing inaccurate findings (Philip, 1998). This chapter combines the use of qualitative and quantitative data and methods to answer the research questions.

Data were collected through surveys over a three-month period in 2015. During the surveys, in-depth interviews with respondents were carried out. A two-stage sampling method was used to select the respondents. In the first stage, three areas that represent urban, coastal, and peatland areas were chosen. Then, in the second stage, random sampling was used to select households in the three areas to be interviewed and to complete the questionnaire. In these surveys, the household was the analyses unit, and its head was the respondent (or, if the latter was absent, the spouse of the head of household). Before selecting the respondents, local community leaders in the case study areas were interviewed to discuss the proposed respondents, that is, who were most prone to and affected by land subsidence, and ways to interact with them. In all, 330 respondents in 12 subdistricts from all case study areas were selected as respondents. This led to 90, 124, and 116 households in Jakarta, Semarang City, and Indragiri Hilir, respectively, being interviewed for 30–45 minutes. The respondents were asked about what land subsidence means to households, how they respond to the consequences, and how much they spend on dealing with the impacts.

Land subsidence has both direct and indirect physical impacts on households (Abidin et al., 2015). These impacts were combined to define the impacts of land subsidence on affected households in the case study areas. Impacts were categorized as either single types of impact or multiple types of impact. The multiple types of impact are the stronger impacts, since they are caused not only by land subsidence but also by other hazards. Some households suffered from a single type of impact whereas others suffered from multiple types.

Furthermore, the responses of the affected households to the impacts were classified according to the response categories established by Reuveny (2007, 657): 1) stay put and do nothing, accepting the cost; 2) stay put and mitigate the changes; or 3) leave the area. A modification was made by dividing the mitigation part into two, namely repairing and adapting to the damage. The survey collected households' responses from the first time that they had experienced land subsidence.

In addition, to define the cost of dealing with the impacts incurred by affected households, we modified and used the classification of the cost of disaster developed by Mechler and Bouwer (2015), which divides the cost into damage costs or losses, adaptation costs and residual costs. The adaptation costs and damage costs (or the decrease in earning capacity) are used in this chapter. Adaptation costs were determined from the costs of the adjustments, while the decrease in earning capacity was derived from the consequences for household's sources of income, such as ponds, oil, and coconut palm plantations, and fishing grounds. The household income was used to represent the socioeconomic capacity of the affected household to deal with the impacts of land subsidence.

Data were analyzed using quantitative and qualitative methods. The quantitative data were processed using SPSS Statistics software to reveal the distribution of the severity of impacts of land subsidence on affected households, the cost of their responses to land subsidence, and their loss of income due to land subsidence. The qualitative data were manually grouped into their thematic analyses, which were used to support the quantitative analyses. Some of the data are presented in the form of respondents' quotations.

3.4 RESULTS

This Subsection first presents the impact of land subsidence on households and then discusses the range of responses to the impacts and their loss of income, which was influenced by land subsidence.

3.4.1 Impacts of land subsidence on households

Of the 330 surveyed households, 291 (88%) had been suffering from various direct and indirect impacts of land subsidence for various lengths of time. The direct impacts were in the form of damage to houses, plantations, ponds, mangroves, and land (Figures 3.2(a) and 3.2(c)). Damage to houses was mainly in the form of the subsiding, tilting, or cracking of walls and floors, and the infiltration of water from beneath floors. In addition, numerous pond owners in coastal areas had suffered damage to their ponds, leading to the escape of fish, crabs, and prawns. The indirect impacts were on the environment and social status, such as the expansion of daily inundation (Figure 3.2(b)), the worsening of annual flooding impacts in rural peatland areas, the lowering of the groundwater level, and a decrease in the value of properties. Other indirect consequences were health and psychological problems resulting from the daily inundation and unhealthy houses. The impacts had become worse the longer people had been affected by subsidence. One respondent in Semarang City said: "We have been experiencing sinking for years. Our house was damaged; the seawater floods our house every day. It is becoming deeper year after year. The longer we live here, the more severe the flooding."

(a) (b) (c)

Figure 3.2 Impacts of land subsidence (2015): (a) subsided house (Tanjung Mas, Semarang City); (b) daily inundation (Penjaringan, Jakarta); (c) damaged plantation (Enok, Indragiri Hilir)

Table 3.2 Percentage of affected households based on the severity of impacts

Location	Rate of land subsidence	Severity of and the most common impact(s)		Number of affected households
		Single type of impact	Multiple types of impact	
Jakarta	1–28 cm/year	20.2%; expansion of daily inundation / flooding	79.8%; damage to the house, expansion of daily inundation, damage to ponds / garden / paddy field	89
Semarang City	8–13.5 cm/year	14%; damage to the house	96%; damage to the house, expansion of daily inundation, damage to ponds / plantation, damage to mangrove, health problems	121
Indragiri Hilir	4-6 cm/year	71.6%; mostly damage to the house or plantation	28.4%; damage to the house, expansion of inundated area, damage to plantation	81
Total		32%	68%	291

Source: questionnaire analyses (2015)

The severity of the impact of land subsidence on households was diverse. Although some households had suffered only a single type of impact, most had suffered multiple types (see Table 3.2). For instance, the subsided settlement in the coastal area had also suffered from permanent inundation, since the area is also affected by the rise in sea level. Using this logic in our case study areas, the households in the coastal areas of Semarang and Jakarta had suffered from a strong impact because the households were also prone to other hazards, such as tidal inundation and sea level rise. The combination of these hazards with land subsidence had caused households to suffer from the enlarged inundated area. This finding supports those of Wang et al. (2012) and Warren et al. (1975), who showed that the combination of coastal flooding, sea level rise, and land subsidence had caused a permanent inundation.

Our findings show that in different geographical areas, the impacts of land subsidence were also different. Their association with activities in such areas and the existence of other hazards also influenced the variation of the impacts.

3.4.1.1 Impacts of land subsidence on households in urban areas: Jakarta

In urban and coastal areas of Jakarta, most of the affected households had been experiencing subsidence for 15–25 years. Most of the properties and land of the households had sunk about 100–150 cm; some had sunk as much as 200 cm. Of all of the affected households, about two fifths had suffered a single type of impact, namely the expansion of either flooding or the daily inundation. In some areas of Jakarta that were far from the coast but close to the river, the affected households suffered mostly from damage to the house (i.e., subsided), or the deepening of flooding from the river surrounding the area or runoff from the rain. The affected households in the coastal area had experienced the expansion of the daily inundation.

Furthermore, the rest (i.e., more than three fifths) had suffered multiple types of impact (Table 3.2). The impacts were a combination of direct and indirect impacts, which were mainly damaging to houses, followed by the expansion of the inundated or flooded area. It was mostly the affected households in the two subdistricts of Tanjung Priok and Penjaringan that experienced these impacts. In addition, about 7% of affected households in Cengkareng had suffered damage to their houses and plantations (i.e., gardens or paddy fields).

3.4.1.2 Impacts of land subsidence on households in coastal areas: Semarang City

The households in Semarang City had suffered the most since most of them had been experiencing subsidence for about 25 years. Of the affected households, just less than one fifth had experienced a single type of impact; the rest had suffered multiple types (Table 3.2).

The impacts of land subsidence in coastal areas are the most severe, since such impacts are aggravated by coastal erosion and the rise in sea level. This is why in Semarang we found that land subsidence had drowned a vast number of ponds and mangrove ecosystems, which had been sources of income for many of the affected people. In addition, the combination of those hazards had increased the frequency, volume, and depth of inundation. Worsened by the unsanitary condition of their houses and the drainage around the settlement, the inundation had caused health problems for 47 households. The inundation was always followed by rubbish flowing from the sea into the settlement. Most members of the households, mainly the children, suffered from skin diseases, diarrhea, and breathing problems. A respondent in Tanjung Mas told us: "Land subsidence causes our house to be flooded by seawater every day. The water is dirty. My children get itchy."

At the subdistrict level, households in Genuk, Tanjung Mas, and Tugu had suffered even more because most of them had experienced very severe impacts, namely damage to houses, followed by the expansion of the daily inundation, damage to ponds, and health problems. To make the impacts more complicated, in Tanjung Mas and Genuk almost all affected households have two inundations a day, as a result of land subsidence combined with sea level rise and coastal erosion. The respondents indicated that inundation is becoming more severe, more extensive, and deeper due to the continuous sinking of their houses. Thus, the other hazards have made the impacts of land subsidence bigger and more serious.

3.4.1.3 Impacts of land subsidence on households in peatland area: Indragiri Hilir

Households in the rural peatlands of Indragiri Hilir had mainly suffered from a single type of impact, namely damage to their houses or plantations (Table 3.2). The damage to the houses was mostly in the form of the houses and their piles sinking or tilting. Most of the sinking houses were located in the plantations that were surrounded by drainage channels. Because most of the affected households had been suffering from land subsidence for only 5 years and most of their houses and plantations had sunk only about 40 cm, land subsidence had had a

minimal impact, compared with other areas. Thus, the low level of the severity of the impacts was influenced by the short duration and slow rate of land subsidence.

The damage to plantations and the expansion of inundated areas also had a severe impact on the households. Almost all of the plantation areas around the Indragiri River suffer from the highest annual flood (the *pasang keling*). Our interviews revealed that the inundated and flooded areas around the plantations were expanding year by year, triggered by the gradual sinking of the plantations. Regarding the damage to plantations, a peasant in Enok stated: "The land on my plantation is sinking. The roots of the coconut palms are exposed higher above the ground than when I planted them." In addition, peat subsidence in the plantation had also caused the coconut and oil palms to lean and die off, and the drainage channels were breached. Therefore, in peatland areas, land subsidence had seriously damaged not only houses but also plantations, which are the source of income of many affected households.

3.4.2 Responses of affected households to the impacts of land subsidence

Considering the repeated and severe impacts of land subsidence on the affected households over an extended period of time, we expected that all of them (291 households) would have responded to the impacts effectively. However, we found that just a little over half of them (55.3%) had taken measures. Thus, the affected households were categorized into 1) those who did nothing or made minor repairs, and 2) those who adapted to the damage.

3.4.2.1 Do nothing or repair the damage

The households that regarded the impacts as severe but did not have enough money to take adaptation measures, and those that regarded the impacts as not yet important enough to be responded to (i.e., they intended to make some adjustments after more significant impacts occur), had decided to do nothing or to make minor repairs.

Of the affected households, about 44.7% (130 households) had not responded to the impacts as they lacked the money to do so. A respondent in Semarang City told us: "My house is sinking every year. About 15 years ago, I couldn't touch my rooftop, but now I can! I don't have enough money to raise the roof. I'll wait for several years, and then see what I can do." Furthermore, households that had suffered multiple types of impact were not inclined to adapt to the problems. Our research indicated that of the households that had not responded, 60% had suffered from strong impacts.

However, about 9.3% of the affected households (27) had repaired the damage to their assets. The house was always given priority. When they repaired their houses, most used the same materials that were used when their houses were first built. For instance, those whose houses are permanent had repaired the damage using similar materials (i.e., concrete), which were brought in from outside the area or recycled from the ruins of abandoned houses. Those who lived in wooden stilt houses had replaced broken piles with the same kind of pile. They

also changed their floors gradually. To minimize the cost, some households in Tembilahan Hulu and Tempuling collected wood from the surrounding forest to modify their floors and piles.

Fixing the damaged plantation was also the concern of the affected households that lived in peatland areas. They repaired the damaged drainage channels and restored the damaged oil and coconut palms. The repair of the drainage channels had mainly been a matter of plugging the leaks, whereas the restoration of the palms was focused on supporting them. A peasant in Enok stated: "Some parts of the channels have been damaged. It was even worse when the highest annual flooding occurred. I used to rebuild the channels after the flood ended. My friends used to help me."

3.4.2.2 Adapt to damage

The households that responded to the impacts also invested in some adaptation measures, such as elevating or modifying their houses and optimizing the plantation drainage channels. The 134 affected households that had taken some structural measures to adapt to the damage had chosen measures to prevent worse consequences in the coming 5 to 10 years. Most of those who had adjusted their houses were households whose houses had already sunk 100–250 cm. They had also been experiencing annual floods and daily inundations for years.

To adapt to the damage to houses, all had raised or modified their floors, walls, and/or roofs. To raise their houses, some households had brought in sand from outside the area, while others had used rubble from abandoned houses. In addition, some households whose houses had already sunk 250–450 cm also raised their walls and roofs. This measure had to be done because the houses had become uninhabitable. A respondent in Genuk told us: "As our house wall had cracked badly and the house had been very low, we raised not only the floor but also the roof and wall." Raising the walls and roof was the only solution when a house became unhabitable due to subsidence.

Figure 3.3 shows an example of a new house built on the former roof, which is now the foundation of the house. The house was built on the former roof because the original house had been destroyed. It was rebuilt to prevent seawater from the daily inundation entering the house. Figure 3.4 shows the wall and roof that had been raised because the original house had become too low and thus uninhabitable.

Furthermore, in a limited number of cases, affected households in rural peatland areas of Indragiri Hilir had modified their houses by using stronger wooden piles together with cement inside the buildings' foundations. This minimizes fissures in the foundations due to land creep during subsidence and increases their elasticity. In addition, due to an unstable peatland condition and land creep during the land subsidence process, almost all affected households that lived in stilt houses replaced some of the house piles. This happens almost every year. To avoid having to do so, some households used a stronger type of wood (ironwood).

In peatland areas, the affected households tried to adapt to damage to the plantations by optimizing the drainage. A limited number of them had dug gullies and elevated the dams in the channels to prevent water from flooding their plantations; a few others had dredged

sediment from the channels. Even though some adaptation measures had been taken to protect plantations, our survey found that the problems remain.

Figure 3.3 Elevated floor to protect against daily inundation

Figure 3.4 Raised wall and roof of a previously damaged house

3.4.3 Impact of land subsidence on households' income

Most of the measures discussed above cost money. We expected that the income of the affected households would be enough to cover the cost of the measures. However, we found that the income of some affected households was even lower due to an increase in expenditure on responding to subsidence and a decrease in earning capacity.

3.4.3.1 Increase in expenditure

Of the affected households, 120 had spent money on repairing and adapting to the damage. In 2015, each household spent on average about US$ 107 on repairing damage—which was about a quarter (28%) of their average total annual expenditure (US$ 382) (see Table 3.3). Table 3.3 also shows that the households in the coastal areas of Semarang had spent more on repairs than those in rural peatland areas of Indragiri Hilir, namely an average of US$ 113 (40% of average total expenditure) vs US$ 105 (26%). This high percentage is a result of the more severe impacts in coastal areas and of the combination of land subsidence and other coastal hazards, such as sea level rise and coastal erosion. The amount of money spent by the households differed according to the type and degree of damage, the materials used, and the availability of money.

Table 3.3 Cost of response to impacts of land subsidence in 2015

Location	Type of response					
	Repair the damage			Adapt to the damage		
	Average repair costs per household	Average total expenditure per household	Avg. repair costs as a percentage of avg. total expenditure	Average adaptation cost per household	Average total expenditure per household	Avg. adaptation costs as a percentage of avg. total expenditure
Jakarta	-	-	-	US$ 110	US$ 537	20%
Semarang City	US$ 113	US$ 283	40%	US$ 232	US$ 536	43%
Indragiri Hilir	US$ 105	US$ 405	26%	US$ 308	US$ 630	49%
Total (N=120)	US$ 107	US$ 382	28%	US$ 172	US$ 541	32%

Source: questionnaire analyses (2015)

To adapt to the damage, every household had spent on average about US$ 172 (32% of their average total expenditure). Households in the rural peatlands of Indragiri Hilir spent more than those in other areas, namely about 49% of their average total annual expenditure (US$ 308) (see Table 3.3). Households in coastal and urban areas had also had spent a significant portion of their total expenditure on adaptations, namely about 43% in Semarang City and 20% in Jakarta. Thus, the affected households had allocated at least one fifth of their entire expenditure to adapting to the impacts of subsidence.

To summarize, the affected households that had responded had spent an enormous amount of money doing so, especially compared to the total amount of money they spend over their lifetimes. Responding to the damage caused by land subsidence might not solve the problem, however, as affected households will have to continue spending money on various measures.

3.4.3.2 Decrease in income earning capacity

Of the 291 affected households, the capacity of 110 households to earn an income had been reduced due to damage to their sources of income. Land subsidence had ruined their primary sources of income, such as ponds, oil and coconut palms, and fishing grounds. It had also undermined the secondary sources of income of some affected households, especially those whose primary work was related to the affected area, such as pond owners and peasants. Even households whose primary jobs were not affected—such as civil servants, entrepreneurs, and employees—had been affected by land subsidence as it decreased their income from secondary jobs as, for example, farm workers or fishermen. For those reasons, the average loss of income in 2015 was about US$ 113 per household, or 5.3% of their average total income (US$ 2152) (see Table 3.4). Thus, the decrease in earning capacity of the affected households had limited their choice of responses.

The decrease in income earning capacity of households in Jakarta

In urban and coastal areas of Jakarta, every affected household had lost an average of about US$ 59 of its income (in 2015), which is less than the amount lost by households in other areas. Of the 36 affected households, eight had lost income from their main jobs and 28 others had lost income from their secondary jobs. A respondent in Penjaringan whose secondary job was assisting fishermen told us: "We used to catch a lot of fish around the mangroves. Now, many man-groves have been damaged. Land subsidence damaged their roots. There are only a few fish left." As the income of the fishermen dropped, so did that of this respondent.

The decrease in income earning capacity of households in Semarang City

The affected households in coastal areas of Semarang City had suffered the most significant average loss of income compared to those in other areas, namely US$ 151 or 9.7% of average total incomes. One of the triggers of this significant figure is that almost half (30 out of 62) of the affected households in these areas depend on fishing. Fishing is one of the jobs most prone to land subsidence, as subsidence directly affects fishermen through the decrease in their production. A fisherman in Tugu told us that:

Table 3.4 Affected households' loss of income due to land subsidence in 2015

Location	Number of households that lost income	Average loss of income per household	Average total income per household	Avg. loss of income as a percentage of avg. total income
Jakarta	36	US$ 59	US$ 2,869	2.1%
Semarang City	62	US$ 151	US$ 1,553	9.7%
Indragiri Hilir	12	US$ 79	US$ 3,098	2.6%
Total	110	US$ 113	US$ 2,152	5.3%

Source: questionnaire analyses (2015)

"The mangrove forest was destroyed by land subsidence and coastal erosion. We hardly find any fish or crabs near the damaged mangroves." The damage to mangroves caused by land subsidence was indicated as the main factor that reduced the quantity of fish caught. In coastal areas of Semarang City, the impacts of land subsidence on mangroves were accelerated by coastal erosion.

Pond owners had also lost income as a result of damage to their ponds. A pond owner in Genuk told us: "Our ponds are always inundated a couple of times a year. Many fish and prawns escape from the ponds when the seawater covers it. We believe land subsidence worsens the problem."

An important remark is that in coastal areas, it is difficult to separate the costs caused purely by land subsidence from the costs caused by other coastal hazards. The costs of land subsidence are always accompanied by the costs of the impact of sea level rise, coastal erosion, and/or coastal flooding. However, as mentioned in the impact subsection, land

subsidence itself directly costs the affected households or indirectly increases the costs of indirect impacts. In short, land subsidence often increases the costs by increasing the impacts of other coastal hazards.

The decrease in income earning capacity of households in Indragiri Hilir

In the rural peatlands of Indragiri Hilir, each household had suffered a loss of income of, on average, about US$ 79. This resulted from damage to their sources of income, such as oil and coconut palms. Some palms were leaning due to the sinking and unstable ground, which had reduced production. The income not only of peasant farmers but also of farm workers was affected, because the decrease in the productivity of coconut or oil palms led to a decrease in the working hours of the farm workers. Thus, due to the high dependence of the peasants and farm workers on the plantations, the continuous damage to plantations will make it difficult to save money to deal with the problems.

3.5 DISCUSSION

Land subsidence had affected almost all of the households in various ways, ranging from physical damage to their land and properties, to environmental and socioeconomic problems (e.g., the undermining of their income). Many had suffered from multiple types of impact. The affected households consistently stated that their assets are sinking continuously, and increasingly. In the future, the affected households in coastal areas will suffer the most because they also experience other coastal hazards. The combination of land subsidence with other hazards, such as tidal flooding and sea level rise, exacerbates the impacts of land subsidence (Harwitasari and van Ast, 2011; Marfai and King, 2007). A study by Bappenas (2010) also shows that a combination of coastal hazards—in their case, receding coastlines and expanding inundated areas—exacerbates problems for households.

In the urban and coastal areas studied, the land subsidence problems may well continue to worsen, as the populations and the physical developments in those areas are growing rapidly (Nicholls and Cazenave, 2010; UN, 2016). Furthermore, land subsidence in rural peatland areas will accelerate, since the utilization of peatland for agricultural activities is continuing. Thus, the affected households will remain vulnerable to land subsidence.

To deal with their vulnerable status, the affected households must make an adequate response. However, almost half of them have not done so, despite the severe damage they have suffered. Why did they not respond? According to Yohe and Tol (2002), whether affected people take measures to reduce their vulnerability depends on their access to funds. In our case, we found that the lack of income was one of the factors behind their failure to respond. A respondent in Tembilahan: "I know that I live in an area that is prone to subsidence. I change my house's pillars regularly. I cannot buy stronger pillars, such as ironwood, because I don't have enough money." Many scholars argue that the availability of and access to money are vital to reduce vulnerability to the risks and to determine the success of adaptations (Adger, 1999; Alam et al., 2017; Alwang et al., 2001; Blaikie et al., 2014; Cutter et al., 2003; Pelling, 2010).

Other households had not responded because they were waiting for more significant damage to their properties before responding in a particular way. Both households that had been subject to a slow rate of light subsidence and those that had been subject to a fast rate of severe subsidence gave this reason. The main reason for ignoring the impacts differed from household to household, but it depended on the severity of the impacts and the rate of land subsidence. For instance, the head of a household in the coastal area of Tugu (Semarang), whose house had sunk about 50 cm, said that he had not yet taken any action because he believed that damage that is more significant would occur in the next couple of years. Instead of repairing it repeatedly, he preferred to respond to the damage in one go, after more significant damage occurs. Another respondent in coastal Tanjung Mas (Semarang), whose house had sunk about 100 cm but had done nothing, said that he would wait till his present house had been destroyed and then build a new one. Therefore, the affected households that delayed taking measures perceived land subsidence as a bottomless pit.

A little over half (55.3%) of the affected households had responded to the impacts of subsidence not only by repairing the damage but also by adapting to it. This finding supports Reuveny (2007), by adding that in responding to a long-term disaster, households not only prevent impacts by adapting to the damage but also take a small and immediate measure: they repair the damage. A significant difference between these two responses is that repairing is a reactive activity while adapting is a proactive strategy to prevent future impacts. This finding concurs with Paavola and Adger (2006) and Füssel (2007), who found similar types of responses by affected people in the face of climate change.

The affected households believe that by responding to the damage, the problem can be solved. However, we found that this type of measure was ineffective. Many households had attempted to adapt to future damage, but their responses had been of no use. Most households had taken measures to repair or adapt their houses, and only limited measures to repair the damage to their sources of income, namely plantations or ponds. In addition, the wrong choice of building materials when repairing the damage had also made their measures ineffective. For instance, when raising their houses, only a few households in coastal areas had used lighter materials, such as wooden planks or corrugated roofing sheets. Most had used ceramic tiles for their floors, bricks and cement for their walls, and roof tiles for their roofs. Since in coastal areas the construction load is one of the triggers of land subsidence (Abidin et al., 2011; Marfai and King, 2007), this decision is undoubtedly wrong.

Finally, the inappropriate responses are not the only issue: Households are unable to deal with the impacts of land subsidence due to their lack of money. Land subsidence is a continuous process and it has a long-term effect on income. However, the income capacity of some of the affected households—especially fishermen, farmers, and farmworkers—was diminishing. Land subsidence had destroyed their sources of income, which further eroded their ability to cover the adaptation costs. Their lack of capacity to effectively respond to the impacts will leave them vulnerable to land subsidence, and responding to the damage will be a never-ending activity. Therefore, since their responses cannot prevent future impacts and/or

their income cannot cover the costly and ineffective adaptation measures, households must consider increasing their income capacity or leaving the affected areas.

3.6 CONCLUSION

Unlike single-shock disasters, land subsidence has a gradual and long-term impact on households, which suffer severe and repeated damage. This study shows that land subsidence affects extensive areas and has various consequences for almost all households. For many households, land subsidence has both direct and indirect impacts. In many cases, the direct impacts trigger indirect impacts in the form of social and economic problems. The combination of these types of impacts means that households suffer from impacts of varying severity. Almost three quarters of the affected households in this study had suffered from multiple types of impact. Such households are the most vulnerable to huge potential impacts because they are also vulnerable to other hazards, such as sea level rise, flooding, peat fires, and coastal erosion, which are interrelated (Abidin et al., 2015; Bappenas, 2010; Harwitasari and van Ast, 2011; Hooijer et al., 2012; Marfai et al., 2008).

Nevertheless, only just over half (55.3%) of the affected households in this study had taken measures to reduce their vulnerability to land subsidence. This shows that people's responses to land subsidence are different from their responses to single-shock disasters. Because immediate responses are not required, affected households can take the measures that their economic capacities allow. The availability of money, knowledge of land subsidence, information about ways to reduce their vulnerability, and the perception of the impacts, fundamentally influence a household's responses to land subsidence. The present research confirms that households with less income will suffer more (Adger, 1999; Harwitasari and van Ast, 2011; Kellens et al., 2012; Satterthwaite et al., 2007; Yohe and Tol, 2002).

This study argues that responses must be accompanied by a stable and sufficient economic capacity. Although some of the affected households had been able to take measures, namely short-term solutions and adaptations, the situation will remain problematic especially for about the one third of the affected households whose sources of income have been ruined. As land subsidence has reduced the households' earning capacity, their ability to pay for measures has been weakened. This supports the studies by Alwang et al. (2001), Cutter et al. (2003), and Siagian et al. (2014) that show the economic capacity of affected households is vital to increase their ability to take measures. The case of land subsidence as a long-term disaster shows that economic capacity is even more critical, since the affected households must keep spending money over a long period of time.

To conclude, it cannot be ignored that land subsidence costs a lot of time and money, and that repeated measures need to be taken over a long period of time. This research shows that even though the affected households have responded to the impacts using their economic capacity, the problems remain. Therefore, to avoid more severe consequences, households must consider increasing their income from other sources or taking adaptive measures based on a proper understanding of the characteristics and impacts of land subsidence.

However, this study strongly suggests that appropriate measures need to be considered by the affected households to avoid the bottomless pit of land subsidence. To do so, they must consider increasing their income capacity, taking more preventive measures, or leaving the affected areas.

Beyond Fires and Deforestation: Tackling Land Subsidence in Peatland Areas, a Case Study from Riau, Indonesia

4

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ABSTRACT

Peatland plays an important ecological and economic role in many countries all over the world. At the same time, due to various human and non-human interventions, peatland is also a fragile ecosystem, which is currently facing severe problems, such as deforestation, fires, and peat subsidence. Peat subsidence is one of the most severe but least recognized issues. Because of its interconnectedness with other peatland problems, peat subsidence intensifies when there is a lack of appropriate interventions. In this chapter, types of problems that arise along with and from peat subsidence and how various actors deal with it are analyzed. This chapter uses an example from peatland areas in Indonesia to address two questions: (1) What kinds of problems are related to peat subsidence? And (2) how do various actors deal with peat subsidence and what are the consequences of their interventions? Based on in-depth interviews with key persons from government institutions and NGOs, followed by focus group discussions with communities, analyses of policies, and desk study, the present research discovered that peat subsidence is a hidden problem that is highly interconnected with other peatland problems that have caused severe physical environmental and socioeconomic impacts. While various actors have made numerous interventions to deal with deforestation and fires, those concerning peat subsidence are still limited. Since dealing with peatland problems as a whole requires an ecosystem-based intervention, a more comprehensive approach is needed to manage peat subsidence.

Keywords: peatland; peat subsidence; governments; non-governmental organizations (NGOs); communities; Riau

4.1 INTRODUCTION

Peatland plays an essential ecological and economic role in many countries all over the world. While it only covers about 2.84% of the world land area (i.e., about 423 million ha), peatland stores approximately 10% of global freshwater resources and more carbon than all the world's forest biomasses (Joosten and Clarke, 2002; Joosten, 2015; Xu et al., 2018). However, in recent decades, peatland has been destroyed by human and natural activities, which has created severe problems. Natural and human activities, such as climate change, agricultural exploitation, peat fires, and drainage systems have caused this degradation (Couwenberg and Hooijer, 2013; Hooijer et al., 2010; Urák et al., 2017), leading to the loss of land cover, emission of carbon, loss of biodiversity and ecosystem, fires, and land subsidence (Dohong et al., 2017; Hooijer et al., 2012; Page et al., 2002).

Among peatland problems, peat subsidence is one of the most severe but least recognized issues (Joosten, 2015; Saputra et al., 2017). It is triggered by a combination of the decomposition and compression of peat volume due to peat fires and massive growth plantations surrounded by canals (Evers et al., 2017; Hooijer et al., 2012; Thorburn and Kull, 2015; Wösten et al., 2008). The vast agricultural development that necessitates drainage has accelerated the drying out and decomposition process of organic matter, resulting in the sinking of peatland (Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Kieft et al., 2016).

Over an extended period, peat subsidence triggers numerous problems. It releases a large amount of carbon dioxide (Hooijer et al., 2012), increases the potential for drought and flooding (Wösten et al., 2008), decreases the storage of freshwater caused by saltwater intrusion (Laura et al., 2005), and ruins buildings, roads, and utilities (Saputra et al., 2017). It also generates economic losses and external costs (Butler et al., 2016). Soon, it will increase the permanent loss of peatland (Evers et al., 2017). Peat subsidence is a severe problem since it leads to other peatland problems (see, e.g., Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Saputra et al., 2017; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015).

This chapter analyses the types of problems that peat subsidence causes and the interventions of various actors to deal with it. To do so, two research questions are addressed. First, what kinds of problems are related to peat subsidence? The aim of answering this question is to understand the physical environmental and socioeconomic consequences caused or triggered by peat subsidence. At the same time, this exploration is used to discover the relation between peatland problems. The second question is: How do various actors deal with peat subsidence and the consequence of their interventions? Answering this question reveals interventions made by various levels of government as well as NGOs and communities to deal with peat subsidence and other problems. It also reveals information concerning the impacts of their interventions. The extent to which peat subsidence has been a concern for the actors as well as links between such actors is also explored. There is ample and proven scholarly evidence showing the importance of disaster response in the context of rapid-onset or short-term disasters, for example, earthquakes, tsunamis, flooding, landslides, hurricanes, and volcanic eruptions (Birkmann et al., 2010; Perry and Lindell, 2008; Shaw, 2003; Topno, 2018).

In contrast, the discussion about responding to long-term disasters, such as land subsidence, is limited. This contributes to the gap in the debate on the measures actors have taken to deal with peat subsidence within the context of complex peatland issues.

The presence of various actors and their collaboration in solving these land problems is highly debated. At the global level, the Sustainable Development Goals (UN–SDGs) were often used as a blueprint to improve the status of the land, by introducing governance ideas to stimulate collective actions. The existence of actors along with their goals and strategies in a governance frame is a vital part of the success of the SDGs (Biermann et al., 2017). Therefore, this chapter contributes to this debate by providing an example of measures taken by various actors to deal with peatland problems. Since indicators of the success of partnership in achieving the SDGs are still being developed, this chapter is not intended to evaluate collaborative actions, but to discover the interest and dynamics of actors in peatland issues.

Using an example from Indonesia's peatland, this chapter answers the research questions based on in-depth interviews, policy evaluation, representatives from the actors, focus group discussions, and field research. Indonesia has the fourth largest area of peatland in the world and accounts for about 56% of all tropical peatlands (Itoh et al., 2017). Riau can represent peatland in Indonesia since it has about 19.3% of Indonesia's total peatland, more than all but one of the country's other provinces (Warren et al., 2017). Thus, this case study can characterize the complexity of peat subsidence worldwide.

This chapter is organized into six subsections. The following subsections explain the theoretical framework followed during the data collecting process. Subsequent subsections describe the complex consequences of peatland development and the interventions of actors to deal with the problems. It ends with a discussion and some conclusions.

4.2 LAND SUBSIDENCE, COMPLEX PROBLEMS, AND ACTOR-CENTERED APPROACH

Land subsidence is the gradual settling or sudden sinking of the earth's surface due to a movement of earth materials (Galloway et al., 1999). It is a result of the compaction or consolidation of the inter-bedded layers of clay and silt within the aquifer system due to the intensive exploitation of groundwater (Shi et al., 2008). In the peatland area, it is caused by the combination of the decomposition and compression of peat volume (Evers et al., 2017; Hooijer et al., 2012; Thorburn and Kull, 2015; Wösten et al., 2008). The development of drainage, following the massive expansion of plantations in peatland, accelerates the drying and decomposition of the organic matter, which triggers peat subsidence (Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Kieft et al., 2016).

The continuous sinking of peatland leads to severe consequences for peatland ecosystems and people (see Butler et al., 2016; Evers et al., 2017; Hooijer et al., 2012; Laura et al., 2005; Saputra et al., 2017; Wösten et al., 2008)). Peat subsidence may trigger more complex problems since it leads to and is led by other peatland problems (Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015). Even though its consequences are

severe, peat subsidence is often ignored because it is a gradual process. This lack of attention causes it to be known as a "sleeping disaster" (Galloway et al., 1999; Saputra et al., 2017). This is also why research on the measures taken by actors to deal with peat subsidence is lacking. Thus, it is necessary to understand the responses of various types of actors aimed at dealing with these complex problems in order to establish the readiness of actors to deal with such problems.

In complex disaster and environmental problems, an actor-centered approach is considered an adequate approach since it puts various and multi-level actors at the center of the debate. This approach may help to understand the various ways that various actors deal with problems (Sloat, 2002). It also considers state and non-state actors' interventions and measures to be vital in dealing with a problem (Mohammed and Inoue, 2016). To illustrate this approach, the focus is on three types of actors: governments, NGOs, and communities. Governments are vital actors in responding to disasters and environmental risks since they are the most responsible bodies to guarantee safety for citizens through appropriate policies and construction measures (Kumar, 2018). Governments can create a national system and legal framework to manage risks and promote sustainable risk management (Bollin et al., 2003; Topno, 2018). NGOs also play a critical role in reducing the risk of disasters through community-based disaster management, mediation, and advocacy (Shaw, 2003). NGOs can compensate for the weakness of governments in solving problems because of their particular knowledge of local-level issues and their flexibility to deliver strategic solutions to communities, while governments are mostly unwelcome (Agarwal, 2001; Benson et al., 2001; Haque, 2002). Through their specific abilities and experience, the initiatives by both actors might increase the ability to deal with disasters (King, 2007). Furthermore, since communities own the problems and consequences of any interventions, it is necessary to understand that their roles and involvement in developing strategy and programs might also increase the opportunity to deal with the problems (Pandey and Okazaki, 2005).

All actors are expected to tackle peatland problems, which are usually complex (Thorburn & Kull, 2015). Peat subsidence, combined with other peatland problems, is complex since it involves various causal factors and triggers conflicts among actors concerning the nature of the problem and the first steps toward finding a solution. All problems are analyzed carefully using problem characteristics similar to those of Howes and Wyrwoll (2012) to see how complex the problems are (see Table 4.1). The understanding of the wickedness of the problems is needed to parse complex problems based on their characteristics and relationships. This framework is applied by defining peat subsidence and other peatland problems with three characteristics. To understand such complexity, it is essential to engage actors involved in policymaking who have enough experience and knowledge of problems from the national down to the local level.

Table 4.1 Characteristics of wicked problems

Characteristic	
Problem formulation	No definitive formulation due to extreme complexity. The problem is constantly evolving and is never completely resolved. Any solution(s) may be only temporary.
Interdependency	The problem is composed of and related to many different problems. All of these different elements affect each other through a network of linkages.
Solution set	Any solution causes feedback effects. The linkage between constituent elements means that the total effect is difficult to ascertain. A potentially infinite solution set exists. The merits of different solutions are determined by the judgement of different stakeholders.

Source: Howes and Wyrwoll (2012, 30)

This research is about governance, which refers to a new process of governing society (Rhodes, 2007). It concerns the activities of governmental and non-governmental actors at multiple levels (Biermann et al., 2014). In this chapter governance includes the rules, regulations, and policies of the actors. In analyzing the realities on the ground, this research also pays more attention to interest, interaction, and dynamics between the actors. Thus, an actor-centered approach is needed as it can analyze the dynamics and complex interactions of different actors, which cannot be done by another approach, such as an institutional approach (Beckert, 1999). It is in line with one of the strategies to deal with the wicked problems, namely collaborative strategies among actors whose power is dispersed (Roberts, 2000). The complete picture of the problems from the local to the broader scale needs to be considered to successfully tackle the problems by involving all levels of governments and a range of NGOs (Australian Public Service Commission, 2012).

The actor-centered approach is operationalized by first identifying the actors involved in peatland issues, followed by an explanation of their interventions to deal with the problems. Diverse perspectives and the roles of various actors are important factors in this approach (Vervoort et al., 2012). This chapter explores the different roles of the national, provincial, and local governments, national and local environmental and developmental NGOs, and local communities in dealing with peatland problems, including peat subsidence. In addition, the interactions and dynamics among these actors in building or improving measures are also considered. The interactions might create two patterns of relationships, that is, complementary or contradictory relations (Topno, 2018). The exploration of the actors' interventions and interactions makes the actor-centered approach very suitable for application because it is set to facilitate mutual understanding and networks among the actors (Vervoort et al., 2012).

4.3 DATA COLLECTION AND ANALYSIS METHODS

Data were collected using four methods: in-depth interviews with representatives of the actors, focus group discussions (FGDs) with communities, evaluation of policies and documents of the actors, and field research. According to Yin (2014), a case study qualitative method that combines several sources of evidence—such as open-ended interviews, documents and policies, and focus group interviews—is suitable to address research questions since this method allows the researcher to gather complete and detailed information that is strictly related to the research aims. Furthermore, these data sources (i.e., in-depth interviews, FGDs, and policy and document analyses) were used to strengthen the understanding and facts about peatland problem phenomena using a data triangulation principal (Yin, 2014). Data triangulation was also used to prevent invalid information regarding a phenomenon that could come from multiple sources of data.

First, in-depth interviews were held at the beginning of 2015 and the end of 2016 to collect information from the government and NGOs at the national and the local level. To select interviewees, the government institutions and environmental and developmental NGOs in Indonesia and Riau Province were listed. From the list, those whose tasks were closely related to peatland and forest issues were chosen (see Table Appendix 1). In addition, the interviewed NGOs were also selected by considering the NGOs in Riau as well as those that are outside Riau but work regularly in this province. Their spatial coverage (international, national, or local) and working focus were also considered. The local NGOs, which were selected from 158 NGOs, were prioritized since most of them have enough experience and knowledge of the local problem. A standard guideline was used during the interviews to direct interviewees answering research questions. The types of peatland problems, problem interconnections, and interventions of actors to deal with such problems were asked about. In some interviews, actors were represented by one or more high-level representatives. The interviews were conducted mostly in the offices of the actors. On average, the duration of the interviews was about 60–90 minutes. Phone interviews were used for actors that could not be interviewed face to face due to distance or time constraints.

Second, FGDs with communities were held to discover problems of peatland at the local level and how the community responds to the issues. The on-the-spot FGD was focused on a locality in a particular district, Indragiri Hilir District, particularly Harapan Jaya Village, in which the impacts of peat subsidence are massive, and the community has responded to some of the issues. The participants in the FGD, held in 2016, were representatives of various community group leaders, such as representatives among the fire care community, women, youth, and religious groups or leaders. In the FGD, a total of 30 group representatives were invited.

The in-depth interviews and FGD were recorded using an audio recorder with the agreement of the interviewees. The records were then translated into the transcripts of the interview. To analyze the transcripts, framework analysis was used (Krueger, 1994; Ritchie & Spencer, 2002). Framework analysis describes and interprets different aspects of phenomena from cross-section data in a particular setting (Ritchie and Spencer, 2002). This analysis helps

the researcher to manage a large amount of complex data, from data familiarization to data analyses (Rabiee, 2004).

Furthermore, to complete the information gathered from in-depth interviews and FGDs, an analysis of governments' and NGOs' policies and documents was also made. This analysis was carried out from the beginning of 2015 until the beginning of 2019 to gather sufficient information and anticipate the change in policies and documents. Various policies from the national, the provincial, and the local government regarding peatland and forest management, spatial planning, and disaster management and risk reduction were listed and summarized. Next, policies that were strictly related to peatland, forest, and disaster issues were studied more intensively, as was information from obtained from actors' official documents, such as reports, newsletters, books, social media, and websites.

An effort to recheck the information gathered via the mentioned methods and to obtain missing field research information was also made. Some information gathered from in-depth interviews, FGDs, and analyses of policies and documents were rechecked through field research, especially in areas that had been particularly severely damaged, to discover the detailed and comprehensive status of land subsidence and measures taken by various types of actors. The field research, which was conducted in 2015 and 2016, was focused on five subdistricts that have been suffering from peat subsidence and other peatland problems for years, namely Tempuling, Enok, Tembilahan Hulu, Batang Tuaka, and Tembilahan. Thus, field research was mainly used to collect information at the local level.

4.4 RESULTS

4.4.1 Physical environment and socioeconomic issues caused by peatland development

Riau, on the island of Sumatra, has about 3.87 million ha of peatland, representing one fifth of the total peatland in Indonesia and three fifths of the total peatland in Sumatra (Pemerintah Provinsi Riau, 2018; Warren et al., 2017). Of this peatland, about 86.8% is categorized as moderately deep or deep peatland; that is, the depth is more than 2 m (Pemerintah Provinsi Riau, 2018) (see Figure 4.1). In this province, districts and cities in the northern and eastern part (i.e., Indragiri Hilir, Indragiri Hulu, Kepulauan Meranti, Pelalawan, Siak, Bengkalis, Dumai, and Rokan Hilir) manage more than half of the total peatland.

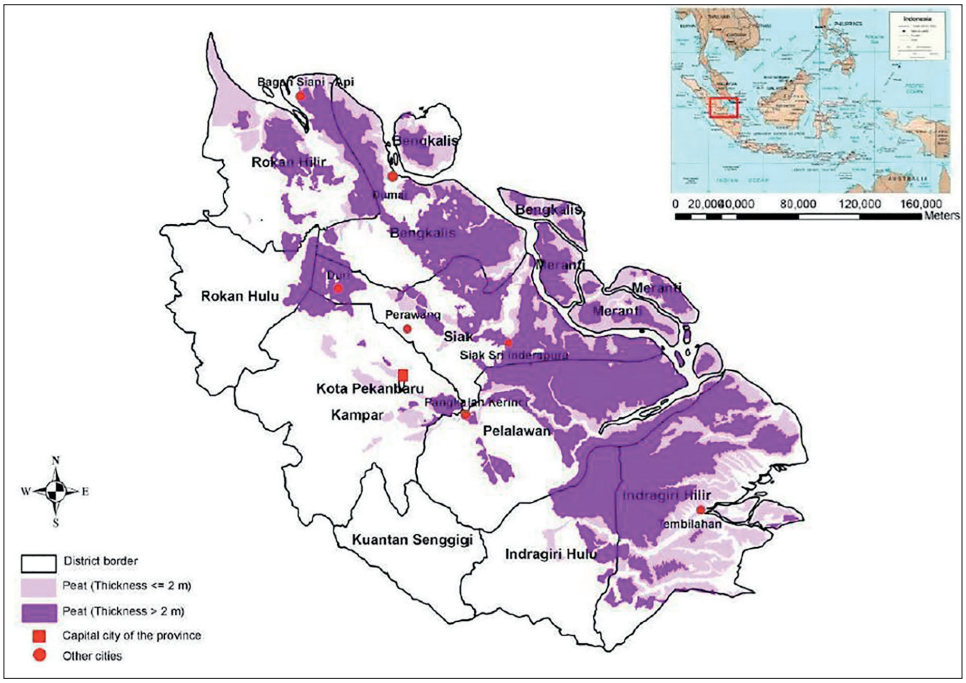

Figure 4.1 Distribution of peatland in Riau (source: Center for Soil and Agroclimate Research, 2011, in Susanti and Burgers (2012)).

Since 1982, Riau peatland has been overexploited for various non-forestry purposes, such as plantations (Uryu et al., 2008). The massive peatland development was a response to the demand for peatland commodities and the increase in foreign and local investment in peatland areas (WWF Indonesia, 2006). The plantation is dominated by private and smallholder oil palm, timber, and coconut palm estates. The oil palm sector in Riau is growing faster than in other provinces in Indonesia, since this province is the target area for oil palm plantation development to fulfil the global demand (Susanti and Burgers, 2013). In 2017, oil palm plantations covered about 2.5 million ha, of which about 40.66% is owned by private estates (MoAgr, 2017b). Besides oil palm, Riau also contributes to 72.85% of total pulp and paper production and leads in coconut plantations in Indonesia, with about 515,000 ha (MoAgr, 2017a; Statistics Indonesia, 2016). The combination of the growth of these plantations has caused severe problems, such as deforestation, fires, and peat subsidence, followed by a decrease in the economic status of the affected people (Dohong et al., 2017; Hooijer et al., 2012; Page et al., 2002; Saputra et al., 2019).

4.4.1.1 Deforestation

Deforestation has been spreading all over the province and has become a serious issue due to the massive amount and high rate of occurrence (Figure 4.2). Uryu et al. (2008) record that within 25 years, about 65% of land cover has been lost. Between 1982 and 2007, about 1.83 million ha of peatland (equal to 57% of total peatland) had been converted to non-forest

purposes (BRG, 2016). This vast deforestation was mainly driven by a rapid expansion of oil palm estates and pulp and paper industries (WWF Indonesia, 2006). Between 2008 and 2012, for instance, the area devoted to oil palm plantations increased from 29% to 70% of total peatland (Ramdani and Hino, 2013; Uryu et al., 2008). This also decreased the percentage of forest coverage, from about 63% to about 22% (Ramdani & Hino, 2013). Areas covered by forest were even smaller due to the massive growth of pulpwood plantations (Uryu et al., 2008). In addition, a government policy that provided an incentive for oil palm and pulpwood mills and the lack of capacity and the corruption at the local level government caused increased deforestation (Howes and Wyrwoll, 2012; Kieft et al., 2016).

The massive deforestation has triggered severe problems. It has caused a vast loss of peatland and biodiversity, the emission of carbon, the decomposition of deep peatland, and a decrease in rice fields (Busch et al., 2015; Susanti and Burgers, 2013; Warren et al., 2017). The consequences could become worse since the Indonesian government has set a target to increase the use of biofuels and triple the area of timber plantation by 2030 (MoFor, 2011).

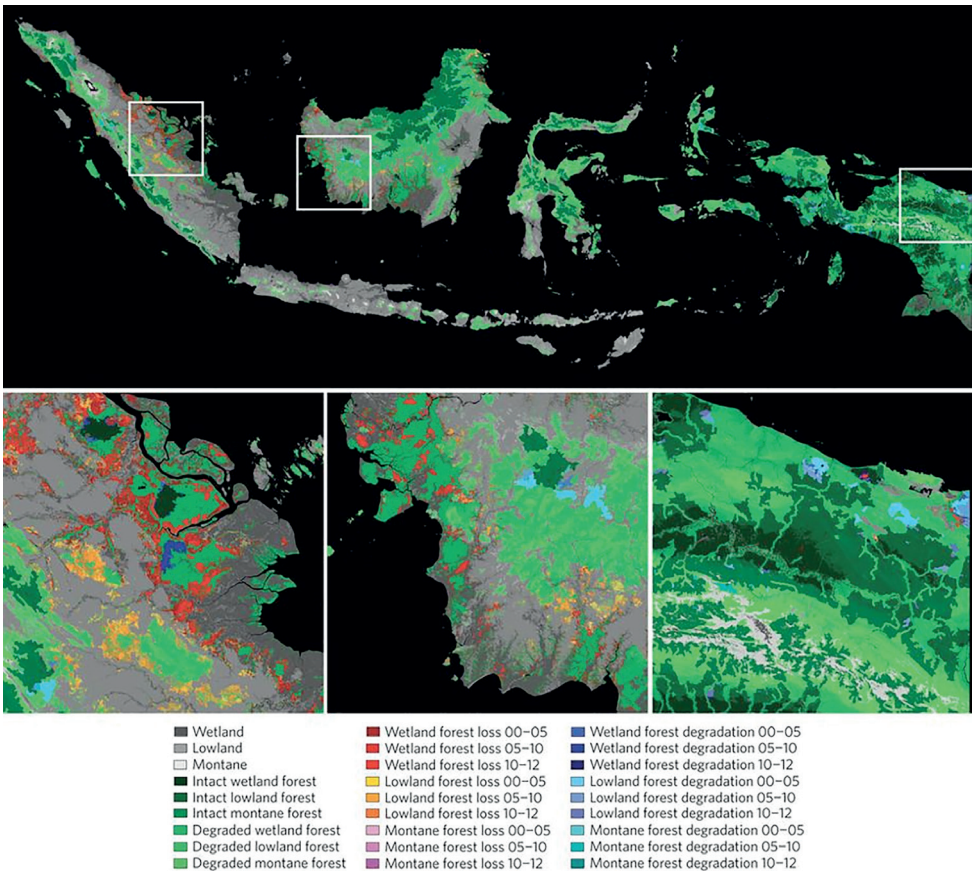

Figure 4.2 Deforestation in Riau (lower left). Both the rate and the amount of deforestation are higher than in other areas in Indonesia (Source: Margono et al. (2014)).

4.4.1.2 Fires

Riau is the Indonesian province with the most frequent fire events (Sizer et al., 2014). The fires are mostly triggered by human activities (Page et al., 2002). The development of plantations by clearing the land using fire is one of the triggers of fires, since the peatland is easily burnt (Kieft et al., 2016). This type of land preparation was used by both small-scale local farmers and large-scale private companies (Miettinen and Liew, 2005). The development of canals through the peat bog surrounding the plantations also decreased the surface level of peat and dried it out, which made the area prone to fires (Uryu et al., 2008).

In Riau, numerous large-scale fires have been recorded since the beginning of the 1980s (Kieft et al., 2016). The mega-fires of 1997/8 were the biggest fires events in Riau (and also in Indonesia) due to their massive impact on communities—about 10% of the total population in Riau suffered health problems (Glover, 2006). During this event, there were about 5,870 hotspots in Riau (equal to 23% of the total number of hotspot in Sumatera), of which one third were on oil palm plantations (Suyanto et al., 2004). The mega-fires also caused severe air pollution, damaged plantations, and pushed the local government to close schools, offices, and airports. After this event, fires were increasingly frequent. Between 1997 and 2007, one third of 72,000 active hotspots in Riau had been burnt at least once (Uryu et al., 2008). More fires in 2014 burned about 11% of the peatland (Prayoto et al., 2017). This was followed in 2015 by another big fire event that burned about 169,119 ha of forest and land (BNPB, 2016). In 2018, fires burned about 5,776 ha of land (Jikalahari, 2018b).

All fire events have severe physical and socioeconomic impacts, including loss of property, cross-boundary haze, air pollution, loss of forest and peatland ecosystem, carbon emissions, peat subsidence, and even deaths (BNPB, 2016; Herawati and Santoso, 2011; Kieft et al., 2016; Tacconi, 2003; Uryu et al., 2008). The relevant actors should pay attention, since the current fires management system focuses only on fighting rather than preventing fires (Kieft et al., 2016).

4.4.1.3 Peat subsidence

Peatland development also triggers peat subsidence. Some areas sink about 4–6 cm/year (Hooijer et al., 2012; Saputra et al., 2017). Peat subsidence is caused by the oxidation, shrinkage, and compaction of peatland, which is triggered by peat fires and the development of large- or small-scale drainage around plantations (Hooijer et al., 2012; Kieft et al., 2016; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015). The fires increase the oxidation and degrade peatland ecosystems, while the drainage accelerates the drying out and the decomposition of organic matter (Couwenberg and Hooijer, 2013; Kieft et al., 2016). Land clearing processes and drainage development surrounding plantations also increase the oxidation, which accelerates the sinking, especially in the early stages of plantation development (Evans et al., 2019).

Peat subsidence leads to various consequences. It causes a massive and continuous loss of carbon (Couwenberg and Hooijer, 2013), triggers the infiltration of saltwater (Schrier-Uijl et al., 2013), and ruins oil and coconut palms through tilting, drowning, and dying (Saputra et al., 2017; Thorburn and Kull, 2015). As an indirect impact, during the rainy season, peat subsidence

expands flooding in the agricultural areas, which increases costs to the agricultural sector (Hooijer et al., 2012). At the household level, it damages houses (i.e., cracking, sinking, and leaning) and undermines the income earning capacity of affected households (Saputra et al., 2017; Saputra et al., 2019). Peat subsidence is a serious problem since it needs a complete restoration through methods like maintaining the level of groundwater level and reducing subsidence through drainage and water conservation and management (Wosten et al., 1997).

Considering the three mentioned issues, it is clear that peatland development has caused various problems. Even though the development of peatland for plantations, for instance, may lead to significant short-term economic profit for local people (smallholders), private estates, and local governments, it also may trigger long-term costs for the physical environment and socioeconomic status of peatland ecosystems and people (see Figure 4.3). All problems are interrelated and driven by various sources. Some of them have a causality linkage. The deforestation caused by the construction of drainage surrounding the estates has accelerated peat subsidence and increased the risk of fires, while fires have increased peatland oxidation, which caused peatland sinking. Fires can be minimized by tackling the drivers of peat subsidence through, for example, measures to maintain the water table level in plantations. This interconnectedness must receive serious attention, since each problem is intrinsically linked not only to various drivers but also to both small- and large-scale consequences. Therefore, all actors—such as governments at all levels, environmental and developmental NGOs, and communities—must make interventions to solve the problems.

Figure 4.3 The interconnectedness of peatland problems

4.4.2 The responses of various actors to peat subsidence

The issues mentioned in subsection 4.4.1 need to be resolved. Actors—namely the national, the provincial, and the local government, environmental and developmental NGOs, and communities—have tried to deal with the problems by making various interventions based on their capacity and understanding of the problems.

4.4.2.1 The responses of the government

Since peat subsidence happens gradually, it is recognized mostly from its impacts. In Riau, because the impacts (such as severe damage to plantations) have been discovered only recently, peat subsidence is still not a top priority of the government. Peat subsidence research has been intensified only in the last two decades. Thus, measures to deal with it have been limited. The government at various levels has focused more on deforestation and fire issues.

One of the crucial measures of the national government in managing peatland has been the forest moratorium policy (MoEF, 2018). The moratorium aims to postpone formal licenses for companies, prohibit land clearance activities for plantation development, and oblige every business to allocate parts of their concession areas for conservation purposes. The moratorium has been issued three times: A two-year moratorium on new concessions in primary natural forest and peatland areas (2011), a two-year moratorium on the protection and management of peat ecosystems (2015), and a three-year moratorium on postponing and evaluating the development of oil palm plantations (2018). The latest moratorium, which includes activities to verify cultivation rights on land (*Hak Guna Usaha*, or HGU), is intended to solve peatland problems that are caused by planting activities. However, this intention is questioned, since the moratorium only concerns the activities in new concessions, and not those in existing ones.

In addition, the national government tried to manage peatland by allocating land to accommodate its protection and production function through national spatial planning (RTRWN). The aim of the RTRWN is to increase the productivity of the areas and protect them from environmental damage. At the provincial and district/city government levels, the policies and strategies in the RTRWN are expected to be accommodated in spatial planning, detailed spatial planning, and zoning regulation. In Riau, the provincial government issued Spatial Planning (RTRW Riau) 2018–2038, incorporating protected and production areas. It is intended to manage land problems in the entire province, including deforestation and other peatland problems. However, numerous academics and NGOs doubt the RTRW Riau can solve peatland problems because it does not consider various issues that have been the triggers of land conflicts, for example, company–community estate borders and holding zone allocation.

The national and the provincial government have taken measures regarding not only deforestation, but also the prevention and fighting of fires—a problem that receives more attention than the other problems. For instance, (the former) National REDD+ Agency along with universities initiated a seasonal fire early warning system (the Fire Risk System; FRS) and trained the local government in Riau to recognize fire risks (Kieft et al., 2016). Regarding a more

technical solution, in 2014 the Riau government and the Indonesian National Board for Disaster Management (BNPB) obliged every plantation around the drained peatland to construct a drainage canal blocking system to reduce the amount of water being drained off in order to maintain the water table level and thus minimize the risk of fires. However, this solution failed because the fires reoccurred in the following year (BNPB, 2016).

Other government institutions at the national, provincial, and local levels have also taken measures to deal with fires. For instance, the Provincial Board for Disaster Management (BPBD Riau), supported by the BNPB, reinforced a Task Force for Forest and Land Fires (*Satgas Karhutla*) to quickly respond to fires. At the local government level, the governments of Pelalawan, Rokan Hilir, Siak, and Kepulauan Meranti districts regularly invite vulnerable communities to participate in various training sessions and meetings. Also, the Siak district government labeled the district a 'green district', as part of its mission to maintain forest areas by keeping deep peatland as the protected zones. In 2018, the Rokan Hilir district government initiated the Regional Action Plan for Land and Forest Fires (*RAD Karlahut*) to prevent fires in peatlands.

Furthermore, community-based fire prevention is also a concern of various governments. For instance, following the 'green district' initiative, the government of Siak introduced a community-based program called Community-Based Forest Fire Management (CBFFM). Also, the Ministry of Environment and Forestry (MoEF) initiated a Fire Care Community (MPA) to monitor and prevent forest fires at the community or village level. In some areas, MPAs were enhanced by the local government or private sector to be a Fire Care Village (DPA). This means that the responsibility for dealing with fires has been devolved from the community to the village government. The establishment of MPAs and DPAs inspired some companies, such as Asia Pulp and Paper (APP) and Riau Andalan Pulp & Paper (RAPP), to support the government's program by allocating money for DPAs around their concessions or by developing new DPAs initiated by the companies (Mongabay, 2018; The Jakarta Post, 2017). Both MPAs and DPAs were tasked with increasing the community's awareness of and ability to prevent fires. However, the effectiveness of this community-based program to prevent fires is questioned, since their activities are focused more on fighting fires than tackling their causes (Ni'mah et al., 2018).

Unfortunately, the mentioned policy measures did not include measures concerning peat subsidence. There was only a local government program that promised to deal with peat subsidence. In 2015, the government of Indragiri Hilir introduced the *Trio Tata Air* program, the aim of which was to maintain water levels in sinking coconut plantations by combating drainage leaks and blocking canals. The initiative was expected to save about 10,000 ha of the plantation from damage caused by sinking and flooding. Even though it was promising, the lack of continuous funding restricted the implementation, resulting in continued damage to the plantation and the sinking of peatland.

At the beginning of 2016, the Peatland Restoration Agency (BRG) was established to coordinate and facilitate activities to restore peatland in seven provinces, including Riau. In Riau, BRG has been slowly delegating restoration activities to Regional Peat Restoration Teams since 2018 (*Tim Restorasi Gambut Daerah*, or TRGD). To ensure ideas from various actors are

covered, BRG and TRGD involve in their activities government institutions, NGOs, national and international donors, academia, private sectors, and local communities.

By 2020, BRG expects to have restored about 800,000 ha in Riau within peatland hydrological units (PHUs) through three approaches (3R), namely rewetting, revegetation, and revitalization. These approaches have been started by BRG by giving priority to the rewetting measures. The rewetting was applied by developing drainage canal blocks and deep wells in districts or PHUs where peatland has suffered extreme damage. By 2017, BRG had constructed 309 canal blocks in 24 villages and 400 deep wells in eight villages in various districts (BRG, 2018). BRG had developed 34 and 38 canal blocks, respectively, in PHU Pulau Tebing Tinggi and PHU Pulau Padang, Kepulauan Meranti District. It had built 41 canal blocks in three villages in Dumai City and developed 50 deep wells in Rimbo Panjang Village in Kampar District. Then, in 2018, another 108 canal blocks and 34 deep wells in Kepulauan Meranti and 47 canal blocks in Dumai City were constructed (BRG, 2018; JawaPos, 2018). Furthermore, some revitalization and revegetation activities were also launched, usually almost simultaneously. For instance, BRG initiated the economic revitalization programs for communities in Kepulauan Meranti District by promoting paludiculture and allocated 2 ha of land to be revegetated (BRG, 2018). BRG also trained local communities to increase their economic status through an activity to intensify the value of fishery commodities in peatland and participatory revegetation. To ensure the economic revitalization is in line with revegetation efforts, BRG obliged local people to plant local commodities—for example, sago, pineapple, coconut, and jelutong—in the areas that had been restored. Then, to ensure the sustainable involvement of the community in BRG's activities, the 3R approach was continued by establishing a Peatland Care Village (*Desa Peduli Gambut*, or DPG). By 2017, BRG had promoted 11 DPGs where programs initiated by BRG were built up by the local community or even NGOs and the private sector (BRG, 2018).

4.4.2.2 The response of NGOs

For decades, environmental and developmental NGOs at the national and the local level have been playing crucial roles in managing Riau's peatland. Some of them have even expanded their tasks from a single social movement into experience- and knowledge-based activities, such as policymaking assistance and knowledge-sharing initiatives.

Among all these measures, advocacy was still the primary activity in maintaining the sustainability of peatland. The advocacies were intended to deliver protests and increase awareness of peatland issues in governments (especially provincial and local governments), the private sector, and communities. The issues the NGOs dealt with and the way they delivered ideas were determined by their working locality and area of focus. Some environmental NGOs—such as Wetlands International Indonesia, Greenpeace Indonesia, Indonesian Society for Disaster Management (MPBI), and WWF Indonesia—advocated to the national government and multinational companies regarding deforestation and peat fires through frequent campaigns. Wetlands International Indonesia also worked with the bank and industry certification agency to increase investors' awareness of sustainable peatland. WWF Indonesia

promoted Roundtable for Sustainable Palm Oil (RSPO) certification to palm oil industries to encourage the sustainable growth and use of oil palm commodities.

Moreover, for years, local environmental NGOs have been focusing their advocacy on local issues related to peat fires, deforestation, and estate development. NGOs Walhi Riau, Jikalahari, Hutan Riau, YMI (*Yayasan Mitra Insani*), and LSM Rupari frequently delivered campaigns regarding the loss of forest cover caused by large-scale oil palm and pulpwood plantations, land conflicts between communities and companies, and the weakness of law enforcement regarding the actors and corruptors behind the frequent forest and peatland fires. Furthermore, Jikalahari also delivered their thoughts in various national and international forums to keep issues of deforestation and fires a matter of global concern. Then, various environmental NGOs expanded their advocacy to target younger people and students, by disseminating their ideas through booklets, newsletters, books, social media, or websites. Unfortunately, peat subsidence appeared as a supplement and a small part of peat fire and deforestation debates.

To support their advocacy activities, some NGOs also worked in practical ways. The failure of their campaigns and protests to attract government and private-sector activities triggered some national and local environmental NGOs to work directly with other actors on small-scale activities. For instance, Greenpeace Indonesia established a voluntary Forest Fire Prevention Team (*Tim Cegah Api*) to detect and fight fires. Walhi Riau, Hutan Riau, and Jikalahari also worked to identify hot spot distributions and delivered information to the governments, communities, and MPAs. Jikalahari, YMI, and Walhi Riau also tried to prevent forest fires and ecosystem damage by actively participating in a Tesso Nilo Ecosystem Revitalization project in Pelalawan, Kuantan Singingi, and Kampar districts. Furthermore, since 2013, YMI has been working with a local community in Harapan Jaya Village, Indragiri Hilir District, to prevent fires through community-based peatland management and community economic empowerment. Along with the community, they initiated a Village Participatory Contour Map and a "Grand Design of Village Water Management," developed fire early warning systems, and built demonstration plots of small-scale oil palm plantations.

In the last few decades, NGOs have increased their knowledge of and experience in peatland management. They have been supported by the openness of the national and local governments to NGO involvement, and some environmental NGOs assisted such governments in designing policies and programs. Walhi Riau, Jikalahari, Hutan Riau, Walhi Indonesia, Wetlands International Indonesia, and Greenpeace Indonesia, for instance, were repeatedly involved in designing spatial planning and peatland restoration agendas. They regarded the meetings as opportunities to push the idea of sustainable peatland management into the governments' policies and programs. The involvement of NGOs was important to support the lack of government capacity to collect information at the community level. To some extent, their information was key to the local government and communities initiating particular programs. For example, the Siak district government initiated a 'green district' program, which was supported by Walhi Riau, Jikalahari, YMI, and Yayasan Elang, while villagers and village governments in Bengkalis District, helped by Jikalahari, issued a Village Regulation on

Water Management and Fire Prevention, which then was formalized by the local government (Jikalahari, 2017).

Furthermore, some developmental and environmental NGOs have also used training and capacity building activities to encourage the government and affected people to start taking measures. For instance, at the national level, YPB (*Yayasan Pembangunan Berkelanjutan*) conducted training on sustainable development and disaster management for leaders from government institutions, the community, academia, and other stakeholders. At the local level, Hutan Riau, Walhi Riau, YMI, Greenpeace Riau, and Jikalahari trained local government officers and communities in Siak, Kepulauan Meranti, Pelalawan, Indragiri Hulu, and Indragiri Hilir districts to identify degraded peatland, the hotspots, and fire distribution, as well as to manage canals around plantations through a canal blocking system. WWF Indonesia trained independent oil palm smallholders in Kuantan Singingi District to increase their knowledge of sustainable palm oil (WWF Indonesia, 2016).

As peat subsidence also undermines the income earning capacity of affected people (Saputra et al., 2019), some NGOs offered activities to increase the income capacity and income source variety of those affected. Wetlands International Indonesia and Jikalahari proposed a community-based planting system—"paludiculture"—which combines local commodities with non-peat-based income sources, such as livestock. The paludiculture could increase people's income and also delay peat subsidence (FAO and Wetlands International, 2012). Additionally, YMI facilitated affected people in Tempuling subdistrict in Indragiri Hilir to increase the value of coconut by producing coconut-based cooking oil. These extra income generators are expected to increase the economic capacity of affected people.

Thus, environmental and developmental NGOs have taken various measures to deal with peatland problems. However, only some of them were designed with peat subsidence as the main concern. The lack of knowledge of peat subsidence, supported by their priority to deal with more obvious problems like fires, were reasons why the NGOs did not make peat subsidence their top priority. The gradual process of peat subsidence was another reason, as it seemed like a hidden problem and a minor issue. Therefore, most NGOs argued that rapid responses were not yet needed. This assumption was worsened because most local environmental NGOs were struggling to maintain sustainable funding, which pushed them to work on regular activities instead of peat subsidence.

4.4.2.3 The responses of communities

Communities that are affected by peatland problems and the measures taken by external actors had also taken measures. They had tried to deal with peat subsidence in their surrounding areas by focusing mainly on managing canals and dealing with fires. Even though the measures were infrequent and small in the coverage area (village level), their interventions indicated that they were aware of such issues.

Their measures were categorized into measures that were initiated by themselves and those that were developed by external actors, which then were improved or taken over by the

community. Activities to rehabilitate and normalize canals were common measures initiated by communities. The oil and coconut palm plantations had dried out due to canals drying out, and had caused improper growth or killed the palms. The damage had decreased the income of affected people (Saputra et al., 2019). Therefore, to avoid a bigger loss, communities rehabilitated the canals by patching the leaks to maintain an appropriate depth and managing the water table level in plantations using traditional canal blocks. At the community level, these measures prevented the damage from becoming worse. However, in some cases, the establishment of private oil palm estates near the villages had destroyed the smallholders' canal system since they were not properly connected with those of private estates. Communities had not only taken measures to deal with current problems, but had also tried to prevent future problems. Through village governments, locals issued a Village Regulation on Forest and Land Fires Prevention, which aimed to build community-based fire prevention and a self-control mechanism among communities by arranging punishment points for people who burn their land and trigger fires on other people's land. Since the establishment of this regulation, fires caused by community activities have been minimized. However, fires from private estate activities could not be prevented.

Communities also continued and improved measures established by the national and the local government or environmental NGOs. Some measures that required a particular skill were handed over to communities after some training in capacity building. For example, YMI designed a participatory contour map to assist communities in designing canal blocking systems and initiated a "Grand Design of Village Water Management" to provide communities with strategies to manage water and canals surrounding plantations. Communities are now slowly enhancing the map with the latest data gathered from independent surveys to maintain the canal blocking system. They also combine programs arranged by MPA with the village regulations on fire prevention. According to communities, this combination has promoted the prevention of fires.

The interventions of governments, NGOs, and communities addressed different peatland problems, but mostly fires (Table 4.2). Some local environmental NGOs had also begun working collaboratively with other NGOs or with the government, mostly the local government, to initiate measures. The NGOs started to work together due to the mutual issues and targeted areas, while their collaborative work with the government was triggered by their need to share both knowledge and experience. Most of the measures were taken by a collaboration of two or three types of actors. The measures that involved more than a single actor could be originated from ideas of a particular actor or combined actors that were executed together. Therefore, this subsection shows that the measures had formed and increased interactions and dynamics between various types of actors.

Table 4.2 Summary of interventions of the government, NGOs, and communities to deal with peatland problems in Riau

Intervention	Involved actor(s)	Related Issue			Level(s) of intervention
		Deforestation	Peat and forest fires	Peat subsidence	
Policy and non-construction measures					
1 Allocating protected peatland areas in spatial planning	Bappenas, provincial and local government, Walhi Indonesia, Greenpeace Indonesia, Wetlands International Indonesia, Bappeda, Walhi Riau, Hutan Riau, Jikalahari	+++	++		National, provincial, and local
2 Designing an action plan to prevent forest and peat fires	Riau government		+++		Provincial
3 Designing and implementing a disaster management policy	BNPB, BPBD Kabupaten/Kota, MPBI		+++		National and local
4 Protecting deep peatland by issuing protected zones through the Green District program	Local government, Walhi Riau, YMI, Jikalahari	+++	++		Local
5 Oblige smallholders and private estates to construct canal blocking systems	BNPB		+++	++	Local
6 Campaigns on deforestation, fires, and peatland restoration	Walhi Indonesia, Greenpeace Indonesia, WWF Indonesia, Wetlands International Indonesia, Walhi Riau, Greenpeace Riau, Hutan Riau, YMI, LSM Rupari, Jikalahari	+++	++	+	National and local
7 Offering RSPO certification	WWF Indonesia	+++		++	National
8 Designing village contour maps for canal development	Village government, YMI, communities		++	+++	Community
9 Mediating community-company land conflicts	Walhi Riau, Hutan Riau, LSM Rupari	+++	++		Local
10 Sharing peatland-based data	Jikalahari, Walhi Riau, Hutan Riau	+++	++	+	National, provincial, local, and community

Intervention	Involved actor(s)	Related Issue			Level(s) of intervention
		Deforestation	Peat and forest fires	Peat subsidence	
11 Pushing law enforcement	Jikalahari, Walhi Riau, Greenpeace Indonesia, Walhi Indonesia	++	+++		Local and national
12 Initiating a village regulation on water management and fire prevention	Jikalahari, YMI, village government, and communities		+++	+++	Community
13 Training in sustainable development and disaster management	YPB	+++			National
14 Training in increasing peatland issue awareness for private sector	Wetlands International Indonesia	+++	++	+	National and local
15 Training to identify degraded land for local government and people	Walhi Riau, Hutan Riau, Jikalahari, YMI	++	+++	+	Local
16 Initiating workshops in peatland restoration	Wetlands International Indonesia, Jikalahri	+	+++	++	Local
17 Providing funding through IPPF program	Wetlands International Indonesia		+++	+	Community
Construction/applied measures					
18 Restoring peatland through rewetting, revegetation, economic revitalization approach	BRG, WWF Indonesia, Wetlands International Indonesia, Walhi Riau, Jikalahari		+++	++	National. Provincial, Local
19 Fighting fires by Establishing Fire Care Communities (MPAs) and Fire Care Villages (DPAs), reinforcing Satgas Karhutla, designing RAD Karlahut, initiating the CBFFM program (Initiating community-based forest fire programs)	BNPB, MoEF, Riau Government, BPBD Riau, local government		+++		Provincial, local, and community
20 Establishing Peatland Care Villages (DPGs)	BRG		+++	++	Local
21 Initiating a Trio Tata Air program to rehabilitate plantations	Local government			+++	Local
22 Establishing Forest Fire Prevention Teams	Greenpeace Indonesia		+++		Local
23 Initiating "paludiculture" planting system	Wetlands International Indonesia, Jikalahari, BRG		+++	++	Community

Intervention	Involved actor(s)	Related Issue			Level(s) of intervention
		Deforestation	Peat and forest fires	Peat subsidence	
24 Involvement in Tesso Nilo Ecosystem Revitalization	Walhi Riau, Jikalahari, YMI	++	+++		Local
25 Empowering economics of local community	YMI		+++	++	Community
26 Rehabilitating and normalizing canals	Village government, YMI, communities		++	+++	Community

Note: the number of '+' reflects the degree of priority that actors assign the issue
Source: Data analyses (2016)

4.5 DISCUSSION

This chapter analyses the types of problems caused by peat subsidence and the interventions by various actors to deal with it by addressing two questions: (1) What kinds of problems are related to peat subsidence? And: (2) How do various actors deal with peat subsidence and what are the consequences of their interventions? The following subsections reveal the severity of peatland problems by explaining the complex consequences of the problems and their inter-relationships, as well as numerous interventions made by various actors to deal with such issues, along with their consequences.

4.5.1 How severe is the problem of peat subsidence in Riau?

This chapter shows that many peatland areas in Riau have been experiencing severe peat subsidence and other peatland problems. Peatland development is the main trigger of deforestation, fires, and peat subsidence, which are interrelated (see Figure 4.3). Peat subsidence can be triggered or exacerbated by other problems. Deforestation and fires can accelerate peat subsidence. The decomposition of peat soil and the emission of carbon that follows deforestation and the development of drainage canals can trigger the sinking (Hooijer et al., 2012; Kieft et al., 2016; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015). At the same time, the fires that cause peat oxidation increase the rate of sinking (Couwenberg and Hooijer, 2013; Kieft et al., 2016).

These problems have numerous physical environment and socioeconomic consequences for peatland and the affected people. One of the serious consequences is the loss of the peatland ecosystem and biodiversity. Peatland is a scarce resource that is difficult to renew because it is mostly composed of organic soil. Once peatland has been damaged, there is little chance that it will be restored. Drained peatland also triggers various indirect impacts, such as fires and a decrease in plantation productivity. From the economic aspect, the intensive development of peatland has threatened its sustainable economic use. Although the development of peatland can increase the income of smallholders, such as from estate development, it also increases food insecurity by decreasing the amount of land devoted to

food crops (Susanti and Burgers, 2012). Peatland development also triggers social conflict. For instance, in Riau, Scale Up (2017) found that there had been about 631 land conflicts between communities and companies in the previous decade, and that 19 people had been killed as a result. As one problem can be a symptom of others, peatland development can trigger or create more complicated problems. The interrelation between problems and the severity of their consequences could be illustrated by characteristics of wicked problems from Howes and Wyrwoll (2012).

4.5.1.1 Problem formulation

The problems in the Riau peatland originate from the complex drivers and scales of a fundamental problem. Common causes include an increase in estate growth in districts where peatland is prone to damage, inappropriate government strategies in accommodating how peatland development can generate income, and the local governments' and communities' lack of knowledge of the causality relationship among peatland problems. The lists of these substantial drivers will grow depending on the scale interpretation of the problem. The causes at a local level will be different from those at the regional or national level.

Due to the complexity and interrelationship of the problems, the interpretation of the issues from different actors is dissimilar. In our case, there is no definitive comprehensive problem formulation by all actors. To start issuing policies and taking measures, peatland status must be monitored repeatedly by each actor using their resources and capacity, resulting in, again, a different interpretation of the problems. Consequently, measures taken were mostly partial and could not fit the entire problem. The measures solved only some of the problems, and only temporarily. Therefore, the problems will remain and even worsen.

4.5.1.2 Interdependency

In this case, the problems are linked to many drivers and consequences. Because of their causality relationship, any interventions made for one problem will influence others. It is inarguable that peatland development (e.g., oil palm estates) could increase the income of local people, private sectors, and the provincial and local governments. For the provincial and local governments in Riau, it has long been an essential source of revenue (Susanti and Burgers, 2012). On the other hand, the development of peatland caused serious damage to the peatland ecosystem that triggered various impacts on the physical environment status of peatland. Most of the problems were connected to the potential long-term damages of peatland ecosystems and the decrease in the welfare of affected people. Even worse, people who were not related to peatland development—for example, those who did not have or were excluded from estate activities—have seen only negative impacts on their environment without directly receiving economic benefit. The high interdependency of the problems led to interventions by various combinations of actors. Some argued that the solution must be developed from a small-scale (community) level, while others believed that the interventions must be based on policies that embrace all problems. Thus, the complexity and interdependency of the problems have

attracted various actors to take measures based on their interpretation of the problems and their interconnectedness (Howes and Wyrwoll, 2012).

4.5.1.3 Solution set

The solutions offered by various actors were determined by their perpsectives on the problem (Howes and Wyrwoll, 2012). Measures such as the forest moratorium policies, strengthening government institutions to deal with fires, empowering the economic capacity of the local community, and dealing practically with local-level problems were some of the notable solutions offered by the actors. These various measures seem able to solve the complex problems of the Riau peatland. However, the extent to which the solution addresses the entire problem is still arguable and hard to define (Howes and Wyrwoll, 2012). For example, a conflict between the community and a company that was triggered by a different interpretation of the design and use of canal blocks (Jikalahari, 2018a) shows that the solution was not easy to establish. Also, the inability of the measures taken by BRG to prevent reoccurring fires in their demonstration plots (see BNPB, 2016) indicates the same. Occasionally, the solutions also caused a feedback effect. In relation to the scale, a solution designed to deal with fires in a village by blocking canals, for instance, had also caused the damage to the plantation to worsen due to the increase in the drainage of water from the plantation into the canals, especially because the canal had been constructed without considering the relation to bigger canal systems. Thus, the solutions must be reformulated to meet all problems.

Therefore, peatland problems are both complex and interrelated. The main issues discussed by actors are the fires and the deforestation that have occurred for several decades with massive consequences. Peat subsidence is still hardly noted even though its impacts are severe and the coverage area is huge. Indeed, due to the interconnectedness of the problems, interventions directed to solve one problem will affect others. This assumption also applies to peat subsidence. However, peatland problems need to be solved entirely and comprehensively. Therefore, the actors must have the ability to deal with this combined problem.

4.5.2 Can the government, NGOs, and communities manage peat subsidence using their measures?

To prevent the extensive consequences of peat subsidence and other problems, the governments at all levels, environmental and developmental NGOs, and communities have taken numerous measures (see Table 4.2). The measures aimed primarily at peat subsidence were limited, however, due to a lack of knowledge or awareness among the actors. Because peat subsidence is a slow-onset disaster, it was not mentioned in any government documents. The measures to address peatland problems were not optimal, because little attention was paid to the impacts of subsidence over time in a vast coverage area and its important role in worsening other peatland problems cannot be established.

In addition to the lack of attention to peat subsidence, measures taken by all actors could be seen as quick and partial solutions for peatland problems. Measures were mostly designed by considering the current impacts of peatland development on the peatland ecosystem and the affected people. Unfortunately, many interventions were designed mainly based on each actor's understanding of the problems, which somehow could not be linked to other measures taken by other actors. Consequently, those measures could not be combined or be complementary. To deal with the complex and interrelated problems of peatland, complementary measures originating from all involved actors are needed (Espia and Fernandez Jr, 2015).

Thanks to BRG through peatland restoration activities, opportunities for different actors to collaborate more intensively in making measures were created. Restoration activities are not a new way of managing peatland in Indonesia (Suryadiputra et al., 2005). Previously, the restoration was arranged by an individual or a group of actors based on their resources. By the establishment of BRG, activities to restore peatland were rather organized and various actors have been involved. Consequently, some collaborations between actors have also been initiated. The collaborations between BRG and local environmental NGOs from the beginning of the designing of restoration programs up to the implementation of the programs, shows that intensive interactions among such actors have been formed. The extensive knowledge of such NGOs about detailed peatland problems in a particular area and their experience in designing solution-based activities for communities were the keys to their involvement. From the NGOs side, their need to maintain their activities, improve their knowledge of peatland issues, and enhance their ability to manage peatland had pushed them to collaborate with other actors, including BRG. The need for knowledge and resource sharing has led to the development of relationships among the actors (Bebbington et al., 2005). In practice, the collaborations started as activities to rewet the peatland, which is the priority activity of BRG to restore peatland. The rewetting through blocking drainage canals is the way to maintain the level of the water table (Page et al., 2009; Suryadiputra et al., 2005). For peatland in Riau—where peat subsidence and fires are triggered by the unstable water table (Hooijer et al., 2012; Saputra et al., 2017; Schrier-Uijl et al., 2013)—these activities might reduce the acceleration of sinking.

The ways the environmental NGOs supported the restoration agenda were also beyond the activities designed by BRG. Some of them initiated measures that were not handled by BRG or other government institutions by expanding their advocacy activities into knowledge-based actions. For instance, Jikalahari and Wetlands International Indonesia conducted workshops on peatland restoration and peat fire preparedness to share their knowledge of the peatland rewetting process and water table management, attended by the local community, NGOs, and MPAs. Wetlands International Indonesia supported BRG's 3R approach by providing funding for communities in the targeted areas of BRG through the Indonesian Peatland Partnership Fund (IPPF) program. These supporting measures can be seen as highlighting the problems. Measures outside the collaborative works but needed by the government can be complementary to the government's measures (Espia and Fernandez Jr, 2015).

The mentioned measures, both collaborative and complementary, seem likely to continue since they are fully supported by communities. Measures initiated by local environmental NGOs and the governments with communities at the village or community level could be effectively directed to deal with the core problems based on detailed information provided by communities. Support from communities to implement the measures had also increased the opportunity to deal with the problems. Some measures aimed at managing the water table level in smallholder plantations through the participation of communities indicated that they worked directly to mitigate current impacts and prevent the drivers of peat subsidence. Therefore, by working with communities who own the consequences and are the target of interventions, the measures can lead to the root of the problems.

All types of actors had tried to deal with peatland problems. Some measures were taken individually, others collaboratively. Some actors interacted with others and initiated collaborative works in an effort to adapt to their limited knowledge and resources to take action, expand their ability to influence other actors' activities, and enhance the output of solutions. These ways could increase the kinds and effectiveness of measures. These findings support the notion put forward by Mohammed and Inoue (2016), namely that measures from state and non-state actors are crucial in dealing with problems. In the context of peat subsidence, even though limited because of problem interconnectedness, measures to deal with other problems intersected with peat subsidence. Even though they are not yet effective enough to prevent peat subsidence, the measures could slightly delay peat subsidence.

Thus, this chapter shows that interventions by both types of actors work to deal with current problems, such as fire damage to canals and plantations. In addition, peatland restoration programs that were done collaboratively by different actors seem promising if applied in similar peatland areas in Indonesia or around the world where there are similar characteristics to the case study areas. However, one notable concern is that to optimize measures to deal with peatland problems, the comprehensive measures based on the peatland ecosystem unit must be thought through, something that has not yet been entirely considered by current measures.

4.6 CONCLUSION

This chapter analyzed the types of problems that are caused by peat subsidence and the interventions of various actors to deal with them. It shows that subsidence in peatland areas is a result of human behavior. The massive exploitation of peatland for economic and non-food-related activities has triggered severe peatland problems, such as massive deforestation, fires, and peat subsidence, followed by costly consequences for the physical environment and the socioeconomic status of peatland and affected people. In the absence of appropriate interventions, the massive consequences of peatland development will continue. Severe problems—such as the loss of peatland ecosystem and biodiversity, huge fires, damage to plantations, followed by a decrease in the economic status of affected people, and land conflicts between communities and companies—will continue to exist and arise. The constant

multidimensional impacts, interdependency of the problems, and some solutions that might trigger other problems have shown that peatland problems look like a wicked problem.

Among all problems, peat subsidence is one of the most severe but least recognized issues. Peat subsidence and other problems are interrelated and driven by various sources. Peat subsidence may trigger more complex problems since it leads to and is led by other peatland problems (Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015). Even though peat subsidence occurs on a massive scale for an extended period of time and undermines people's income-earning capacity (Hooijer et al., 2012; Saputra et al., 2019), peat subsidence in itself has never been a top concern of actors in managing peatland. The most commonly and intensely debated issues are peat fires and deforestation, which lead to a massive loss of ecosystem, serious health problems, and frequent land tenure conflicts between communities and companies (BNPB, 2016; Herawati and Santoso, 2011; Kieft et al., 2016; Scale Up, 2017; Tacconi, 2003; Uryu et al., 2008). The regional and international impacts of fires have attracted public attention to the issue of peat subsidence. It is worsened by the fact that the consequences of subsidence for peatland and affected people can only be noticed after a long period of sinking. As a consequence of their hidden status, peat subsidence debates often came later on or as a part of other issues. Later, the lack of attention to peat subsidence together with other peatland problems prevents the problem from being solved.

To deal with severe peatland problems, the case study highlights several interventions by the government at various levels, environmental and developmental NGOs, and communities. In a general pattern, the governments provided policies and worked on practical measures to manage risks (Bollin et al., 2003; Topno, 2018); NGOs supported the governments' measures through their knowledge of problems at the local level (Benson et al., 2001); and communities initiated small-scale community measures and ensured measures from other actors were accepted and maintained. In some cases, measures taken by these actors to deal with peatland problems in the areas near the concessions of private actors were also supported by some companies. For instance, with a limited involvement, some private sectors became involved voluntarily in developing MPA and restoring peatland in their concessions (The Jakarta Post, 2017). On the other hand, private sectors were also obliged to restore peatland in their concessions (BRG, 2016). Therefore, this shows that regulations issued by the national government that push private sectors to actively support the governments' program, as well as initiatives by other actors to rehabilitate peatland, have been able to trigger the companies to take action.

Some of the measures were designed collaboratively, while others were not. The different measures taken by the actors were driven by their dissimilar interpretations of the problems (Howes and Wyrwoll, 2012). So the success of collaborative measures to manage some problems and direct the solutions close to the root of problems underlines the importance of actors to engage actively in activities to solve peatland issues.

Thanks to peatland restoration activities, the attention that all actors pay to the multifaceted peatland problems has been improving and the resources have been distributed more

proportionally based on the degree of the problem. Various peatland problems are in the process of being solved, generally because of an increase in the involvement of different actors outside the formal authority. Even though the activities are more focused on restoring the damage caused by fires and drainage canals, the peat subsidence issue has been gradually attracting attention. Therefore, the peatland restoration agenda can be regarded as a point of departure to deal with complex peatland problems through a comprehensive measure and the collaboration of various actors. By getting various actors to undertake collaborative actions, the restoration agenda can be seen as a promising approach to the complex peatland problems. In the case study area, the collaboration between BRG, local governments, environmental NGOs, and other actors increased the variety and quality of the measures. Therefore, the notion put forward by Lewis (2004), namely that the government and NGOs could be constructive partners, is supported by these findings. At the same time, it supports Roberts's (2000) statement that the collaboration might lift the ability of each actor up to the optimum level to create better outputs.

To conclude, it is unquestionable that the challenge to maintain the productivity and sustainability of peatland is huge. The increase in economic demand for commodities produced on peatland and the aim of the national government to intensify the use of peatland for economic purposes, means that peatland will continue to be exploited. The extent to which various actors can maintain and sustainably use peatland will determine the degree of risk of peatland. An approach is needed that is actor-centered, rather than promising to deal with peatland problems that look like wicked problems. However since not all of the problems can be solved and their interconnectedness is strong, a comprehensive approach to deal with all peatland problems at one time is needed. All problems must be considered, including peat subsidence.

Land subsidence in coastal areas: How can governments and NGOs better manage this problem? An example from Semarang City, Indonesia

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ABSTRACT

Land subsidence in coastal areas is an important issue due to the simultaneous threat posed by other coastal hazards. These combined hazards have severe and long-term physical and economic impacts on coastal areas and the affected people. Those affected often cannot manage land subsidence because of their lower income capacity and the hazards' vast coverage area. Therefore, the situation calls for the involvement of government and non-governmental organizations to deal with these hazards. This present research explored land subsidence in coastal areas with an emphasis on the role of governments and NGOs in managing it. Two major research questions were addressed: 1) What do the problems look like? And 2) what interventions are being implemented by the governments and NGOs to deal with the problems? Using the governance approach, these questions were answered through in-depth interviews, a desk study, and a scoping study. Using an example from coastal areas of Semarang City, Indonesia, this chapter shows that land subsidence is a critical issue with severe impacts on the affected people as it continues to spread along the coast. To deal with subsidence, various levels of government and local NGOs have created interventions to manage the impacts and prevent future drivers, some of which were designed through collaborative actions. However, the problem as a whole cannot be resolved. The collaborative measures improve the situation only slightly. Therefore, more integrative measures are needed to enhance the potential for symmetric collaboration among the involved actors.

Keywords: Semarang City, land subsidence, governance approach, coastal hazards, actors' interventions, government–NGO relations

5.1 INTRODUCTION

Land subsidence in Indonesia's coastal areas has been a global concern for decades, as numerous coastal areas have been sinking on a massive scale (see Dang et al., 2014; Stanley and Clemente, 2017; Zhang et al., 2018). The unstable soil and natural compaction of the sediment in these areas accelerates the sinking process (Sarah et al., 2018; Syvitski et al., 2009; Teatini et al., 2011; Zhang et al., 2018). The natural process is hastened by various human interventions, such as groundwater extraction and the reclamation and drainage of coastal areas (Abidin et al., 2013; Carbognin et al., 2004).

Continuous land subsidence has had severe impacts on the coastal areas. It has led to damage to buildings and infrastructure, shoreline regression, inland intrusion of saltwater, and an increase in coastal flooding (Fiaschi and Wdowinski, 2017; Marfai and King, 2007; Minderhoud et al., 2017). Furthermore, in combination with other coastal hazards (e.g., sea level rise and storm surge), the area of permanent inundation has increased (Chen and Tfwala, 2018). These combined hazards have formed a disaster chain that has caused significant damage (Wang et al., 2012). In Indonesia, a massive growth of economic activities, physical development, and the population of coastal areas has increased the risk of coastal hazards, including land subsidence, which threatens the environment and socioeconomic status of the areas and people (Abidin et al., 2015; Chaussard et al., 2013; Saputra et al., 2017; Sarah et al., 2018).

To mitigate the worst impacts of disasters, numerous scholars have suggested various actors to prevent and manage such disasters. Among the actors, governments and NGOs are critical in reducing disaster hazards (Nolte et al., 2012). The government could improve people's safety by designing legal instruments and policies (Renn, 2017). The involvement of intergovernmental actors will create better and more diverse responses through a cooperative approach to combine resources and prevent duplication of measures (Kapucu et al., 2010). NGOs could support the government through their extensive knowledge of local problems (Waugh and Streib, 2006). Their collaboration could compensate for the limitations of the other actors' abilities and resources (Moser and Ekstrom, 2010).

This chapter explores land subsidence in coastal areas with an emphasis on the roles of two kinds of key actors—namely governments (the central and local governments) and NGOs—in dealing with it. In Indonesia, these actors have long been the crucial actors in dealing with various single-shock disasters and environmental damage, since they can complement each other by providing high-level and community-level actions (Lassa, 2013). Furthermore, the increase in democratization and decentralization, which started in 1999, has pushed both types of actors to collaborate to extend their ideas and work (Antlöv et al., 2008). In other developing countries, the increase in democratization has enhanced the governance of environmental problems (Tang and Tang, 2006).

To comprehensively understand land subsidence in the coastal areas, this chapter addresses two major research questions, that is: What do the problems look like and what interventions are being implemented by governments and NGOs to deal with the problems? The aim of answering the first question is to understand the status of land subsidence. It is crucial because

it has been happening for decades, while people have to deal not only with the sinking of their land but also with other hazards, namely the rise in sea level, the increase in inundation coverage, and the damage to the coastal ecosystem. As land subsidence has a huge coverage area (Chaussard et al., 2013) that sometimes includes more than one administrative area, people struggle to deal with it due to the limitation of resources (Saputra et al., 2019). Land subsidence is a daily problem for these people (Saputra et al., 2019; Syvitski et al., 2009). Thus, actors other than those who are affected are required to take action. The second research question addresses land subsidence by detailing the types of measures taken by these two types of actors to deal with current problems and potential future issues.

The multifaceted problems of coastal areas may provide the impetus for various interventions by the mentioned actors, which will lead to multiple types of relationships among the actors. This chapter also helps define the roles of each actor in land subsidence governance that are still lacking in literature. The roles of these actors regarding single-shock disasters in different geographical areas have been discovered through various interventions (e.g., see (Benson et al., 2001; Lassa, 2015; Luna, 2001). Therefore, this chapter contributes to the literature on disaster governance by examining multi-actor interventions and relationships in dealing with sleeping disasters, specifically land subsidence in coastal areas, based on types of NGO–government relations defined by Najam (2000).

Understanding the status of land subsidence in the coastal areas of Indonesia and other developing countries, as well as its relation to other hazards, is becoming more crucial due to the massive growth of economic activities and populations (Abidin et al., 2013; Marfai and King, 2007; Syvitski et al., 2009). This growth has significantly increased exposure to various coastal hazards (Nicholls et al., 2007). By understanding the status of land subsidence and other coastal hazards, the interrelation among the hazards, and the interventions made by various actors to deal with the problems, this chapter reveals how big the issue is and the capacity of such actors to deal with the long-term and combined hazards.

The case study comes from the coastal area of Semarang City—a city that has been experiencing land subsidence for more than a century and also suffers from combined coastal hazards, namely sea level rise, coastal erosion, flooding, and inundation (Abidin et al., 2013; Marfai et al., 2008). The vulnerability of this area has also been increasing due to a massive increase in population and economic activities (Marfai et al., 2008; Rahardjo, 2000; Setioko et al., 2013). The example from this area will be useful for other areas with similar geographical and development characteristics to understand the governance aspects of long-term disaster from land subsidence viewpoint.

To elaborate the research questions, this chapter is divided into seven subsections. Subsection 5.2 briefly describes the theoretical review of disaster governance and the government–NGO relationship. Subsection 5.3 explains the methods, while Subsection 5.4 describes the case study area. In Subsections 5.5 and 5.6, the actors' responses and relationships are explained. The last section discusses and concludes the findings.

5.2 DISASTER GOVERNANCE AND THE TYPES OF GOVERNMENT–NGO RELATIONSHIPS

Various actors at different levels have long been involved in dealing with disasters through various measures. However, disasters cannot be solved by the actions of a single actor due to a limitation of resources (Moser and Ekstrom, 2010). Disaster governance is needed to increase the resilience of people at the local level. Disaster governance not only combines various formal government institutions, private companies, and civil society organizations, but also addresses combined social, political, and economic dimensions (Douglass, 2016; Tierney, 2012). The complexity of the dimensions has steered the actors, such as the government and NGOs, to work together in governance activities (Tierney, 2012).

The relationships vary and are determined by a variety of interests and organizational backgrounds (Sen, 1999, 351). Scholars such as Coston (1998), Young (2000), and Najam (2000) propose several types of relationships based on various considerations. Coston (1998) classifies government–NGO relationships into eight typologies based on three considerations, which are the acceptance of the actors on pluralism, the degree of formalization, and the power relationship. Young (2000) divides the NGO–government relationship into supplementary, complementary, and adversarial types, which are based on the historical perspective of two kinds of actors. Najam (2000) offers the Four-C's of NGO–government relations based on the four combinations of goals and strategies: cooperation, confrontation, complementarity, and co-optation (see Figure 5.1).

		Goals (Ends)	
		Similar	Dissimilar
Preferred Strategies (Means)	Similar	Cooperation	Co-optation
	Dissimilar	Complementarity	Confrontation

Figure 5.1 The four C's of NGO–government relations (Najam, 2000)

The types of relations are complex. However, we draw from and modify various models, particularly Najam's model, since it is compatible with characterizing the relationships of the actors triggered by various measures during a long-term process of land subsidence. Najam's categorization—which divides the relationship by similarity and dissimilarity of measures—might help to understand the readiness of the actors to work collaboratively and effectively to deal with the issues. This theory has an advantage in defining the relationships of the actors, as it counts both the government and NGOs as policy entrepreneurs. Assuming that there has already been a local government that plays a role in taking responsibility to tackle problems at the local level, there will be an overlap of measures taken by NGOs that is used to work at the

same level. Therefore, this chapter reviews the kinds of government–NGO relations derived from Najam's theory (2000).

5.3 METHODS

The present research adopted a case study qualitative method. This method, which combines several sources of evidence, such as open-ended interviews, documents, and policies, is suitable for addressing the research questions, as it allows the researcher to gather complete and detailed information strictly related to the research aims (Yin, 2014).

The data were collected using three methods, namely in-depth interviews, a desk study, and a scoping study. The in-depth face-to-face interviews with key persons from government institutions and representatives of NGOs were held during field research in 2015 and 2016. The interviewees were from the central and local government institutions and local environmental and developmental NGOs. The interviewees from both actor types were purposely chosen based on tasks related to disasters, the coast, and the environment, and their locus of study in the coastal areas. Finally, 12 actors were selected and studied (see Table 5.1). Interviews were primarily used to gather data focused on actors' measures to deal with the causes and impacts of land subsidence and their collaboration with other actors in taking actions.

The in-depth interviews were audio-recorded with the agreement of the interviewees. The records were then translated into the transcripts of the interview. To analyze the transcripts, framework analysis was used as it can describe different aspects of phenomena from cross-section data in a particular setting (Ritchie and Spencer, 2002).

Second, a desk study explored secondary data to understand the information gathered from the interviews. Various regulations, project documents, official publications, and official websites from each type of actor were studied and sourced in hard copy, digital file, or online.

Third, the scoping study was conducted by visiting the areas mentioned by the actors to enhance the knowledge of and clarify the actors' measures. It was conducted to support, confirm, and complete the information gathered from the interviews and desk study. All areas in coastal Semarang were surveyed by prioritizing the most prone areas. Overall, four surveys were conducted in two ways, namely individually or in the presence of government officials or community leaders.

Using the mentioned methods, various policies regarding coastal issues and management, spatial planning, and disaster management and risk reduction were listed and summarized. Policies that were strictly related to coastal hazards were then studied more intensively. Responses of the governments and NGOs were also investigated, determined from their activities regarding land subsidence from the first time such actors took the measures. The measures were in the form of actions to mitigate the impacts and prevent the drivers of land subsidence. In addition, since land subsidence and other coastal problems (e.g., coastal erosion, inundation, inland seawater intrusion, and sea level rise) are interrelated (Andreas et al., 2018; Marfai and King, 2007; Sarah and Soebowo, 2018; Suripin et al., 2017), measures of the

actors in dealing with or preventing the other problems were also taken into account. These are the measures considered to combat the impacts of land subsidence.

Since both types of actors have taken measures for an extended period, we assumed that some relationships had been formed. The types of relationships between those actors were categorized based on the framework of the four C's relationship model of Najam (2000). The effectiveness of the relationships in creating effective measures was assessed using this model. This was done based on the assumption that the more cooperative and complementary the measures, the more effectively they deal with the problem. At the end of the analyses, Najam's classification was linked with adaptation and mitigation measures to understand actors' time-scale priority. This link was used to verify whether the measures were more focused on combating the impacts or on preventing the drivers. Thus, this chapter also provides an additional way to present the relationship between the actors in a long-term disaster.

5.4 SEMARANG CITY: A SUPERMARKET OF COASTAL HAZARDS

Semarang City is in the coastal area of the northern part of the island of Java. It is divided into two morphological areas: The northern part is dominated by coastal plains, whereas the southern part is mostly hilly (see Figure 5.2). Semarang City covers an area of 37.3 thousand ha and has a 13.6 km coastline. In 2016, the population of Semarang was about 1.73 million people, which grows about 1.66% annually (BPS Kota Semarang, 2017). The massive growth is determined by the increase of transportation and warehouse areas, resulting in the massive growth of urban settlements (Rahardjo, 2000; Setioko et al., 2013). The growth has increased the land pressure, which has increased the vulnerability of the coastal area (Marfai et al., 2008).

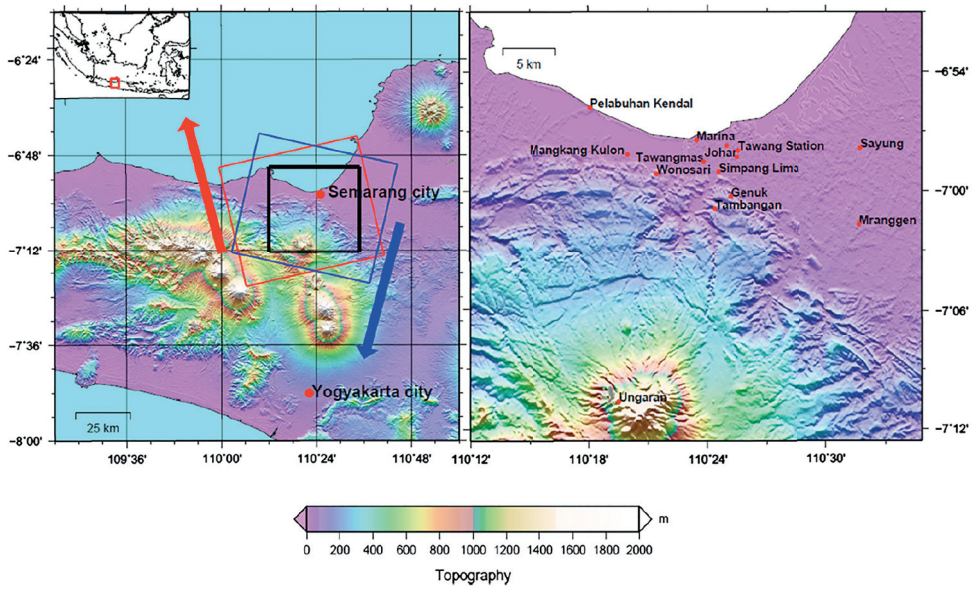

Figure 5.2 Semarang City (Lubis et al., 2011)

As a result of that massive growth, coastal areas of Semarang have been experiencing sinking for more than a century (Abidin et al., 2013). Some areas are sinking at a rapid rate, namely 6–19 cm a year (Chaussard et al., 2013; Lubis et al., 2011; Marfai and King, 2007). The triggers are alluvium soil consolidation, the construction load, and the excessive groundwater extraction (Abidin et al., 2013; Chaussard et al., 2013; Lubis et al., 2011; Marfai and King, 2007; Soebowo and Sarah, 2014). The extraction of groundwater will continue since only about three fifths of the households are served by piped water (Semarang City Government, 2016). As a result, land subsidence will continue. Over time, the land subsidence has had severe and costly physical and economic impacts (see Figure 5.3). Numerous areas have experienced damage to infrastructures (e.g., buildings, roads, and railroad tracks), an increase in inland seawater, and the widening of permanent inundation in coastal settlements (Andreas et al., 2018; Marfai and King, 2007; Marfai and King, 2008b; Saputra et al., 2017; Sarah and Soebowo, 2018).

Both daily and permanent inundation pose a severe threat to people in almost all areas in coastal Semarang (Marfai et al., 2008). Frequent inundation deteriorates coastal settlements, disturbs daily activities, and decreases people's quality of health (Abidin et al., 2013; Marfai et al., 2008). Even worse, coastal inundation also undermines people's economic status by destroying their sources of income, such as ponds and mangrove ecosystems (Saputra et al., 2019). The link between land subsidence and inundation is strong, since Suripin et al. (2017) argue that land subsidence has increased the risk of inundation by 23.59%.

a b c

Figure 5.3 Problems in coastal areas of Semarang City: (a) abandoned facilities due to permanent inundation, (b) damaged mangrove and graveyard due to coastal erosion, and (c) a sinking house

Semarang has also suffered from coastal erosion, flooding and tidal flooding, and sea level rise. These hazards are interrelated with land subsidence and inundation. Sea level rise widens the coverage area of flooding (Suripin et al., 2017), the frequent coastal inundation and land subsidence increase the coastal erosion and coastal ecosystem (Marfai, 2017; Wahyudi et al., 2012), and land subsidence widens the tidal flood (Wahyudi et al., 2012).

The impacts of the mentioned hazards are also severe. Coastal erosion has changed the coastal landscape by eroding about 500 m of the coastline (Marfai, 2017). Consequently, a vast number of mangrove ecosystems have been damaged (Nugraha et al., 2018). The flooding, which happens repeatedly in five coastal subdistricts (*kecamatan*) (i.e., Semarang

Utara, Semarang Barat, Semarang Timur, Tugu, and Genuk), damages houses, pushes people to migrate, reduces the quality of the environment and the health of the people, disturbs the transportation flow, and undermines sources of income (Isa et al., 2015; Pemerintah Kota Semarang, 2011). In 2017, thirteen flood events damaged 1,197 houses and affected 1,333 people (some of whom have now migrated) (BNPB, 2018).

Thus, Semarang City has faced combined and interrelated coastal hazards, with costly impacts. Since the problems are a common enemy for those affected, it was assumed that they were able to deal with them. However, not all of the affected households have responded to the problems appropriately or were even aware of them (Saputra et al., 2017; Saputra et al., 2019). Those who were aware of the problems were hesitant to move out of the affected areas because their jobs were connected to the coastal areas and they did not want to be separated from family (Tyas, 2018). Therefore, the government and NGOs must support the affected households in dealing with the problems.

5.5 POLICY MEASURES AND INTERVENTIONS BY THE GOVERNMENT AND NGOS

This study found that central and local government institutions and NGOs have tried to deal with coastal problems by creating adaptation and mitigation measures to fix and prevent the problems (see Table 5.1).

5.5.1 Adaptation: Combatting the impacts

For several years, both types of actors have focused their measures on coastal inundation, coastal erosion, and coastal flooding. As they are interrelated with land subsidence (see sub section 5.4), measures to deal with these problems were considered as the means to deal with the consequence of land subsidence.

5.5.1.1 Coastal inundation

Inundation is a daily problem in coastal Semarang. The local government deals with it through various measures at the village- or neighborhood-level. In Semarang Utara and Semarang Timur subdistricts (e.g., Kemijen, Tambakrejo, and Tambak Lorok), the local government along with the local community regularly raise the level of the settlement's roads to prevent them from being inundated. In this collaborative work, the government provides the funding, while the communities act as human resources. This measure is a common way for governments to prevent inundation in almost all areas in coastal Semarang. Nevertheless, our survey revealed that the measure is not enough to prevent inundation, since the seawater still drains into the settlement due to open waterways in the coastal areas. The effort also could not prevent inundation around the settlement since there were still many houses with floors much lower than the road level. Consequently, during high tides or heavy rains, the water flows directly

from the roads into the houses, which causes the latter to sink even more. Thus, this measure is not sufficient to decrease inundation.

5.5.1.2 Coastal erosion

Coastal erosion is also a big concern for both types of actors. Local NGOs and the local government frequently allocate resources to take measures concerning coastal and mangrove rehabilitation. For instance, in Mangunharjo, Mangkang Kulon, Trimulyo, and Mangkang Wetan village, a local NGO (Bintari) initiated the reforestation of damaged mangroves, while the government provided funding for activities in growing mangrove seeds in areas known as the green belt. Local people acted as partners that were responsible for keeping the program sustainable by building and preserving the mangrove area. Furthermore, in Tugurejo Village (Tugu subdistrict), Bintari and LSM Prenjak Tapak have been working for several years with various volunteers (e.g., local communities and university students) to protect coastal areas from erosion and further damage by planting mangroves and developing mangrove tourism areas, which generate income for locals. In another area, Tambak Lorok (Semarang Utara subdistrict), LSM Camar and KeSeMat conserved the mangrove areas by planting mangrove seeds and building mangrove nurseries. The mangrove conservation not only reduced the threat of coastal erosion and inundation to settlements and ponds, but also increased income and the awareness of people in and outside the affected area about the complexity of coastal problems.

The mentioned initiatives seem promising to protect coastal areas from erosion and other damages. However, the scale and effect of the measures must be increased since they still cannot cover entire damaged areas.

5.5.1.3 Flooding

Flooding is the primary concern of the central government, the local government, and environmental NGOs because of its extensive impact on coastal and land areas and its multiple triggers, namely seawater and river water. To deal with flooding, both types of actors focus on the rehabilitation of coastal areas and rivers through construction and non-construction measures.

The central and local government have initiated some construction measures, followed by social aspect developments. In 2015, the Ministry of Public Works, supported by JICA (Japan International Cooperation Agency), built Jatibarang Multipurpose Dam to prevent Semarang from flooding and to supply people with fresh water. By providing fresh water, the government expected that the groundwater extraction would decrease, which might delay the sinking of the land. Furthermore, the Semarang City Government enhanced the city drainage systems to control the flow of river water and prevent tidal waves by optimizing two big canals, namely West Floodway *(Banjir Kanal Barat/BKB)* and Garang River and East Floodway *(Banjir Kanal Timur/BKT)*. At the beginning of the development, these canals were intended to

manage water in Semarang City, but they still could not function effectively due to massive sedimentation caused by intensive development in the upstream stretch of the canals. In the peak of the rainy season, the canals could not hold the water volume, resulting in flooding in the downstream stretch of the canals. Some measures have been taken to enhance their function. In 2010, the BKB was normalized, which could reduce the impacts of flooding in the northern and western part of Semarang (Gunawan et al., 2015). Also, in 2017, the central government via Regional Office of River Basin Management (*Balai Besar Wilayah Sungai/BBWS)* Pemali Juana and the local government built a rubber dam in the upper stretch of the BKB to control the volume of water flow. BKT was also normalized in 2017, which was expected could manage the drainage for about 14.8 km by 2019 (Pemerintah Kota Semarang, 2018). This effort could maintain the depth of the canal. However, to accomplish this, about 4,000 units of street vendor blocks and squatter settlements and hundreds of people needed to be displaced to the apartment (*rusunawa* Kaligawe) (Metrotvnews, 2018). The displacement was problematic, because the new place was often unsuitable for the displaced people to build upon and to generate income (Maimunah et al., 2011).

On a smaller scale, the government at various levels built a polder system as a part of the city drainage system management. In 2010, the government built Banger Polder to protect the Banger area from flooding and recognized the polder board, *Badan Pengelola Polder SIMA (BPP SIMA).* This pilot project was funded by the central, provincial, and local governments. The polder covers about 520 ha in nine villages and approximately 84,000 inhabitants in Semarang Timur subdistrict (Jayanimitta et al., 2018). The polder development has both positive and negative impacts on surrounding areas: Whereas it has prevented some polder areas, such as Kemijen, from daily flooding, it cannot protect the neighborhood outside the area from deeper inundation (Nugraha et al., 2018).

At the community level, some significant construction and non-construction measures have been taken. The local government provided water pumps in some drainage channels around coastal settlements, such as in Genuk and Gayamsari, to drain the water from the settlements out to the sea. The pumps were needed even more when the flooding was worsened by the tidal inundation. The BBWS Pemali Juana chose Tambak Lorok for a pilot project of Maritime Village *(Kampung Bahari),* aiming to prevent flooding, adjust slum areas, and increase people's economic capacity. This project was started by building seawalls around the coastal settlement. However, its effectiveness in preventing flooding is questionable, because the construction of seawalls has caused worse inundation in the surrounding areas. BPBD Semarang City also established Disaster Preparedness Village *(Kelurahan Siaga Bencana* or *KSB)* to increase the awareness and readiness of the local community to respond to flooding. Thus, the KSB is expected to minimize various coastal risks in the village.

Furthermore, Bintari has been working for a long time to deal with flooding through some non-construction measures. Since 2012, Bintari has been working to conserve Garang Watershed, which is the inlet of BKB and one of the big freshwater suppliers for Semarang City. Through the Garang Watershed Leadership Program (GWLP)—which is supported by some

universities, provincial government institutions, and private sectors—Bintari conserved the watershed by educating people around the area and increasing the capacity of stakeholders to protect the watershed from destructive activities. Bintari, in partnership with the Semarang City Disaster Management Board (BPBD), *Dinas* PSDA ESDM, MercyCorps Indonesia, and Diponegoro University, built flood early warning systems (FEWS) in seven subdistricts along the Beringin River as a part of the ACCCRN (Asian Cities of Climate Change Resilience Network) Project. In 2018, this program was expanded by the American Red Cross by building 10 FEWS tools.

5.5.2 Mitigation: Combatting the drivers

Land subsidence in Semarang is triggered by the natural consolidation of alluvium soil, the massive extraction of groundwater, and the construction load (Abidin et al., 2013; Marfai and King, 2007; Soebowo and Sarah, 2014). To effectively stop land subsidence, measures to prevent these drivers should be taken. To some extent, the government of Semarang City and local NGOs have tried to initiate some policy-related and construction measures to combat the mentioned drivers. One of the principal measures of the local government (i.e., *Bappeda Kota Semarang*) was their involvement in the Georisk Project—a technical collaboration between the Geology Agency of Indonesia and the German Federal Institute for Geosciences and Natural Resources (BGR). This collaboration led to the land subsidence map of Semarang City. Furthermore, some policies and interventions were made based on the drivers.

Concerning construction load, the local government has issued policies to control physical development in the coastal areas. Bappeda's Spatial Planning of Semarang City 2011–2031 is regarded as the central policy to control the development in these areas. The Spatial Planning is expected to protect coastal areas from massive economic activity development by designing land utilization based on carrying capacity. Policy regarding coastal management has also been introduced to protect coastal areas from extensive structural development. This policy supports spatial planning by restricting massive physical development in the protected coastal areas. These policies seem useful in managing Semarang coastal areas. However, they cannot prevent physical development throughout the protected areas. Therefore, the implementation of these policies must be optimized to decrease pressure on the coastal areas.

Another unsolved driver is the massive groundwater extraction. In Semarang City, the government water companies (PDAM and non-PDAM) can only provide piped water for about 68.4% of the area, which does not serve most of the coastal areas impacted by land subsidence (Semarang City Government, 2016). The inability of the government to provide clean water for all households and the increase in the need for water for manufacturing activities has caused the extraction of groundwater. To increase the coverage of fresh water service to 83%, in 2018 the local government started building the Semarang Barat Fresh Water Supply System (*Sistem Penyediaan Air Minum* or *SPAM*), which is expected to be finished in 2021. Also, to control the massive groundwater extraction, the Semarang City government issued a groundwater management policy to control the utilization of and conserve the groundwater by designing groundwater conservation zones. However, this policy was weakened by the

local government law that transferred the authority to issue groundwater extraction permits from the local government to the provincial government. Consequently, the local government cannot completely control groundwater extraction activities in their area. At the community level, in Tambak Lorok, the government built one artesian well and delivered the pipe water to houses with no access to fresh water using CSR funding (Tyas, 2018).

The effectiveness of these policies is still weak, according to local NGOs. Therefore, most of the NGOs act as watchdogs by delivering campaigns about issues of massive groundwater extraction and physical development in the protected areas. Walhi Jawa Tengah and LBH Semarang protested to the local government since they believed that the government had not yet made a serious effort to deal with land subsidence. They argued that land subsidence would continue for two reasons. First, the massive groundwater extraction by manufacturing activities continued, even in the critical zone of groundwater conservation. Second, the government's policies could not entirely control the physical development, such as manufacturing, in the coastal areas, which increased the construction load. These NGOs also evaluated the policies of the local government and helped them to monitor the activities of private sectors in the coastal area. They concluded that in the current level of implementation, the Spatial Planning, the Groundwater Management Regulation, and the groundwater extraction limitation policy were ineffective in stopping land subsidence since violations by the manufacturing companies and local people were still found. Some representatives of NGOs argued that the governments should be critiqued about measures to deal with land subsidence and other coastal hazards. The government should focus their activities not only on combatting the problems, but also on avoiding repeated problems.

This subsection shows that various actors have tried to adapt to and mitigate land subsidence. The difference between the actors in these measures lies in the scale of their activities. The government tends to work at the regional level, while the local NGOs work more at the community level. Both worked mainly in their traditional roles and scale of activity, although some measures were inspired by other actors through cross-scale activities and activities funded by external actors through international collaboration activities, which provided more flexible funding. Among the measures, both types of actors put more emphasis on adaptation than mitigation (see Table 5.1). In light of the current high costs of land subsidence, this seems a reasonable way to avoid even more significant costs. Adaptation must be continued, especially in the affected areas that have not yet been several damaged. Along with adaptation, current mitigation measures must be optimized to prevent repeated and broader problems.

Table 5.1 Policy measures and interventions of actors to deal with land subsidence in Semarang City

Actor	Type of interventions	
	Adaptation	**Mitigation**
A. The government		
1 DKP (The Department of Marine and Fisheries)	Rehabilitating coastal and mangrove ecosystems Empowering economic status of coastal community	
2 BLH (Environmental Protection Agency)	Rehabilitating mangrove ecosystems (via Mangrove Working Group of Semarang City (Kelompok Kerja Mangrove Kota Semarang or KKMKS)	
3 BPBD (Regional Disaster Management Board)	Initiating Disaster Preparedness Village Building FEWS	
4 Dinas PSDA-ESDM (Water Management/Energy and Mineral Agency)		Designing groundwater management policy Limiting groundwater extraction activities
5 Bappeda (Regional Development Planning Agency)		Designing spatial planning, including protected coastal areas Involvement in the Georisk project
6 Regional Office of River Basin Management (Balai Besar Wilayah Sungai/BBWS) Pemali Juana	Initiating Maritime Village Building rubber dam in BKB	Building Jatibarang Dam
7 The NGO		
8 Walhi Jawa Tengah		Advocating about massive groundwater extraction and physical development Designing spatial planning
9 Bintari Foundation	Initiating coastal and mangrove rehabilitation programs Initiating KKMKS Initiating FEWS development and river protection programs	Collaboratively designing groundwater management policy Capacity building for people around Garang watershed
10 LSM Prenjak Tapak	Rehabilitating coastal and mangrove ecosystems	
11 LBH Semarang		Advocating for the physical development of coastal areas
12 LSM Camar	Rehabilitating coastal and mangrove ecosystems Empowering economic status of coastal community	
13 KeSEMat	Rehabilitating mangrove ecosystems (via KKMKS)	

Source: Data analyses (2016)

Finally, to increase the quality of both types of measures, both types of actors should accommodate some measures initiated by local people. For instance, in Tambak Lorok, local people tried to prevent the coastal inundation by building a small dike made of cement sacks to prevent the seawater from entering their house. In Tugurejo, local people planted mangrove seeds along the damaged coast to prevent inundation. Even though the measures were small scale, every single measure must be considered by other actors. By welcoming measures from various actors, collaborative actions can begin.

5.6 THE GOVERNMENT–NGO RELATIONSHIP IN SOLVING LAND SUBSIDENCE

Responses of both types of actors to the long-term impacts of land subsidence led to the formation of various relationships. This subsection uses Najam's mode of relations to explain them.

5.6.1 Cooperation

Both types of actors had been trying to develop a collaborative relationship through various measures. They were pushed to work cooperatively to maximize efficiencies. The cooperation was formed in two ways. They either directly designed similar strategies and goals at the beginning of the first collaboration, or they enhanced their complementary relationship by making it a cooperative one.

The cooperative relation started designing spatial planning. Both types of actors agreed that effective spatial planning could protect coastal areas from the worst impacts of land subsidence and/or minimize the drivers. They confirmed that the process of designing spatial planning is the best way to start developing joint strategies to reduce land subsidence through well-designed land allocation. With the government as the leader in designing policy, this invited various environmental and developmental NGOs to design spatial planning through numerous public discussions and consultations. During the meetings, the NGOs shared their knowledge and experience of the local problems, while the government raised regional-level issues and provided experts and funding. In this case, the ability of the NGOs to delineate the distribution of the affected areas of land subsidence and other coastal problems based on the evidence from local communities, was a valuable input in designating strategies and zones in spatial planning. This capability was one of the most significant issues the local government had in accommodating the dynamic problems at the local level in the planning products. Over time, the cooperative works also appeared during the implementation of spatial planning in controlling land utilization in the coastal areas.

The cooperative relation also happened during the process of designing the groundwater management policy. In the past, local NGOs, such as Walhi Jawa Tengah, Bintari, and LBH Semarang focused merely on advocacy about the overexploitation of groundwater and the failure of the government to provide people with fresh water, due to the unwillingness of both

types of actors to sit side by side to solve the problems. The NGOs focused their advocacy on issues of manufacturing growth in the critical groundwater zone, the government's low awareness of the groundwater exploitation activities, and the weak law enforcement regarding groundwater overexploitation. Then, in 2010, Bintari and the office of *Dinas* PSDA-ESDM agreed to collaborate to design a groundwater management policy, with an output in critical groundwater zones. Bintari reported that during the collaboration, they provided information about the overexploitation of groundwater by industrial activities and the issue of the scarcity of freshwater at a community level, while office of *Dinas* PSDA-ESDM strengthened that information spatially. The information was used to support the academic consideration related to deciding the zoning classification.

5.6.2 Complementarity

Unlike the cooperative relation, there have been complementary relations among the actors for decades. Even though the relationship was not directly focused on land subsidence issues, issues of coastal degradation and mangrove ecosystem damages were the entry point of their relation. In this type of relationship, the governments generally worked on the policy aspect and large-scale projects, while the NGOs focused more on the community-level actions. For instance, while the local government decided to design coastal management policy and build the coastal dike, polder system, or artesian wells to deal with inundation, coastal erosion, and land subsidence, the NGOs supported those measures by rehabilitating coastal areas and training coastal people to adapt to damaged areas. For both types of actors, these different roles were formed naturally or triggered by the limitation of each actor. For instance, the inability of the local government to work frequently with local people, or NGOs' lack of funding to support their constant work, were compensated for by their complementary measures, which led to reciprocal relationships.

Both types of actors obtained advantages by building complementary relations. In the issues of coastal inundation and coastal erosion, for instance, the weakness of the NGOs in keeping their programs sustainable due to the absence of supporting policy was covered by the local government, which issued coastal management policy with a focus area on the locus of NGO activities. The establishment of mangrove tourism areas through the local government's intervention, by allocating a specific area for the mangrove education park, supports the NGO activities to conserve coastal areas. Therefore, the complementary measures from both types of actors not only could increase the variety of mitigation and adaptation measures, but also could guarantee the sustainability of the measures of both.

5.6.3 Co-optation

The long process of land subsidence has also expanded the role of the NGOs by being a catalyst for the local government, which formed the co-optation type of relation. A local NGO, Bintari, along with local people of Tapak, Tugurejo, have been conserving mangrove forests since 1986. Funded by international and national donors, Friends of the Earth (FoE) Japan

and MercyCorps Indonesia, Bintari established the mangrove education center and initiated community empowerment programs. The projects were aimed not only at preventing worse impacts of land subsidence—namely the widening of the coastal inundation and the increase of coastal erosion rate—but also at increasing the economic status of local people and the awareness of coastal problems. The intensive works of Bintari, which attracted various actors to their activities, had inspired different actors, including the local government, to work with multi-actors in a group to conserve mangrove forests and adjust coastal areas. In 2010, initiated by Bintari, KeSEMat, and the Marine Affairs and Fisheries Office of Semarang City (DKP), the major of Semarang City established KKMKS, which consists of 35 members from diverse organizations (government institutions, academics, students, NGOs, and local communities). In this consortium, all actors work collaboratively in designing the area of interventions and strategies to achieve their goals. Following this extensive network, the area of conservation has also been enlarged along the western and eastern part of the coast.

In another area, the initiative and the eagerness of LSM Camar in Tambak Lorok to restore mangrove ecosystems also attracted the local government to become involved in their activities. Since their establishment, LSM Camar has focused their activities on coastal rehabilitation through mangrove plantation and replantation. To fulfil the need for mangrove seeds, they developed mangrove nursery activities. In the beginning, they produced the mangrove seedlings to meet their needs, but later the seedlings were sold to other neighborhoods or districts. Then, in 2014, they expanded their target group by launching Kelompok Merah Delima to assist women in the coastal areas to increase their income by intensifying the value of mangrove through mangrove-based food enterprises. The persistent efforts by LSM Camar to conserve mangrove forests and generate income for local people led government institutions (e.g., the DKP and the Agriculture and Forestry Office of Semarang City) to regularly support their activities by providing facilities and conducting training to increase their abilities and the awareness of coastal rehabilitation.

5.6.4 Confrontation

Due to differing views, confrontation among both types of actors could not be avoided. Concerning the reclamation issue, for instance, the government believed that coastal reclamation was an effective means to control the scattered urban physical and population growth, which could help mitigate coastal area damage. Contrarily, NGOs contended that the reclamation would accelerate coastal erosion and widen the inundation. By considering their thoughts on reclamation, the local government chose to continue reclaiming coastal areas. The reclamation has been a sensitive issue among coastal people, NGOs, the local governments, and business sectors. The reclamation was not a new phenomenon in Semarang. For the last six decades, coastal areas of Semarang had been reclaimed four times for various purposes, including local settlements (Tanjung Mas), an international port (Tanjung Emas Port), and large-scale settlements (Marina coastal area). The recent reclamation was the most problematic due to the wide area to be reclaimed, about 232 ha, and the conflict with the local coastal

communities. The local NGOs contended that the reclamation, carried out by a company (PT. IPU), had caused the deepening of inundation in the coastal settlements and accelerated the coastal erosion in both the affected and the surrounding areas. Conversely, the government insisted that the reclamation was needed to manage the coastal areas by providing settlement, education, and recreation areas. The government even decided the areas of reclamation for the settlement in the spatial planning (RTRW Kota Semarang 2011–2031). Therefore, the confrontation must be ended and both types of actors should think about a more productive relationship; otherwise, the coastal problems will remain and even worsen.

This subsection showed that in responding to land subsidence and other coastal hazards, the government and NGOs built various types of relationships based on their measures. The long duration of land subsidence and the common goals opened the opportunity to build cooperative and complementary measures. In some cases, local NGOs were a catalyst for the local government to create better measures. Their trend in working complementarily and cooperatively could be seen as a promising way to develop optimal measures. These types of relationships generated more sufficient outputs (Najam, 2000).

The collaboration increased the number of measures, which are useful to deal with the current impacts of land subsidence. However, some improvements are needed since not all actors involved were satisfied with the designed means. For instance, a local NGO (Bintari) was disappointed with the output of the groundwater management policy, even though they were involved in some preliminary discussions with the local government about designing this policy. The policy issued was considered unfit according to their agreement during the meetings. They realized that the output was not people-oriented, which is an essential point for the NGOs. The asymmetric position among the actors was indicated as one of the obstacles to designing a policy that meets all the actors' needs. The disappointment of the NGOs increased due to violations of the policy, especially by the business activities. Neither the cooperative nor the complementarity relations could guarantee that both types of actors would be satisfied with the measures or be able to effectively implement the measures if a single actor, such as the local government, still dominated the process. The enhancement of the quality of measures through collaboration is clearly needed to increase experience and knowledge sharing and to level the power relationships among both types of actors based on their capacity.

5.7 DISCUSSION AND CONCLUSIONS

Coastal areas of Semarang City have been experiencing serious land subsidence. Many areas have sunk more than 2 m, while people are affected daily in terms of the widening of the coverage area and depth of coastal inundation. Some of those affected have had to spend money at least every 5 years to repair the damage to their houses and sources of income due to the sinking of the land (Harwitasari and van Ast, 2008; Saputra et al., 2019).

Because the awareness of various actors of land subsidence is still low, it is becoming more important to understand and tackle it. Otherwise, land subsidence will become worse. Even

though the cost of land subsidence is high, the phenomenon is often invisible compared to other hazards since it happens gradually over an extended period of time. In addition, the issue has been pushed aside by the widespread and global debates on sea level rise and other climate change issues. The risk is likely to be further exacerbated by inundation, coastal erosion, flooding, and sea level rise. Along with these hazards, land subsidence damages the environment and reduces people's socioeconomic status (Saputra et al., 2017; Sarah et al., 2018). It is worsened by the fact that many affected people are not able to leave the affected areas and cannot deal with land subsidence due to their lack of income capacity (Saputra et al., 2019). For those who are willing to leave, their close relationships within coastal environments and relatives in the affected areas discouraged them from doing so (Harwitasari and van Ast, 2008). Therefore, if no appropriate actions are taken, this coastal area and its affected people will remain vulnerable, and increasingly so.

In addition to the land subsidence issue, in the last several years governments at many levels and environmental and developmental NGOs have tried to deal with coastal problems and prevent severe impacts through various interventions. They have focused their measures not only on the drivers of land subsidence, but also on the impacts. The interventions were also different, based on different time scales, such as adaptation measures to solve the current consequences and mitigation measures to minimize the drivers. Besides, both types of actors have tried to create various relationships based on the similarity and dissimilarity of their activities and goals, and to adapt to the activities of other actors by extending their traditional roles. For instance, the local government has started to work more frequently at the local level, while the local NGOs have extended their roles from a social movement into capacity building and policy design.

Could the interventions of both types of actors solve land subsidence? It depends. The adaptation measures are useful in temporarily protecting affected people from the current problems. Various adaptation measures to deal with inundation, flooding, and coastal erosion, for instance, could prevent an increase in the cost of such problems. These measures, mainly small-scale ones, such as a group of settlements or households, were regarded as the success of actors to minimize the consequences of land subsidence for a short period. However, adaptation measures cannot guarantee that affected people will be permanently safe from land subsidence. For example, the intervention of the government in a particular area by creating the Maritime Village, or various actions of the local NGOs to rehabilitate the coastal ecosystem, only delayed rather than stopped the impact of land subsidence. The action that was taken at the settlement level would not be able to tackle the consequence of land subsidence in surrounding areas because the impacts in other areas will then cause the same problem to reoccur in the area that has been planned. Another example showing the ineffectiveness of the measure to prevent land subsidence was from groundwater-related policy and spatial planning. The protected groundwater and physical development zones in coastal areas could well prevent the problems. However, the different interpretations of these policies by various stakeholders, the lack of the implementation of the policies, and the

weakness of law enforcement has caused these policies to not be entirely useful. Therefore, the interventions from both types of actors have improved the situation but failed to prevent future subsidence.

Even though the measures have not solved the problems, some promising relationships among the actors have been built. Thanks to these relationships, especially collaboration, complementarity, and cooptation, the variety and quality of measures have been improving. These types of relationships have triggered mitigation measures, meaning that the efforts to prevent land subsidence in the long term have been considered. The more mitigation measures that are taken by the actors, the greater the chance of combatting the drivers and preventing reoccurring problems. The increase in mitigation measures indicates that the awareness of the actors of the problems and the process of knowledge sharing among them has succeeded, which implies an enhanced ability of each actor to formulate measures to deal with the core problems. Thus, this chapter confirms the conclusions drawn by Kapucu et al. (2010) and Moser and Ekstrom (2010), namely that the collaboration of various actors might create a better response.

Further, synergism among the adaptation and mitigation measures taken by different actors is needed to enhance the effect and quality of the measures. Both types of actors must consider optimizing adaptation and mitigation measures by pushing the actors to collaborate to formulate appropriate measures. These include measures that meet the need to solve current problems and prevent the recurrence of similar problems, which are based on the urgency of the problems and the scale of the interventions. The gradual process of land subsidence must be seen as an "opportunity" to design effective measures. The gradual and lengthy process of land subsidence undoubtedly provides a chance for various actors to think about the appropriate measures as well as the scale and time of the interventions to stop land subsidence. Each actor might design measures through collaborative work or by acting as a catalyst for better measures, as shown by an NGO in this case study. The involvement of NGOs in government activities is often compulsory by law, so the opportunity to design such measures is even bigger. It is also supported by the decentralization policy, which has increased the government's acceptance of NGOs' ideas (Antlöv et al., 2008). Thus, through their various opportunities and advantages related to designing the appropriate measures, each actor must start thinking about how to be a positive influencer for the other, instead of extending the ineffective measures.

To conclude, land subsidence in coastal areas is an important issue because it is not a solitary one. The sinking of the land is followed by other problems, such as inundation, coastal erosion, flooding, and sea level rise. These combined hazards make coastal areas and people more vulnerable to land subsidence. Therefore, these issues must be solved at the same time to protect coastal areas from all hazards. The affected people cannot do much because of the high intensity and large scale of the problems, and the limitation of their resources. Their small-scale actions can only delay the problems around their settlement for a while, or may even be useless. This calls for the government and NGOs to be actively involved to help such people to

deal with the problems. Najam's categorization of the government–NGO relations can help to divide the relation of actors in dealing with a long-term disaster like land subsidence. However, to enhance the relationships, this chapter shows that such relations must be based on an asymmetric power relation to increase the quality and effectiveness of the measures.

A series of failures? Governments' responses to land subsidence in the world's fastest sinking city: the case of Jakarta, Indonesia

6

This chapter has been submitted as Erlis Saputra. A series of failures? Governments' responses to land subsidence in the world's fastest sinking city: the case of Jakarta, Indonesia.

ABSTRACT

The president of the Republic of Indonesia has announced a plan to move the capital of Indonesia away from Jakarta. This is in response to Jakarta's status as one of the fastest sinking cities in the world, which has caused costly damages to the environment and socioeconomic status of those affected. This chapter examines the plan and explores, from the local government's perspective, whether there are also local solutions. This chapter also explains how different tiers of governance are trying to solve the issue. Using a case study in the urban area of Jakarta, the chapter shows that even though land subsidence is a severe problem, neither the central nor the local government can optimize their advantages to design effective solutions. It is therefore suggested that the solutions be based on coherent processes and multilevel cooperation.

Keywords: land subsidence, subsidiarity principle, the capital city movement, urban area, Jakarta

6.1 INTRODUCTION

In August 2019, the president of the Republic of Indonesia, Joko Widodo, announced a plan to move the capital from Jakarta to another area outside the island of Java. In addition to locating the central government more centrally in the Indonesian archipelago (Sapiie, 2019), the repeated severe urban environment problems were also serious considerations in developing this plan (Bappenas, 2019).

Jakarta, which is one of the most densely populated cities in the world, is experiencing severe problems due to rapid urban population growth and rapid urban extension into fringe areas (Firman, 2004; Winarso et al., 2015). Some issues–for example, severe traffic congestion, annual flooding, a lack of clean water, a lack of fresh water storage due to saltwater intrusion, poor wastewater management, vast slum areas, air pollution, and land subsidence—have been problems for decades (Abidin et al., 2011; Steinberg, 2007).

Land subsidence is another severe problem in Jakarta. It is also an acute one because of its rapid rate (Abidin et al., 2015; Chaussard et al., 2013; Takagi et al., 2017). Many of the areas sink 1–15 cm a year, and others, especially in the northern parts, sink even faster, up to 28 cm a year (Abidin et al., 2011). This massive rate makes Jakarta one of the fastest sinking cities in the world (Deltares, 2015).

Such rapid land subsidence has severe environmental and socioeconomic impacts. It damages houses, buildings, and infrastructures (Abidin et al., 2011; Abidin et al., 2015; Saputra et al., 2017) and increases inland seawater intrusion (Takagi et al., 2017). It also increases flooding vulnerability in about 40% of the Jakarta area, which is already below sea level (Steinberg, 2007). It expands the coverage areas of flooding and prolongs the duration of its impacts by trapping water in the subsided areas (Abidin et al., 2015; Deltares et al., 2011). Further, those impacts decrease the value of land and undermine the income earning capacity of those affected, by destroying sources of income (Saputra et al., 2019). The consequences are massive (Abidin et al., 2015; Deltares et al., 2011). As such, the central government announced a plan to move the capital city away from Jakarta (Bappenas, 2019).

Many issues can be solved by the central government. If the problem's scale is large, and exclusive power is needed to optimize the decision making, the central government is the appropriate actor to intervene (Head, 2007). However, the problems that have impacts at the local level are better coped with by the local-level government (Firman, 2014; Sheng, 2010). Since land subsidence has vast implications at the local level (Abidin et al., 2015; Saputra et al., 2019), it is important to determine how local governments deal with the issue. The importance of local-level solutions has long been a concern in the global debate (United Nations, 1992). Therefore, in addition to evaluating the central government's plan to move the capital away as a solution, this chapter also explores whether there are local solutions from the local government.

Using a case study in urban areas of Jakarta, this chapter explains how different tiers of governance are solving land subsidence. The case study method was chosen since it combines several sources of evidence to answer research questions (Yin, 2014). Through data gathered

from in-depth interviews, desk studies, and field surveys, this chapter provides different sets of solutions offered by the Jakarta provincial government and the central government.

Jakarta was selected as representative of urban areas for several reasons. First, it is the capital city of Indonesia and the country's most densely populated urban area, and it has been experiencing complex urban environmental problems for decades (BPS-Statistics of DKI Jakarta Province, 2017; Firman, 2014). Its status as one of the world's fastest sinking cities makes its situation more extreme and urgent compared to other sinking cities. Jakarta also has a special decentralization authority at the provincial level, which may introduce a new complexity in managing urban problems (van Voorst, 2016). Jakarta can deal with cross-provincial problems by providing different measures, which can sometimes be initiated by various actors at various levels, such as the central government, the Jakarta government, or other surrounding provincial or local governments (van Voorst, 2016).

The remainder of this chapter is divided into seven subsections. The following subsections discuss the theoretical review, which explains land subsidence in urban areas and multilevel governance, which is used as an analytical framework in the empirical part of this chapter. Subsequent subsections describe the case study area and the solutions offered by the provincial and the central government to tackle land subsidence. It ends with discussions of and conclusions concerning the responses of different tiers of government to land subsidence.

6.2 THEORETICAL REVIEW

6.2.1 Land subsidence in urban areas

Land subsidence is the gradual sinking of the surface in relation to the surrounding terrain or sea level (Galloway et al., 1999). It can happen at different rates and on different scales depending on the types of triggers. In urban areas, land subsidence is caused by both natural processes and human activities. Natural processes include the compaction of overlying sediment and basement tectonic activities (Tosi et al., 2013).

At the same time, anthropogenic-induced land subsidence is caused by such activities as massive withdrawal of fluids (i.e., gas, groundwater, geothermal water, and saltwater) from subsurface reservoirs, underground mining, surface loading, land drainage, and reclamation (Abidin et al., 2011; Gambolati et al., 2006). Of these factors, groundwater withdrawal might be the most important factor in land subsidence (Abidin et al., 2011; Gambolati et al., 2006). The intensive exploitation of groundwater causes the compaction of inter-bedded layers within the aquifer system, resulting in the sinking of the surface (Shi et al., 2008). The overexploitation of aquifers is generated by population growth and intensifying industry (Abidin et al., 2011). Due to these activities, land subsidence in densely populated urban and metropolitan areas has increased (Abidin et al., 2015; Hu et al., 2004). If the groundwater is the only source of drinking water, land subsidence will be even faster because the groundwater will be overexploited (Jusseret et al., 2010).

Constant land subsidence over an extended period of time leads to severe consequences. It causes damage to houses, buildings, and infrastructures (Abidin et al., 2011; Saputra et al., 2017; Takagi et al., 2017) and widens permanent inundation and coastal flooding (Andreas et al., 2018). Due to sinking over several decades, it decreases the value of land and damages land-based sources of income (Abidin et al., 2015; Saputra et al., 2019).

Compared to other areas, such as peatland and coastal areas, land subsidence in urban areas is more complicated in terms of rate and impacts. The constant growth of urbanization, settlements, and economic activities increases the water demand (Abidin et al., 2011). The affected urban areas on alluvial plains or in delta areas also experience the compression of sedimentary formations that can cause accumulated land subsidence with more significant impacts (Dang et al., 2014). It can exacerbate and cause other problems, for example, the widening and prolonging of permanent inundation and flooding in coastal settlements and increasing inland seawater intrusion (Abidin et al., 2011; Andreas et al., 2018; Fiaschi and Wdowinski, 2017). Thus, it is crucial to stop land subsidence in urban areas.

6.2.2 Multilevel governance: the importance of scale

Environmental problems always have varying spatial and temporal scales (Bulkeley, 2005). To deal with or counter the fragmentation of environmental problems on different scales, multilevel governance can be a solution (Lemos and Agrawal, 2006) as it considers the interrelation between different levels of government (Kull and Tatar, 2015, 229). It puts the scale at the center and gives lower levels of government the authority to act, which used to be a responsibility of the central government (Chowdhury and Wessel, 2012). Thus, the central government is no longer the actor that dominates policymaking (Saito-Jensen, 2015).

Both central and local governments have their own advantages vis-à-vis environmental governance. The central government can manage heterogeneity at the local level through dialogues with the community (Dobbs, 2016). It also has better access to human capital and finances, it can reduce conflicts and inefficiencies using a hierarchical approach, and it can manage uncoordinated policies between local governments (Dobbs, 2016; Puppim de Oliveira, 2009). However, local governments tend to have a greater localized knowledge of and expertise in local problems (Dobbs, 2016). They may also provide more accurate information and more easily accommodate the needs of minorities in the community (Dobbs, 2016). Combined with their intensive and close interactions with local people, local-level governments can make decisions faster and introduce innovative local policies (Puppim de Oliveira, 2009).

Land subsidence also happens on various spatial scales. Every so often it affects vast areas and overlaps administrative borders (Chaussard et al., 2013). Because the problems affect a huge area, the vast power of the central government is needed to coordinate the various policies of different local governments (Puppim de Oliveira, 2009). However, local governments are often the most suitable actor since they can make a decision based on the local problems (Sheng, 2010). Different tiers of governments play certain roles to solve different scales of problems (Huffman, 2003; Saito-Jensen, 2015).

6.3 ANALYTICAL FRAMEWORK

In Indonesia, the authority of local governments to manage their areas has been increasing since the decentralization era (White and Smoke, 2005). It could trigger better decisions to solve local environmental problems (Firman, 2014). However, in Jakarta, one of the biggest challenges is solving inter-authority problems (Sheng, 2010). The rise of urbanization has resulted in the expansion of problems that increase the pressure on Jakarta and the fringe areas (Winarso et al., 2015). When the triggers and impacts of urban problems are multi-type, multi-scaled, and across localities, different actors are needed to take the lead in dealing with them (Huffman, 2003). Therefore, solutions to deal with such problems can be initiated by different actors, that is, the central and provincial government or neighboring governments (van Voorst, 2016).

In this case, the question is about not only whether the central government's plan is good, but also how the local government reacts to local problems. In Jakarta, the authority to make decisions rests with the provincial government because of the special province decentralization (van Voorst, 2016). As the Jakarta government is the formal authority, it can tailor solutions that meet the needs of local people (Van den Bergh, 1998). In land subsidence cases, accurate responses to prevent it from deteriorating and being worsened by other urban problems are needed (Abidin et al., 2011). The Jakarta government has to provide quick and appropriate responses that meet the needs of local people and solve their problems (Puppim de Oliveira, 2009). Otherwise, the problems will be more difficult to stop (Deltares, 2015). Thus, the Jakarta government is a legal authority that seems competent in providing detailed solutions and setting priorities for local people.

However, the local strategies have not always been appropriate for solving large-scale problems, because they were mostly aimed at dealing with specific, mostly small, areas (V. K. Dang et al., 2014). To increase the ability to deal with larger scale problems, interventions from the central government are needed (Puppim de Oliveira, 2009). The central government can offer cross-border solutions to reduce inefficiencies through their ability to manage multiple local governments using their powers and resources (Dobbs, 2016). However, the central government also struggles to deal with some issues. It struggles to guarantee that localized solutions will meet the needs of local people due to their infrequent interaction with local people (Dobbs, 2016). And they are not the best body to initiate solutions within the complex interactions between man and nature at the local level, because of their lack of knowledge of the local situation (Murdoch, 1997). Therefore, this chapter explores these actors' strategies to solve land subsidence in Jakarta.

6.4 ONE OF THE WORLD'S FASTEST SINKING CITIES: DEFINING THE MAIN CAUSES

Jakarta lies in a lowland and occupies an area of 662.3 km^2. Its population numbers about 10.27 million and its population density is around 15,500 people/km^2 (BPS-Statistics of DKI

Jakarta Province, 2017). In recent decades, Jakarta's urban areas have grown rapidly into urban fringes that have increased the number of large-scale settlements and trade and service areas (Garschagen et al., 2018; Winarso et al., 2015) (see Figure 6.1). As a result, the size of Jakarta's urban areas has almost tripled over the last four decades (Garschagen et al., 2018).

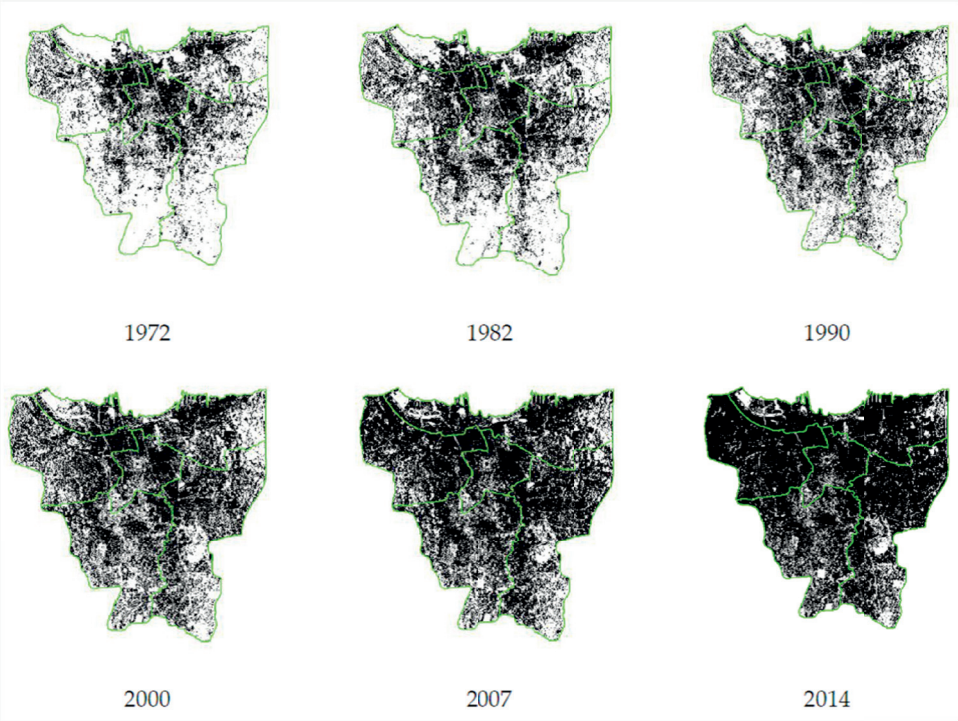

Figure 6.1 Maps illustrate the urban expansion, in black, in Jakarta from 1972 to 2014 (Garschagen et al., 2018).

The city extension has increased risks to Jakarta from various environmental problems, including land subsidence. Jakarta sinks about 1–15 cm a year, while some northern parts sink by as much as 28 cm a year (Abidin et al., 2011). Due to this massive rate, some parts of Jakarta have sunk about 3 m (Budiyono et al., 2015) (see Figure 6.2). Thus, Jakarta is one of the world's fastest sinking cities (Deltares, 2015) (See its comparison with other cities in Figure 6.3).

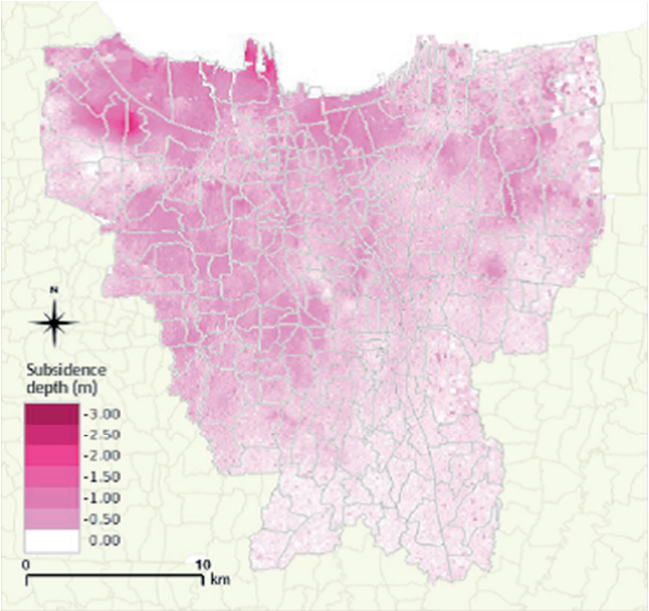

Figure 6.2 Spatial distribution of projected total land subsidence in Jakarta, 2012–25 (Budiyono et al., 2015)

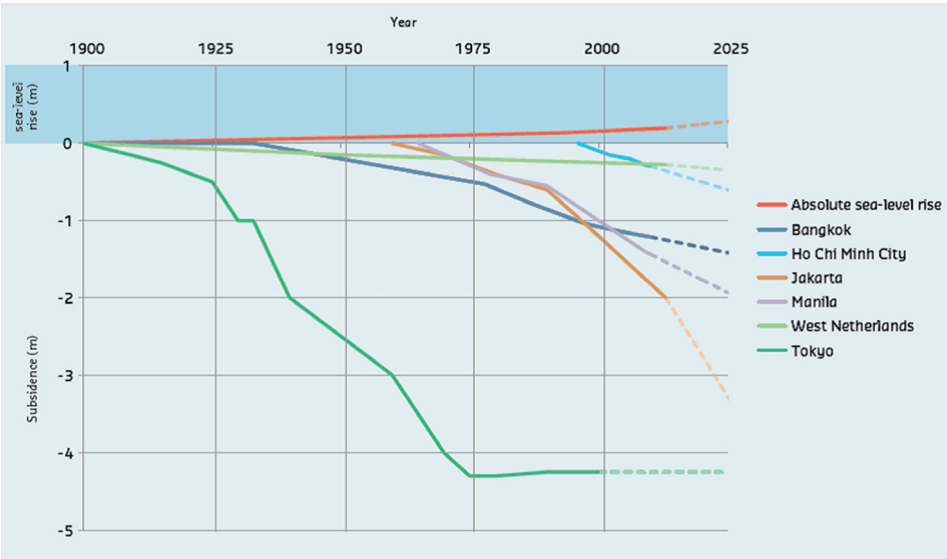

Figure 6.3 Average land subsidence in Jakarta compared with other cities (Deltares, 2015)

Land subsidence in Jakarta is caused by several factors, namely massive extraction of groundwater, construction load, and the natural compaction of alluvial soil (Abidin et al., 2015; Andreas et al., 2018; Takagi et al., 2017). Land subsidence is mostly triggered by massive groundwater extraction, which is a result of the increased need for water for industrial and domestic purposes (Abidin et al., 2011; Chaussard et al., 2013).

Between 2000 and 2010, the population of Jakarta increased by about 15%, namely from 8.36 million to 9.59 million (Cox, 2011). This rapid growth—combined with other problems such as massive polluted water, extremely poor sanitation, and the intrusion of saltwater—has increased the need for freshwater supply (Kagabu et al., 2013; McNabb, 2019). Unfortunately, the supply is lacking, as the Ciliwung River has been the main water source for the entire city (Costa et al., 2016). Water supply from piped water is also inadequate (Bakker, 2007; Hall and Lobina, 2006). Water providers, both the government-owned and private companies, fail to supply water to all of Jakarta (Shaad and Burlando, 2018). Until 2010, the piped-water network covered only about 54% of the area (CMEA, 2012). The inability of the providers to deliver a functioning piped water network and the poor quality of surface water have triggered industrial activities and people to continue to rely on deep and shallow wells (Lovei and Whittington, 1993). Since the beginning of the 1950s, the amount of groundwater extraction has increased by 1400 % (Kagabu et al., 2013). The need for water is even more crucial due to insufficient fresh water supply and serious water losses from illegal wells and network leakages (Bakker, 2007; Hall and Lobina, 2006; McNabb, 2019; Shaad and Burlando, 2018).

Because these activities have increased the risk of land subsidence (Abidin et al., 2011), the different tiers should provide solutions to deal with it.

6.5 THE GOVERNMENTS' STRATEGIES TO TACKLE LAND SUBSIDENCE

The strategies to deal with long-term and complex problems like land subsidence have to originate from different spatial and temporal scales. This calls for the involvement of the local and the central government to provide solutions. This subsection inventories the solutions.

6.5.1 Preventing risks through spatial planning and zoning regulation

Spatial planning has been used to minimize and prevent exposure to different risks (Sutanta et al., 2010). It delineates zones and manages different areas by permitting or prohibiting specific land uses (Carter and Sherriff, 2011). This can be used to manage land subsidence by controlling land allocation, preventing activities that can trigger land subsidence, and increasing the adaptive capacity of the areas to deal with the problems (Carter and Sherriff, 2011). Thus, spatial planning can be optimized by accommodating all hazards into the plan (Fleischhauer, 2008).

In 2012, the Jakarta government designed Provincial Spatial Planning (RTRW DKI Jakarta) followed by the Detailed Spatial Planning and Zoning Regulation. These plans were legalized by the DKI Jakarta Regulation No. 1/2012 about the Spatial Master Plan and the DKI Jakarta Regulation No. 1/2014 about the Detailed Spatial Plan and Zoning Regulation. These plans have determined the affected areas of land subsidence by delineating some northern parts of Jakarta as areas prone to land subsidence and other hazards.

However, these plans left some concerns. Since land subsidence can worsen other urban problems (see Saputra et al., 2019; Steinberg, 2007), it should be given the same importance as other issues, but it is still seen as secondary. The plans also still consist of contradictory

strategies of whether to keep subsiding areas, mostly in the coastal areas, safe from massive groundwater extraction or to accommodate the massive economic growth, which in some ways triggered conflicts of land utilities (Saputra et al., 2019). For instance, some industrial and settlement zones were allocated in protected areas or in unstable areas, such as alluvial plains. Finally, it is a challenge to integrate land allocation and economic growth. The incoherence between land allocation and land suitability and carrying capacity, especially in areas in which groundwater is critical, can cause the area to be unsafe from economic pressures. So spatial planning must accommodate these issues and guarantee that those two aspects can be mutually arranged (Djaja et al., 2004).

6.5.2 Protecting and managing groundwater

Some studies have shown that groundwater extraction-induced land subsidence can be solved by structured interventions targeted at groundwater extraction activities (e.g., see Endo, 2011; Lorphensri et al., 2011). In Tokyo, Bangkok, and southern regions of the Yangtze River Delta, for instance, the massive groundwater extraction was managed by issuing groundwater laws, managing groundwater tariffs, legalizing pumping regulations, boosting groundwater recharge, and implementing land subsidence prevention plans (e.g., see Cao et al., 2013; Deltares, 2015; Lorphensri et al., 2011).

In the case of Jakarta, the government has been focusing its efforts on the piped water supply system and groundwater management strategies, as described below.

6.5.2.1 Controlling groundwater tariffs and taxes

Groundwater tariffs and taxes have been used to successfully control groundwater extraction (Endo, 2015). By charging a higher price based on water management fees and scarcity aspects, users can be encouraged to conserve water (Lorphensri et al., 2011), and the high groundwater extraction tax can control groundwater activities (Kataoka and Kuyama, 2008).

These ways have also been adopted by the Jakarta government. The price of groundwater is managed through the Jakarta Provincial Government Regulation No.4554/1999. The aim is to increase the use of piped water and stop the expansion of critical areas of groundwater storage, especially in the western, eastern, and central parts of the city. To do so, the government-owned water company, *Perusahaan Daerah Air Minum Jakarta Raya (PAM Jaya),* and the management board, set the groundwater price at about 13 times higher than the piped water. Unfortunately, there were still many groundwater extraction activities found, many of which were illegal (Friana, 2017).

Increasing the groundwater tax was also a way to manage groundwater. In 2009, the Jakarta government increased the tax on groundwater by 400–1400%. Then, in 2010, they pushed people and manufacturers to decrease the use of groundwater by setting higher taxes in areas served by piped water. In 2017, the 2010 policy was strengthened by Governor Regulation No.38/2017, which includes fines for lawbreakers of the groundwater extraction tax.

Currently, the groundwater policies are facing two serious problems: the ineffectiveness of the tax regulation and illegal groundwater extraction activities. Siswanto and Suharno (2010) found that the massive groundwater extraction activities could only be decreased in areas that were covered by piped water service (Siswanto, 2010). Besides, illegal groundwater extraction is still found in many areas. For instance, in 2017, there were more than 10,000 illegal wells in various buildings, such as department stores, apartment blocks, hospitals, and universities, of which only about 57 were discovered by the authorities (Friana, 2017). Thus, the groundwater tariff and tax are not sufficient to control the massive groundwater extraction.

6.5.2.2 Building infiltration and injection wells

The Jakarta government also managed groundwater through infiltration and injection wells. These were aimed at maintaining the groundwater storage and minimizing flooding (Sharp Jr, 1997). To achieve this objective, in 2013, the governor of Jakarta issued Governor Regulation No.20/2013, which requires developers to include an infiltration well in all new buildings as a prerequisite to getting a building permit; for existing buildings, a well must be installed to get a permit to continue activities.

Regular inspections followed this regulation. For instance, in 2018, the governor inspected 80 multistory buildings in industrial areas and business buildings around the city to see whether they had installed infiltration wells (The Jakarta Post, 2018). Unfortunately, not all the buildings had obeyed the regulation. Thus, this must be seriously considered since it could continue due to the weakness of law enforcement and sanctions (Tempo, 2018).

6.5.3 Protecting the city through the coastal defense

For the last two decades, the Jakarta government, supported by the central government, has tried to protect coastal areas and the city through coastal defense strategies. Two long-term solutions were initiated to protect the city from flooding and minimize land subsidence: the Jakarta Coastal Defence Strategy (JCDS) and the National City Integrated Coastal Development (NCICD).

After Jakarta suffered severe flooding in 2007, which has been indicated as the starting point of the government's increased awareness of land subsidence, the Indonesian government initiated a partnership with the Dutch government to formulate strategies to deal with flooding. In 2011, this consortium introduced JCDS, in which land subsidence was considered for the first time as an issue that exacerbates flooding (Octavianti and Charles, 2018). The aim of the JCDS is to develop effective, feasible, and sustainable solutions to protect Jakarta coastal areas from various risks (Minkman et al., 2019). This project offered multi-year strategies to protect Jakarta from flooding by building three-level permanent sea defenses, which would contain reclaimed islands in the coastal areas of Jakarta (see Kops, 2012). This project was supported by the Jakarta government by including the JCDS plan, namely 17 reclaimed islands, in the spatial planning. Private sectors also invested in infrastructures and buildings on the artificial islands (Brinkman, 2012).

Colven (2017) and Minkman et al. (2019) believe that this project can effectively stop land subsidence if it focuses on strengthening existing sea walls and dikes, combined with preventing massive groundwater extraction in the city. Presently, four reclaimed islands have been built. It seems like this project is effective. But this project was also rejected by various academics, environmentalists, and displaced local communities due to its negative impacts on coastal ecosystems and local people (Bakker et al., 2017).

Then, in 2014, after another severe flooding in 2013, NCICD was released. This USD 40 million mega-project was aimed at protecting Jakarta from various environmental risks, such as flooding and land subsidence, and providing piped water supply and water sanitation systems. The project was developed through collaboration between the government of Indonesia and the Dutch government (Minkman et al., 2019). This project elaborated on some ideas from JCDS (Salim et al., 2019).

The NCICD comprises two stages. The first was the planning stage, which produced the master plan (The Great Garuda) as a long-term strategy for flood defense and management (NCICD 1). Second, the implementation stage provided detailed design and actions to execute short-term flooding protection measures (NCICD 2). The NCICD 1 comprises three phases: 1) strengthening existing sea defenses (Phase A), 2) constructing outer sea walls and artificial islands (Phase B), and 3) developing the east of Jakarta Bay (Phase C) (NCICD Master Plan, 2014). In Phase A, seven polders and six dikes will be built to strengthen the current dikes to protect Jakarta from tidal flooding, while during Phase B, the west outer sea wall and artificial islands will be constructed. These two phases will create 1,250 ha of new land for the central business district, settlements, and retail, which contain road networks, sewerage and wastewater systems, and piped water supply. Then, by 2030, the eastern part of Jakarta Bay will be built and closed by considering land subsidence rate (Phase C).

In the plan, the NCICD looks promising. However, it was also objected to by many experts and local communities due to its various negative impacts on coastal people as well as lawbreaking issues. In the first stage of its implementation, it caused some problems, namely damage to coastal environments and a threat to income sustainability and the social status of coastal livelihoods (see Bakker et al., 2017). Besides, the planned retention lake, which is expected to provide fresh water for all Jakarta areas, is still in doubt because of the poor quality of the water, which could be the source of environmental degradation and health problems for people (Octavianti and Charles, 2018). To date, corruption cases concerning reclaimed islands have also reduced the public's belief in this project (Octavianti and Charles, 2018). On top of the critics' assessment, land subsidence was still not considered as a major driver of Jakarta's problems (Salim et al., 2019). Since it does not offer significant solutions, the NCICD may not have a significant impact in stopping land subsidence (Bakker et al., 2017). Finally, due to the criticisms and local political tensions, the NCICD project was postponed (Minkman et al., 2019).

6.5.4 Starting a new direction: an integrated approach

Because of the ineffectiveness of the solutions and the protests from many stakeholders against the coastal defense projects, the Jakarta government initiated a new direction. At the beginning of 2019, the Jakarta government, facilitated by the Japan International Cooperation Agency (JICA), started the Project for Promoting Countermeasures against Land Subsidence in Jakarta. The Jakarta government invited various national-level institutions—namely the Public Works and Public Housing Ministry, the National Development Planning Agency, and the Energy and Mineral Resources Ministry—to work collaboratively in a consortium. This consortium collects and analyses data on land subsidence to design mitigation plans, including groundwater extraction management and freshwater production.

The decision to learn from Japan seems reasonable. The Tokyo example might work for the Jakarta case. The success of Tokyo in controlling massive groundwater extraction has been one of the best examples of land subsidence management for other cities all around the world (Sato et al., 2006). For areas that are experiencing groundwater extraction-induced land subsidence and have similar geographical characteristics, the experience of Tokyo might be adopted. However, the ability for Jakarta to imitate the success of Tokyo is still questioned, not only because this project is still in the initiation phase, but also due to the repeated failures of previous measures. Thus, to be effective, this measure must take into consideration earlier and existing measures to avoid redundant measures or maladaptation (Salim et al., 2019).

6.6 DISCUSSION: THE CENTRAL GOVERNMENT'S VS THE LOCAL GOVERNMENT'S SOLUTION

6.6.1 Moving the capital city: A solution—or just trial and error?

The development of urban areas in Jakarta has triggered various problems inside the city and in fringe areas. The increasingly intensive, repeated, and cross-border problems have triggered the central government and lower-level governments to take steps to solve the problems. Some local governments, along with private sectors, offered new solutions by developing new towns, that is, a small town located next to the city (Tan, 2010), while the central government plans to move the capital city.

The development of new towns surrounding Jakarta has been happening since the 1980s, and it has led to a huge agglomeration between Jakarta and surrounding areas, namely Bogor, Tangerang, and Bekasi (Firman, 2004; Winarso et al., 2015). Many of them were intended to supply affordable housing (Dieleman, 2011). For instance, Bumi Serpong Damai (BSD), Lippo Karawaci, and Meikarta were developed to decrease population pressure in Jakarta by offering affordable settlements, business areas, green spaces, and basic needs facilities (Firman, 2004; Kahfi and Sapiie, 2019).

The aim of the new town development is to reduce pressure on the inner city (Tan, 2010). Ideally, it might help Jakarta to prevent an increase in groundwater extraction from

the settlement and industrial areas. Unfortunately, it faces numerous challenges. First, the investment in new towns is expensive and difficult. The economic crises and land conflicts caused by unclear land status have limited the interest of private sectors in building new towns (Firman, 2004). Second, the new towns in Jabotabek have been overdeveloped; many buildings are not occupied and appropriately used (Winarso and Firman, 2002). Third, there is a lack of coordination between Jakarta and the neighboring governments (Douglass, 2005), as they tend to design their areas based on their own interests (Firman, 2014). Fourth, development has been dominated by private sectors (Douglass, 2005). Most private sectors built housing for middle- and upper-income groups, which could not be accessed by the lower-income groups who needed it the most (Firman, 2004). The last challenge is acute corruption in the process of new town development (Kahfi and Sapiie, 2019). The corruption case of Meikarta (see Kahfi and Sapiie, 2019), for instance, has increased the distrust in governments and private sectors. Thus, it seems like the development of new towns cannot entirely solve Jakarta's problems.

This failure and massive land subsidence have triggered the central government to announce an idea to move the capital city to Kalimantan Island (Bappenas, 2019). Considering that various urban environmental problems remain, which are worsened by rapid urbanization, serious traffic congestion, and poor air quality (The Telegraph, 2019), this idea seems reasonable. In some countries, this strategy has solved problems and developed new capitals with balanced economic growth and environmental conservation (e.g., see Choi and Reeve, 2015; Moser, 2010; White, 2009).

To implement this idea, two areas in East Kalimantan Province (i.e., Kutai Kartanegara and Penajam Paser Utara) have been chosen as the location of the new capital. The new city will be the center of the government, while Jakarta will remain the business and economic hubs. The total area (about 442,000 ha) will see the creation of the center for government administration, settlement, and technology and basic needs facilities (Bappenas, 2019). To be finished in 2034, the capital needs a total budget of about USD 32.6 million, three quarters of which is to be shared through the public–private partnership scheme (Bappenas, 2019).

One of the advantages of Kalimantan as capital is its relative closeness to the center of Indonesia. Its centrality means comparatively equal access from different areas. In addition, there are not as many natural disasters in Kalimantan compared to other areas in Indonesia (Bappenas, 2019). Yet, there are some challenges to consider. Kalimantan has various peatland problems, such as a high number of drained peatland ecosystems, large-scale forest and peat fires, and severe peat subsidence issues (Kool et al., 2006; Page et al., 2009). If the central government insists on building a new city in Kalimantan, which will be followed by huge development activities, it will need to be aware of land subsidence and other peatland problems (see Hooijer et al., 2012; Saputra, 2019). Otherwise, it will import the same problems from Jakarta and create new peatland problems in the new city.

The new capital city may decrease the population and activities pressure because some city functions will be moved. This could decrease the need for groundwater, reduce the groundwater extraction rate, and thus delay land subsidence. To avoid the same problem as

in Jakarta, it must be built without generating or worsening the present peatland problems. Even though this consideration has been included in the plan (Bappenas, 2019), there are concerns about the measures to prevent land subsidence. Since land subsidence in Kalimantan is frequent and repeated (Kool et al., 2006; Page et al., 2009), a comprehensive planning of new city development to anticipate potential problems is needed.

6.6.2 Does the subsidiarity principle fit in dealing with land subsidence issues?

A big question concerning the plan to move the capital is how effective the solutions offered by the Jakarta government to deal with land subsidence will be. Many scholars believe that local problems will be effectively solved if the power to deal with such problems is given to local authorities (Dobbs, 2016; Milio, 2014). However, land subsidence has been occurring for decades (Abidin et al., 2011) and is causing greater subsidence (Deltares, 2015), and the Jakarta government has failed to stop it.

Indeed, the different solutions offered by the Jakarta government show that it has understood that Jakarta is under the threat of land subsidence. To deal with such issues, it offered various solutions, namely policies and construction measures from the local to provincial levels, which were designed by involving private sectors, academics, and NGOs. Looking at these numerous and different scales of measures, it seems like the decentralization idea of Jakarta triggers the government to solve urban complex problems. However, there are no single local solutions that could solve all of Jakarta's problems. Spatial planning and zoning regulations that were expected to prevent problems have failed because the plans were designed mainly to respond to problems (Firman et al., 2011). Even groundwater-related measures that are the closest methods of preventing massive groundwater extraction could not be optimized due to the weakness of law enforcement and the inability of water providers to supply enough piped water (Bakker, 2007; Friana, 2017; Hall and Lobina, 2006; Memed, 2017; Tempo, 2018; The Jakarta Post, 2018).

Not only is the Jakarta government still unable to deal with land subsidence, this chapter also shows that the legitimacy and democracy aspects of the solutions are still problematic. Even though in some places the decentralization could succeed (Dobbs, 2016; Follesdal, 2006), the Jakarta case shows otherwise. The coastal defense projects that claimed to solve coastal problems failed to fulfil the needs of local people. Many environmental problems that appeared after their implementation, and some rejections from various stakeholders (Minkman et al., 2019; Octavianti and Charles, 2018), have shown that they lack democratic sense. Due to the strong injustice issue, the coastal defense project (i.e., NCICD) is not a good solution for Jakarta's sinking problem (Bakker et al., 2017).

These continuous failures show that the in situ solutions from the local government were not good enough to stop land subsidence. The subsidiarity could trigger the local government to create solutions based on local problems, but many solutions were fragmented. Therefore, land subsidence that happened on a huge scale and had a high degree of complexity could

not be solved solely by the local government. They could only make a partial or limited contribution.

The solutions offered show that land subsidence has been considered an important issue. Unfortunately, land subsidence is still not the central issue. It is mostly considered subordinate to issues of flooding and sea level rise. It shows that the high degree of the urgency of land subsidence, shown by Budiyono et al. (2015) and Deltares (2015), has not yet totally been noted by the government (Saputra et al., 2017).

There are two windows of opportunity (see Birkmann et al., 2010) for the Jakarta government to better deal with land subsidence. The first is the increase in awareness by the Jakarta government of complex land subsidence issues. It must be considered as the basis to consider land subsidence issues in all planning and policies. Furthermore, another opportunity is the status of Jakarta as a province with special decentralization, which is the direct impact of the rise of the subsidiarity principle (Kull and Tatar, 2015; van Voorst, 2016). The Jakarta government can have more power to coordinate various actors and solutions. This may optimize multi-actors-based solutions, which means the process will be more democratic (Follesdal, 2006).

6.7 CONCLUSION

This chapter shows that land subsidence has been threatening Jakarta for a long time and has triggered severe urban environmental and socioeconomic problems (Abidin et al., 2011; Saputra et al., 2019). The late response to the problems has resulted in a massive rate of sinking, which makes Jakarta one of the fastest sinking cities in the world (Deltares, 2015). By considering its interrelatedness with other urban environmental problems, the unsolved land subsidence can trigger and exacerbate such problems (Abidin et al., 2015).

In response to this issue, there are nuances between the solutions of different tiers of government, namely the central and the local government. The former perceives that there is only a limited solution to combat land subsidence, while the latter believes that there are still plenty of solutions. Therefore, both types of actors offer very different approaches, that is, external and in situ solutions. But such solutions show that there is no consistent and structured timeframe for the solutions as some were short-term and others were long-term solutions.

The central government is expected to ensure more coherent policies between local governments at the local level (Dobbs, 2016; Puppim de Oliveira, 2009). However, in the Jakarta case, despite synchronized solutions from areas surrounding Jakarta, the central government chose to offer a controversial idea, namely to move the capital city from Jakarta. Indeed, in some countries this idea has been successful (e.g., see Choi and Reeve, 2015; Moser, 2010; White, 2009). However, considering the government's plan, this idea may not be a reference. This idea may create the same or new problems in the new city. Then the local government in the new city will be responsible to deal with the problems.

The local government, which is predicted to provide better local solutions using its authority, is still struggling with the fragmented solutions. Considering the subsidiarity principle, the local-level government may be able to solve the problems due to its ability

to tailor local solutions (Van den Bergh, 1998). However, there is a mismatch between the subsidiarity principle and findings in this research. The special province decentralization of Jakarta (van Voorst, 2016) could not be used effectively to design comprehensive solutions, and the fragmented solutions could not fit the circumstances. They even created additional consequences for the environment and the socioeconomic status of coastal people, which led to protests by various stakeholders. Thus, this chapter shows that solely local solutions from the local government are not the best solutions to deal with land subsidence. It confirms that local strategies are too small scale to solve large-scale problems (Dang et al., 2014).

Furthermore, the gap between the solutions offered by different tiers of government shows that both levels of government are unsure of how to prioritize and start dealing with the problems. Most of measures have been taken based on their interpretation of the problem and ways to deal with it. The central government perceives the solutions from an external angle, while the local government sees it from an internal angle. These two different views often create tensions between different actors (Pelling and Dill, 2010). However, since land subsidence is a long-term and gradual problem (Galloway et al., 1999), the tensions are expected and can be managed. The coherence between long-term and short-term solutions can also be managed. Both types of governments may be able to adjust their strategies based on the other's measures to create more effective solutions.

To conclude, the matter of scale is important. Both local- and large-scale solutions are important. For large environmental problems like land subsidence, solutions from the local government are not always the best way to solve the problems. Initiatives by the central government are also needed. However, the solutions to deal with land subsidence must be based on coherent processes and multilevel cooperation.

Conclusion

7

In many areas of the world, land subsidence is a severe, long-term problem (Abidin et al., 2011; Galloway et al., 1999; Hooijer et al., 2012; Phien-Wej et al., 2006). It is a continuous process that occurs over extended periods of time and has severe consequences for the physical environment and the socioeconomic position of affected people (e.g., see Abidin et al., 2011; Chaussard et al., 2014; Hooijer et al., 2012; Marfai and King, 2007; Saputra et al., 2019; Yoo and Frederick, 2017). The interrelatedness of land subsidence with other problems can trigger and aggravate other environmental problems, or vice versa, which then form combined problems (Abidin et al., 2015; Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Thorburn and Kull, 2015).

The severe impacts of subsidence call for different actors to respond to the phenomenon. To respond successfully, the awareness of the issue must be enhanced (Brooks, 2003; Pelling, 2010; Smit and Pilifosova, 2003). Enhanced awareness will increase the sense of urgency about the problems and lead to various responses or actions (Hartmann and Spit, 2014). Several researchers have shown that the awareness and responses of different actors were vital to solving single-shock disasters or environmental damages (e.g., see Heller et al., 2005; Miceli et al., 2008; Perry and Lindell, 2008; Scolobig et al., 2012; Thomalla and Schmuck, 2004). How to raise awareness in the actors is still problematic, as is how they can respond to land subsidence. The discussion about such aspects in relation to long-term disasters like land subsidence is still limited. Awareness and effective responses are especially needed in the case of subsidence, as subsidence can have huge impacts on a vast area that can cause and be exacerbated by other environmental and severe hazards (Chaussard et al., 2013; Hooijer et al., 2012; Saputra, 2019). Thus, awareness of these complex issues is needed in order to design appropriate interventions for each issue to avoid maladaptation (Salim et al., 2019).

The aim of this dissertation is to contribute to a broader understanding of the characteristics of land subsidence and the responses of affected people and various actors to the phenomenon. The present research contributes to a broader understanding of the characteristics and responses of affected people and various actors to a long-term disaster that occurs over a long period of time in different geographical settings, by answering three research questions:

1) What are the characteristics of land subsidence in different geographical settings?
2) What kind of problems does land subsidence generate and how do people respond to those problems?
3) What kinds of measures have been taken by different actors from different levels to solve land subsidence problems and how successful are those measures?

These questions were addressed in three different geographical areas in Indonesia, that is, in urban, coastal, and peatland areas.

This chapter summarizes and reflects upon the main findings of the research. After presenting a synthesis of the main findings from three geographical settings and different kinds and tiers of actors, the research is reflected upon concerning the need for a relevant agenda in dealing with land subsidence. The chapter is closed with some final thoughts.

7.1 SYNTHESIS OF MAIN FINDINGS

The previous chapters have provided valuable insights that help to better understand the status of land subsidence in different geographical regions, and how different actors from different backgrounds and levels respond to the problems. In this subsection, the findings from these chapters are compiled to answer the research questions.

7.1.1 Land subsidence: A wicked problem

The previous chapters showed that land subsidence is a wicked problem that has been threatening various areas of Indonesia for as long as a century (Abidin et al., 2013). As a single problem, land subsidence occurs in huge areas over an extended period of time (Chaussard et al., 2013; Hooijer et al., 2012). There is no guarantee that land subsidence in all case study areas can be stopped by any actors. In fact, in the peatland areas, subsidence can be worsened by the central government's policy to increase the use of biofuels and triple the area of timber plantation by 2030 (MoFor, 2011). And in the coastal and urban areas, the uncontrolled growth of population and economic activities—which need more groundwater supply and increase the surface load—can also cause land subsidence to persist (Abidin et al., 2011; Marfai and King, 2007). The continuous and rapid land subsidence in Jakarta, the country's capital, has made the city one of the world's fastest sinking cities (Deltares, 2015).

The land subsidence issue is becoming more complicated since it is interrelated with other problems that can exacerbate the impacts of subsidence. In peatland areas, subsidence can trigger or be triggered by other peatland problems, such as deforestation, fires, and carbon emissions (see Couwenberg and Hooijer, 2013; Hooijer et al., 2012; Schrier-Uijl et al., 2013; Thorburn and Kull, 2015). In coastal areas, subsidence widens and worsens coastal flooding and inundation (e.g., see Harwitasari and van Ast, 2008; Marfai et al., 2008; Suripin et al., 2017). And in urban areas, it prolongs the duration and coverage area of flooding (Andreas et al., 2018). Land subsidence thus has massive consequences for the affected areas and people. Chapters 4, 5, and 6 have shown the consequences in detail.

Therefore, the findings underscore the fact that land subsidence is a severe problem—especially because subsidence is a sleeping disaster, not many people know that it exists, and it is happening on a huge scale.

7.1.2 Land subsidence: Massive impacts at the local level

At the community level, too, land subsidence has caused severe and repeated damage. For the affected households, land subsidence has become a really serious threat. It has affected households in various ways, ranging from physical damage to their land and properties to environmental and socioeconomic problems. Their assets are sinking continuously, and increasingly so. Chapter 3 showed that land subsidence affects extensive areas and has different direct and indirect consequences for almost all households. Almost three quarters of the affected households in this study had suffered from multiple types of impact, namely

a combination of direct and indirect impacts. They are the most vulnerable households, since not only do they suffer from the consequences of land subsidence, but they are also seriously affected by other interrelated hazards, such as sea level rise, flooding, peat fires and coastal erosion (Abidin et al., 2015; Hooijer et al., 2012; Marfai et al., 2008). Those who are unable to deal with the impacts because their sources of income have been undermined, will always be vulnerable to land subsidence.

People's ability to respond to the problems caused by land subsidence depends on their awareness of subsidence. Chapter 2 showed that awareness, and especially the degree of knowledge of the characteristics of land subsidence, is one of the important triggers of responses. The degree of the impacts of land subsidence and its rate influence whether people respond to the problems. It is more or less similar in all geographical settings. One of the concerns that arose from the affected people case was that many of them overlooked the triggers and the rate of land subsidence in their circumstances. The main reason for their willingness to respond to the impacts of land subsidence was the fact that some of them had suffered severe consequences or damage, or their areas had already been made uninhabitable. As they did not pay much attention to these aspects, the affected people tend to respond to land subsidence randomly. Due to their lack of awareness, knowledge, and resources, they tend to tackle the symptoms rather than the cause.

Thus, it is clear that awareness of land subsidence is a crucial factor in initiating a response. However, Chapter 3 argued that awareness is not the only factor that contributes to the willingness of affected households to respond to land subsidence; economic capacity is also a factor. That some affected people whose homes had become uninhabitable and who remained in their sinking houses and did nothing because they could not afford to take appropriate measures, shows that economic capacity is crucial—as do other examples showing that affected people whose houses had not yet sunk but who had enough money, chose to raise their houses to avoid the worse impacts. It confirms that households with less income may suffer more from disasters and hazards (Adger, 1999; Harwitasari and van Ast, 2011; Satterthwaite et al., 2007).

Therefore, this dissertation confirms that awareness alone cannot guarantee that people will make appropriate responses: Sufficient economic capacity is also needed. This research supports studies by Alwang et al. (2001), Cutter et al. (2003) and Siagian et al. (2014), who that show the economic capacity of affected households is vital to increase their ability to take measures. The lack of income capacity to respond effectively to the impacts will leave them vulnerable to land subsidence. Therefore, households should consider increasing their income capacity or enhancing their knowledge and ability to avoid more severe consequences or respond effectively to the problems. The fact that land subsidence is a long-term disaster indicates that the ability of the affected households to earn enough money is even more critical, since they must adapt to or prevent the problems over a long period of time.

7.1.3 Actors' interventions: Many interventions, but some had failed

In numerous areas, land subsidence is an extremely crucial issue, because combined with related problems it creates a complex problem. The growth of population and economic development in coastal, peatland, and urban areas has increased the risks of land subsidence and other environmental problems. Unquestionably, the government has a responsibility to guarantee the growth of areas, maintain their productivity, and protect them from harm. This combination of efforts is challenging. However, considering that the development process will continue and that affected people cannot always deal with the problems with their own resources, different relevant actors must initiate solutions based on their capacities and roles.

Various actors from different levels have indeed offered several solutions. The government at various levels, environmental and developmental NGOs, and local communities have tackled the problems using their abilities and resources. As shown in Chapters 4, 5, and 6, the central and local governments have issued policies and worked on practical measures to manage existing problems and prevent risks; NGOs have supported the governments' measures or offered their own solutions based on their knowledge of the problems at the local level; and local communities have initiated small-scale measures at the community level and continued the measures started by other actors. Among the actors, the central, regional, and local government bodies are clearly the key actors, because they are the institutions that have huge resources and are formally legalized to protect people against risks (Kumar, 2018).

From the time-scale perspective, actors' interventions have been diverse, ranging from adaptation to existing problems to mitigation measures to minimize the drivers to prevent future or worse problems. Some measures have been initiated and taken collaboratively and complementarily among the actors, which has some advantages. The collaboration between the central government, local government, environmental NGOs, and local communities aimed at dealing with land subsidence in peatland area, for instance, has increased both the types and the quality of responses. Therefore, the notion of Lewis (2006), who states that the government and NGOs could be constructive partners, is supported by these findings. It also supports the idea of Roberts (2000), who states that the collaboration can raise the ability of each actor to the optimum level to create better outputs. They may also increase their ability to share their expertise with other actors.

Despite the various responses, there are still some considerable challenges to overcome in order to solve land subsidence and other related problems in unison. So far, solutions have been fragmented, and this is problematic, since fragmented solutions cannot solve huge problems. Second, the orientation of the solutions has so far been mostly short term. In all affected areas, both types of actors still pay more attention to fixing the short-term issues than combatting the drivers. Third, the scale of interventions has not matched the scale of the problems. The solutions offered at the community level without considering proper solutions at a higher level that fit the scale of the problems will only delay such problems. Finally, there is an obvious difference between the central and local governments, especially in identifying problems and designing solutions. As a consequence, both types of actors have taken very

different approaches. For instance, local governments have continued to work on the local level with local solutions, while the central government has come up with an extreme solution, namely moving the capital. Many scholars believe that local-level governments may have a better chance of solving the problems because they are able to tailor solutions to the needs of local people (Van den Bergh, 1998). However, this research extends these ideas by showing that there are other actors that can provide solutions, revealing a mismatch between van den Bergh's idea and the research findings presented in Chapter 6. In the beginning, the local problems were mainly identified and solved by local NGOs. Ideas and actions to solve local-level problems mostly originated from local NGOs, which had already been working in the affected areas for years. The local government was inspired by the NGOs to start working from the local level. However, Chapters 4, 5, and 6 showed that even though some initiatives at the local level have been taken, there is no single solution from all actors that is able to solve all the problems, due to the lack of a comprehensive solution. Thus, this research confirms that local-level strategies are usually unable to solve large-scale problems only because of the scale difference (Dang et al., 2014).

7.2 REFLECTIONS

The present research used multiple perspectives—namely livelihood, planning, and governance—to understand different actors' awareness of land subsidence and their responses to it. These diverse perspectives, combined with the different geographical characteristics of the case study areas, have provided more insight into the responses of different actors as a contribution to long-term disaster and governance literature.

7.2.1 The need to raise awareness

This dissertation has shown that the awareness of land subsidence differs among different actors, which leads to different interpretations of the solutions needed to deal with the problems. The lack of awareness among the affected people means that they tend to accept the consequences of land subsidence and do nothing to reduce their risks. At the same time, the local government's lack of awareness of subsidence has resulted in a lack of urgency regarding the problem. Land subsidence is often seen as a non-central issue in almost all government strategies to deal with various disasters or environmental issues. The lack of a sense of urgency has also led to a limited number of actions being taken to deal with land subsidence.

Therefore, there is no doubt that awareness of the problem must be increased in order to trigger better responses to land subsidence. Many scholars perceive awareness as key to being prepared for future problems and willing to take measures to prevent hazards (Grothmann and Reusswig, 2006; Miceli et al., 2008; Neuwirth et al., 2000). In the case of land subsidence, this issue, along with the adaptive capacity, must also be regarded as a crucial factor. As land subsidence will continue to happen slowly over an extended period of time, and it is possible

that many actors will not recognize the problem, which can have severe impacts, awareness of the phenomenon is becoming increasingly critical.

However, increasing awareness is not enough to respond to a wicked problem like land subsidence. The awareness must be maintained because land subsidence is a long-lasting process. Because of its duration, subsidence needs to be monitored, continuous research should be carried out to gather appropriate data, and tools or systematic ways to remind policymakers of the importance of land subsidence must be developed. Keeping land subsidence in the forefront of the minds of people and actors—especially public authorities that have the power to design policy and practical measures—is crucial to ensure that subsidence will always be on their agendas. Birkmann (2010) states that by retaining the memory of a disaster, the awareness of communities and institutions can be maintained and increased. In addition, it may cause people and institutions to anticipate and mitigate risks (Le Blanc, 2012). Thus, to trigger responses land subsidence, awareness must be increased and maintained.

Awareness can be increased by optimizing media or public initiatives. Media coverage of a disaster is one of the best ways to keep the public aware of and make them remember a disaster (e.g., see Vasterman et al., 2005). It also important to frame the scale of the importance of an issue (Houston et al., 2012). In addition, Chapters 4 and 5 showed that NGOs play a very crucial role in increasing and maintaining the awareness of people as well as the various actors involved in land subsidence. Their intensive interaction with local communities and different tiers of governments has made them an important actor in this issue.

7.2.2 The need for multiscale approaches

When this dissertation revisited the current discussions on responses to a long-term disaster or environmental problems, it was argued that the spatial scale should be considered because it might increase the effectiveness of the responses. The appropriate scale of an intervention can prevent relevant actors from having to act outside the box (i.e., outside the core problems) or wasting the resources. Chapters 4, 5, and 6 showed that this factor could determine the success of responses. Matching the scale of problems with the scale of the solutions provided by actors could slow down land subsidence.

Land subsidence always affects a vast area that sometimes extends across more than one administrative area (Chaussard et al., 2013). Even though the scale of its impacts varies, the impacts are mainly felt at the community level (Abidin et al., 2011; Saputra et al., 2019). Therefore, both local and larger scale solutions from various actors and different tiers of government are needed in different degrees to deal with such problems. Indeed, each solution has its own purposes. Solutions from local governments are crucial because they mostly consider local needs (Huffman, 2003). This means that their solutions may be more appropriate in terms of combatting the exact and detailed local problems (Dobbs, 2016). However, in the case of huge environmental problems like land subsidence, solutions from local governments are not the best. Thus, solutions from higher levels of government are also needed. One of the advantages

of involving the central government is its better access to human capital and finances, and its ability to manage the uncoordinated policies between local governments (Dobbs, 2016; Puppim de Oliveira, 2009). Therefore, to solve land subsidence, a combination of local and higher-level solutions is needed.

To optimize the scale, local communities and local NGOs should be actively involved, especially in the case of local-scale solutions. The NGOs can compensate for the weakness of the government in solving problems because of their knowledge of local-level issues and their flexibility to deliver strategic solutions to communities (Agarwal, 2001; Benson et al., 2001; Haque, 2002). They also have specific abilities and experience in working on particular issues, which might increase the government's ability to deal with disasters (King, 2007). Chapters 4 and 5 showed that local NGOs played significant roles in helping people to deal with their daily problems caused by land subsidence, and in assisting the government to design policies concerning specific issues in peatland and coastal areas. However, the chapters also showed that the NGOs' solutions did not fit perfectly with those offered by the central and local governments. It is also important to note that the central government has large powers and resources with which to deal with disasters (Dobbs, 2016; Puppim de Oliveira, 2009). Thus, by combining the ability of local NGOs and communities to develop solutions at the local level and the ability of the central and local governments to design multilevel solutions, it seems possible to stop land subsidence.

7.2.3 The need for collaborative actions

Every so often, land subsidence affects vast areas and extends across more than one administrative border (Chaussard et al., 2013) and is followed by severe impacts (Abidin et al., 2011; Hooijer et al., 2012; Saputra et al., 2019). While the problems are diverse and severe, different actors with unique abilities and capacities are required to participate in dealing with the problems. Therefore, solutions from such actors as governments, NGOs, and local communities must be considered valuable contributions to solving the problems. To optimize the solutions, this research shows that collaborative actions are clearly needed.

Chapters 4 and 5 showed that each actor has its own responses to land subsidence in different areas. The actors tend to offer solutions based on the nature of their roles. The government designs policies and legal frameworks to manage the risk; NGOs offer community-based adaptations and strengthen the measures taken by the government or other actors; and local communities, with their better knowledge about the local problems, contribute by supporting the measures in their community. Even though all actors have considerable abilities, the complexity and tight interconnectedness of the problems has induced the actors to work together.

The case from the peatland areas presented in Chapter 4 showed that the environmental NGOs and the central government (i.e., BRG—the Peatland Restoration Agency) could work complementarily in peatland restoration. The NGOs provided local-level data and helped BRG to design peatland-related policies, while BRG allowed the NGOs to contribute more to the

decision-making process. This has also triggered collaboration between local NGOs and local governments through a resource-sharing scheme. The case from the coastal area presented in Chapter 5 also showed there was an intensive interaction between the local government and the local NGO. During the long-term interaction, the local NGO—which has an advanced capacity to manage coastal areas—inspired the local government to initiate a consortium to work with other actors to manage the coastal areas. Therefore, tackling land subsidence by involving various actors from different levels was initiated. To be able to optimize the collaborative solutions, Chapters 4 and 5 showed that the consistency of the collaboration among actors during long-term land subsidence must be maintained by enhancing the power relations among the actors and ensuring that they are symmetric.

7.3 LAND SUBSIDENCE AS A DISASTER

Land subsidence is a sleeping disaster that happens gradually over an extended period of time (Galloway et al., 1999). In other words, land subsidence is a slow-onset or long-term natural disaster induced by geological and hydrological properties and the activities of humans (Guha-Sapir et al., 2012; Twigg, 2004). Even though it happens slowly and continuously over an extended period of time, subsidence affects huge areas (Chaussard et al., 2013) and its consequences are devastating (Andreas et al., 2018; Du et al., 2018; Evers et al., 2017; Fiaschi and Wdowinski, 2017; Hooijer et al., 2012; Laura et al., 2005; Marfai and King, 2007; Phien-Wej et al., 2006; Saputra et al., 2017; Sarah and Soebowo, 2018; Wösten et al., 2008). In addition, the affected people struggle to deal with the problems due to their lack of resources (Harwitasari and van Ast, 2008; Saputra et al., 2019). Therefore, to prevent the impacts becoming worse, the disaster must be awakened, either gently or brutally.

Some serious efforts are needed to make people and the relevant actors aware of the massive potential impacts of land subsidence and to then implement solutions. First, land subsidence must be considered a disaster. By considering it a disaster, the affected areas and people can receive more prominent attention and compensation; land subsidence can be put at the top of the governments' agenda, like other disasters; and there will be more opportunities to prevent its causes rather than just deal with the symptoms. Looking at the huge coverage areas and impacts of land subsidence, as well as the need for a vast adaptive capacity to deal with it (Chaussard et al., 2013; Galloway et al., 1999; Hooijer et al., 2012), it should be considered a disaster (Guha-Sapir et al., 2017). Therefore, the first step toward making land subsidence a central issue is to increase the awareness of people, the government, and the relevant actors, and to enhance the willingness of the government to treat land subsidence as a disaster in every policy and regulation.

Considering land subsidence as a disaster, however, is not enough. As subsidence is mainly a human-made disaster, in order to tackle its causes one must tackle the symptoms. Much extra work is still needed. Many things about land subsidence are not yet fully understood by numerous actors, for instance, concerning the interrelatedness of land subsidence and other societal and physical problems, such as climate change, sea level rise, flooding, and plantations

in peatland. The complexity of land subsidence and other related problems is often ignored, and they are often seen as separate issues. Or, if actors are aware of it, they do not have the same level of understanding. Such a complex issue necessitates a comprehensive approach. To sum up:

- First of all, people should be more aware of and prepared for land subsidence. As they lack the information and resources required to deal with the problems, they need to be supported by either the government or non-government actors.
- Second, land subsidence must be put at the top of the agenda of the actors—especially governments at different levels. By putting it on the agenda, the long- and short-term solutions for this issue can be established and maintained, and may be supported by huge resources from the governments and other relevant actors.
- Third, a series of data-collecting activities is required to gather the missing information. This dissertation has shown that comprehensive data on land subsidence, both its characteristics and its interrelation with other problems, are urgently needed to support long-term responses to land subsidence and to manage resources allocation to cope with it and the combined hazards. However, such data are still limited and incomplete.
- Finally, institutional reform is necessary. As land subsidence is a serious problem in all geographical settings and has been occurring for decades, it is essential to have a powerful institution and system to make land subsidence as important as other disasters. In both literature and practice, land subsidence must be shown to be an urgent issue that requires resolution.

The present research has shown that land subsidence in Indonesia triggers many serious physical environment and socioeconomic problems. It has also shown that the relevant actors, especially the country's governments, have paid fluctuating attention to this sleeping disaster: They awakened it and made the public see it as a problem, but then they made it sleep again by taking inappropriate measures to deal with it. As a result, the affected people, who have limited resources and are unable to solve the problems themselves, will continue to suffer from land subsidence. As land subsidence happens gradually, people who have not yet been severely impacted by it often forget how big the consequences of land subsidence are. Overcoming these issues requires a comprehensive approach, one that starts by increasing the awareness of the problem, then enhances the adaptive capacity of people and various actors, chooses effective measures based on time-scale considerations, and acts based on coherent processes and multilevel cooperation among different actors. Without such an approach, it is unlikely that Indonesia will be able to deal with land subsidence in an effective way.

7

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Appendices

APPENDIX 1. List of selected actors

Selected actor		Actor's level
A.	*Government (national, provincial, local)*	
1.	Indonesian National Board for Disaster Management (BNPB)	National government
2.	Ministry of Environment and Forestry (MoEF)	National government
3.	Peatland Restoration Agency (BRG)	National government
4.	Ministry of National Development Planning/National Development Planning Agency (Bappenas)	National government
5.	Riau Province Government	Provincial government
6.	Provincial Board for Disaster Management (BPBD Provinsi)	Provincial government
7.	District/City Board for Disaster Management (BPBD Kabupaten/Kota)	Local government
8.	Forestry office of Indragiri Hilir	Local government
9.	Environmental office (BLH) of Indragiri Hilir	Local government
10.	Spatial Planning Board (Bappeda) of Indragiri Hilir	Local government
11.	Spatial Planning Board (Bappeda) of Semarang City	Local government
12.	Office of Marine Affairs and Fisheries of Semarang City	Local government
13.	Environmental Protection Agency (BLH) of Semarang City	Local government
14.	Regional Board for Disaster Management (BPBD) of Semarang City	Local government
15.	Water Management-Energy and Mineral Agency (*Dinas* PSDA-ESDM)	Local government
16.	Mining and Energy Office of Jakarta	Local government
17.	Public Works Office of Jakarta	Local government
B.	*NGO (environmental and developmental NGO)*	
18.	Walhi Indonesia	National NGO
19.	Greenpeace Indonesia	National NGO
20.	WWF Indonesia	National NGO
21.	Indonesian Society for Disaster Management (MPBI)	National NGO
22.	Foundation for Sustainable Development (YPB)	National NGO
23.	Wetlands International Indonesia	National NGO
24.	Walhi Riau	Local NGO and work in Riau

Selected actor		Actor's level
25.	Hutan Riau	Local NGO and work in Riau
26.	Greenpeace Riau office	Local NGO and work in Riau
27.	Jaringan Kerja Penyelamat Hutan Riau (Jikalahari)	Local NGO and work in Riau
28.	LSM Rupari	Local NGO and work in Riau
29.	Yayasan Mitra Insani (YMI)	Local NGO and work in Riau
30.	Walhi Jawa Tengah	Local NGO and work in Semarang
31.	Bintari Foundation	Local NGO and work in Semarang
32.	LSM Tapak Prenjak	Local NGO and work in Semarang
33.	LBH Semarang	Local NGO and work in Semarang
34.	LSM Camar	Local NGO and work in Semarang
35.	KeSeMat	Local NGO and work in Semarang
C.	*Local community*	Local communities in Indragiri Hilir Regency, Jakarta, and Semarang City

APPENDIX 2. Questionnaire - Land subsidence impacts and responses

Land subsidence is a hazard that can severely threaten people and urban infrastructure. Unsuitable land allocation and land utilization will bring the hazard into wider problems, from national into local level. This questionnaire is designed to identify the status and impacts of land subsidence to households and their responses to the problems. Data and information from this questionnaire will be used to fulfill the data needed for thesis objectives analyses.

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A. RESPONDENT'S IDENTITY

1.	Name (*optional*)	……	
2.	Age	…….. years old	
3.	Sex	a. Male (*laki-laki*)	b. Female (*perempuan*)
4.	Marital status	a. Married (*menikah*) b. Not married (*belum menikah*)	c. Widowed (*duda*) d. Widow (janda)
5.	Highest education	a. No education b. Elementary school (SD) c. Junior high school (SMP) d. Senior high school (SMA)	e. Academy (Diploma/D3) f. University (Bachelor/S1) g. Graduate (Master/S2) h. Postgraduate (Doctoral/S3)
6.	Number of family members (extended family)	a. Children (*anak*) b. Mother/father (*ibu/bapak*) c. Mother-/father-in-law (*ibu/bapak mertua*) d. Wife/husband (*isteri/suami*) e. Other: ……..	…….. people …….. people …….. people …….. people …….. people
7.	Total number of family numbers who must be paid by the head of family	…… people	

B. RESPONDENT'S LOCALITY (FOR SURVEYOR)

1.	GPS coordinate	X: ……..... Y: ……..... Z: ……..... Accuracy: ……..	
2.	Address	Province: …… District: …… Subdistrict: …… Street: ……	Village …… *RT/RW* …… Number ……
3.	Land-use association (within a radius of 300 m)	a. Commercial area b. Residential area c. Institutional area d. Industrial area e. Utilities f. Plantation area	g. Park/open space h. Fishpond i. Forest j. Tourism area k. Other: ……..
4.	Dominant land-use association	……..	……

C. RESPONDENT'S SOCIOECONOMIC CONDITIONS

C.1 Housing

1.	House type	a. Individual house b. Row house	c. Mixed-use building *(ruko, rukan, dll.)* d. Other: ……
2.	House status	a. Own house b. Rental house c. Family house	d. Official house e. Other: ……
3.	House category	a. Permanent house b. Semi-permanent house c. Non-permanent house d. Other: ……..	House area: …… m^2 House area: …… m^2 House area: …… m^2 House area: …… m^2
4.	Number of family members in the house	…..…… people	
5.	Total land area	……..m^2	
6.	Land status		
7.	Dominant roof material	a. Concrete *(Beton)* b. Asbestos *(Asbes)* c. Roof tile *(Genteng)* d. Palm fiber *(Ijuk/rumbia)*	e. Shingle *(Sirap)* f. Iron sheeting *(Seng)* g. Other ……
8.	Dominant floor material	a. Marble/ceramic/granite *(Marmer/keramik/granit)* b. Wood *(Kayu)* c. Briquette *(Tegel/teraso)*	d. Earth *(Tanah)* e. Cement *(Semen)* f. Other: …….. g. Floor area: …….. m^2

9.	Dominant wall material	a.	Concrete *(tembok)*	c.	Wood *(Kayu)*
		b.	Bamboo *(bambu)*	d.	Other: ……
10.	Water source	a.	Bottled water *(air kemasan)*	e.	River *(sungai)*
		b.	Private well *(sumur pribadi)*	f.	Rainwater *(air hujan)*
		c.	Public well *(sumur umum)*	g.	Other: ……..
		d.	Running water *(air leding)*		
10.1.	Water source for drinking	a.	Bottled water *(air kemasan)*	e.	River *(sungai)*
		b.	Private well *(sumur pribadi)*	f.	Rainwater *(air hujan)*
		c.	Public well *(sumur umum)*	g.	Other: ……..
		d.	Running water *(air leding)*		
10.2.	Water source for cooking	a.	Bottled water *(air kemasan)*	e.	River *(sungai)*
		b.	Private well *(sumur pribadi)*	f.	Rainwater *(air hujan)*
		c.	Public well *(sumur umum)*	g.	Other: ……..
		d.	Running water *(air leding)*		
10.3.	Water source for bathing	a.	Bottled water *(air kemasan)*	e.	River *(sungai)*
		b.	Private well *(sumur pribadi)*	f.	Rainwater *(air hujan)*
		c.	Public well *(sumur umum)*	g.	Other: ……..
		d.	Running water *(air leding)*		
10.4.	Water source for washing	a.	Bottled water *(air kemasan)*	e.	River *(sungai)*
		b.	Private well *(sumur pribadi)*	f.	Rainwater *(air hujan)*
		c.	Public well *(sumur umum)*	g.	Other: ……..
		d.	Running water *(air leding)*		
11.	Total water used	a.	Daily: …….. liters		
		b.	Weekly: …….. liters		
		c.	Monthly: …….. liters		
C.2 Economic condition					
1.	Main job	a.	Civil servant *(PNS)*	g.	Employee *(pegawai)*
		b.	Peasant *(petani)*	h.	Honorary employee *(pegawai honorer)*
		c.	Farm worker *(buruh tani)*		
		d.	Entrepreneur *(wirausaha)*	i.	Laborer *(buruh)*
		e.	Fisherman *(nelayan)*	j.	Soldier/police officer *(tentara/polisi)*
		f.	Service worker *(pekerja jasa)*	k.	Other: ……..
2.	Side jobs	a.	Peasant *(petani)*	e.	Service worker *(pekerja jasa)*
		b.	Peasant worker *(buruh tani)*	f.	Worker *(buruh)*
		c.	Entrepreneur *(wirausaha)*	g.	Other: ……..
		d.	Fisherman *(nelayan)*		
3.	Total income	a.	Daily *(harian)*	a.	…….. rupiahs
		b.	Weekly *(mingguan)*	b.	…….. rupiahs
		c.	Monthly *(bulanan)*	c.	…….. rupiahs
		d.	Quarterly *(tiga bulanan)*	d.	…….. rupiahs
		e.	Six-monthly *(enam bulanan)*	e.	…….. rupiahs
		f.	Annually *(tahunan)*	f.	…….. rupiahs
		g.	Other: ……..	g.	…….. rupiahs

3.1. Detail income	a.	Salary *(gaji)*	a.	…….. rupiahs
	b.	Plantation *(kebun)*	b.	…….. rupiahs
	c.	Paddy field *(sawah)*	c.	…….. rupiahs
	d.	Rent received *(sewa)*	d.	…….. rupiahs
	e.	Remittance received *(kiriman uang)*	e.	…….. rupiahs
			f.	…….. rupiahs
	f.	Other: ……..		
4. Total expenses	a.	Daily *(harian)*	a.	…….. rupiahs
	b.	Weekly *(mingguan)*	b.	…….. rupiahs
	c.	Monthly *(bulanan)*	c.	…….. rupiahs
	d.	Quarterly *(tiga bulanan)*	d.	…….. rupiahs
	e.	Six-monthly *(enam bulanan)*	e.	…….. rupiahs
	f.	Annually *(tahunan)*	f.	…….. rupiahs
	g.	Other: ……..	g.	…….. rupiahs
4.1. Expenses	a.	Food	a.	…….. rupiahs
		- Daily		
		- Monthly		
		- Annually		
		- Other:		
	b.	Transportation	b.	…….. rupiahs
		- Daily		
		- Monthly		
		- Annually		
		- Other:		
	c.	Education	c.	…….. rupiahs
		- Daily		
		- Monthly		
		- Annually		
		- Other:		
	d.	Social expenses	d.	…….. rupiahs
		- Daily		
		- Monthly		
		- Annually		
		- Other:		
	e.	Recreation/leisure activities	e.	…….. rupiahs
		- Daily		
		- Monthly		
		- Annually		
		- Other:		
	f.	Rent paid:	f.	…….. rupiahs
		- Housing rent		
		- Land rent		
		- Other: ……..		
	g.	Other expenses: ……	g.	…….. rupiahs
5. Saving	a.	Daily	a.	…….. rupiahs
	b.	Monthly	b.	…….. rupiahs
	c.	Annually	c.	…….. rupiahs
	d.	Other: ……	d.	…….. rupiahs

D. LAND SUBSIDENCE CONDITION

1. How long have you been living in this area? *(stated the year)*	a. 0 – 5 years b. 6 – 10 years c. 11 – 15 years	d. 16 – 20 years e. > 20 years
2. To what extent are you knowledgeable about/familiar with land subsidence?	a. Do not understand it b. Very little c. Little	d. Great e. Very great
2.1. Who informed you, for the first time, about the land subsidence?		
3. How long have you been affected by land subsidence? *(stated the year)*	a. 0 – 5 years b. 6 – 10 years c. 11 – 15 years	d. 16 – 20 years e. > 20 years
4. Do you know the triggers of land subsidence in your area?	a. Yes b. No	
4.1. If yes, what are the triggers of land subsidence?	a. Groundwater extraction b. Construction loads c. Salinization d. Natural consolidation of alluvial soil e. Tectonic process f. Other: ……	
5. Do you know other areas that are affected by land subsidence?	a. Yes b. No	
5.1. If yes, where are the locations?	a. …….. b. …….. c. etc.	

E. LAND SUBSIDENCE RATE

1. During your life in the area, how much has the land subsided?	…….. cm	
2. Do you know the rate of subsidence under or around your house?	a. Yes	b. No
2.1. If yes, how fast is the subsidence? *(stated the rate)*	a. < 3 cm/year b. 3 – 6 cm/year c. 7 – 10 cm/year	d. 11 - 14 cm/year e. > 14 cm/year f. …….

F. LAND SUBSIDENCE IMPACTS

1.	What are the impacts of land subsidence in your area?	a. Damage to infrastructures b. Damage to houses c. Cracking of permanent constructions d. Expansion of flooded areas e. Lowering of groundwater level f. Increasing inland seawater intrusion g. Damage to coconut plantation h. Damage to timber plantation i. Damage to oil palm plantation j. Health problems k. Other: ……..
2.	What are the impacts of land subsidence on your family?	a. Damage to house b. Flooding c. Lowering of groundwater level d. Health problems e. Other: ……..……..
3.	Does land subsidence affect your daily activities?	a. Yes b. No
	3.1. If yes, how big are the problems that affect your activities?	a. Very small c. Big b. Small d. Very big
	3.2. If yes, what are they?	a. …….. b. …….. c. etc.
4.	Does land subsidence have any impact on your income?	a. Yes b. No
	4.1. If yes, what are the impacts of land subsidence on your income?	a. Decrease in direct income b. Decrease in land production c. Decrease in amount of cultivated area d. Damage to cultivated area e. Other: ……..
	4.2. If yes, how much is the decrease in income caused by land subsidence? *(stated the amount)*	a. < Rp 1,000,000 per year b. Rp 1,000,000 – 2,000,000 per year c. Rp 2,000,001 – 3,000,000 per year d. Rp 3,000,001 – 4,000,000 per year e. > Rp 4,000,000 per year
5.	Does land subsidence influence your expenses?	a. Yes b. No
	5.1. If yes, what do you have to spend more on because of land subsidence? *(stated the amount)*	a. Building repairs b. Housing reconstruction c. Replantation d. Health costs e. Other: ……..

5.2.	If yes, how much extra do you have to spend because of land subsidence? *(stated the amount)*	a. < Rp 1,000,000 per year b. Rp 1,000,000 – 2,000,000 per year c. Rp 2,000,001 – 3,000,000 per year d. Rp 3,000,001 – 4,000,000 per year e. > Rp 4,000,000 per year
6.	Does land subsidence have an impact on your family's health?	a. Yes b. No
6.1.	If yes, what impact does land subsidence have on your family's health?	a. …….. b. …….. c. etc.
6.2.	If yes, how much extra do you have to spend on health expenses because of land subsidence? *(stated the amount)*	a. < Rp 200,000 per year b. Rp 200,000 – 400,000 per year c. Rp 400,001 – 600,000 per year d. Rp 600,001 – 800,000 per year e. > Rp 800,000 per year
7.	Does land subsidence have an impact on your job?	a. Yes b. No
7.1.	If yes, what impacts does land subsidence have on your job?	a. Loss of job b. Decrease in number of hours c. Increase in number of hours d. Other: ……..
8.	Have you changed your main job due to land subsidence?	a. Yes b. No
8.1.	If yes, what was your previous job (before land subsidence impacts)?	
8.2.	If yes, what is your current job (after land subsidence impacts)?	
9.	Do you have side jobs due to the impacts of land subsidence?	a. Yes b. No
9.1.	If yes, what are the side jobs?	

G. RESPONSE TO LAND SUBSIDENCE

1.	What were your first responses to the impact of land subsidence?	
2.	When did you first respond to the impact of land subsidence? *(stated the year)*	a. < 5 years ago b. 6 – 10 years ago c. 11 – 15 years ago d. 16 – 20 years ago e. > 20 years ago
3.	What do you do to respond to the impact of land subsidence?	
4.	What are the problems associated with dealing with land subsidence?	

H. PROGRAMS AND ACTIONS ON LAND SUBSIDENCE AREA

H.1. PROGRAMS	
1. Do you know of any national, provincial, district, or local government programs to deal with land subsidence in your area?	a. Yes b. No
1.1. If yes, what are the programs?	a. …… b. …… c. etc.
1.2. Who are the initiators of the programs? (specific institutions)	a. …… b. …… c. etc.
2. Do you know of any programs run by local communities or NGOs to deal with land subsidence in your area?	a. Yes b. No
2.1. If yes, what are the programs?	a. …… b. …… c. etc.
2.2. Who are the initiators of the programs? (specific institutions)	a. …… b. …… c. etc.
3. What programs do you think are necessary to deal with land subsidence?	
H.2. ACTIONS	
4. Do you know of any national, provincial, district, or local government actions or funding to deal with land subsidence in your area?	a. Yes b. No
4.1. If yes, what are the actions?	a. …… b. …… c. etc.
4.2. If yes, how much is the funding?	
4.3. Who are the initiators of the actions? (specific institutions)	a. …… b. …… c. etc.
4.4. What are the benefits of the actions to you?	
5. Do you know of any actions taken by local communities or NGOs to deal with land subsidence in your area?	a. Yes b. No
5.1. If yes, what are the actions?	a. …… b. …… c. etc.
5.2. If yes, how much is the funding?	
5.3. Who are the initiators of the actions? (specific institutions)	a. …… b. …… c. etc.

5.4. What are the benefits of the actions to you?	
6. What actions do you think are necessary to deal with land subsidence in your area?	

I HOUSEHOLD'S PERCEPTION OF LAND SUBSIDENCE

Please indicate your perceptions below. Note: 10 = the best, 1 = the worst

1) Perception of governments' policies and actions related to land subsidence		
1. To what extent are you familiar with government policies to cope with current and future land subsidence problems in your area?	a. Very little b. A little c. Some	d. Great e. Very great
2. To what extent are you familiar with actions undertaken by the government to deal with land subsidence?	a. Very little b. A little c. Some	d. Great e. Very great
2.1. If familiar, how helpful are consider those actions in general?	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10
2.2. If familiar, how helpful are those actions for you personally?	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10
3. How would you rate the governments' attempts to solve land subsidence problems in your area?	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10
4. How would you rate the governments' attempts to alleviate land subsidence impacts on your household?	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10
2) Perception of multilevel governments' relations and governments–communities cooperation on coping with land subsidence problems		
1. To what extent would you say different actors (district, provincial, and national governments as well as NGOs) are working together effectively to prevent the land subsidence impacts and further problems?	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10

2. Which level would you consider the most important for coping with land subsidence impacts and preventing further problems in general?	a. Local civil society b. Subdistrict government c. Regency government	d. Provincial government e. National government
3. Which level would you consider the most important for coping with land subsidence impacts and preventing further problems for households?	a. Local civil society b. Subdistrict government c. Regency government	d. Provincial government e. National government
4. How effective were governments in coping with land subsidence impacts and preventing further problems? (1 = not at all, 10 = very)	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10
5. How effective were local civil society organizations in coping with land subsidence impacts and preventing further problems? (1 = not at all, 10 = very)	a. 1 b. 2 c. 3 d. 4 e. 5	f. 6 g. 7 h. 8 i. 9 j. 10

Thank you very much for your time.

APPENDIX 3. List of questions for key persons

List of questions for local, regency, provincial, and national governments

A. Response or adaptation to land subsidence
   1. How should the government respond to land subsidence?
   2. What are the government's responses to the current land subsidence impacts?
   3. What are the government's adaptations to deal with further land subsidence problems?
   4. Are there any programs of land subsidence mitigation?

B. Related documents of land subsidence
   1. Land subsidence documents
      a. Are there any documents on land subsidence management?
      b. Which institutions are responsible for drawing up land subsidence management documents?
      c. What is the procedure to manage the disaster?
   2. Spatial planning documents and maps
      a. Have the issues (or maps) of land subsidence been included in the spatial planning documents?
      b. How effective is the spatial planning document in preventing the problems of land subsidence?
   3. What is the further planning for land subsidence areas?
   4. What is the further spatial planning for areas affected by land subsidence?
   5. Who is responsible for guaranteeing the suitability of spatial planning and land subsidence documents?

C. Land subsidence mitigation programs and actions
   1. Are there any programs to deal with land subsidence problems?
      a. What are the programs / main programs?
      b. What are long-term or sustainable programs?
   2. Are there any actions to deal with disaster problems?
      a. What are the actions / main actions?
      b. What are long-term or sustainable actions?
      c. Are there any sustainable budgets for local governments and households to prevent land subsidence? How is the procedure to access the budget?
      d. Are there any incentives for actors who prevent land subsidence?
      e. Are there any disincentives for actors who trigger land subsidence?
   3. Are there any difficulties when applying for the programs and actions? If so, what are they?

D. Multilevel actors' cooperation
   1. Multilevel government cooperation
      a. How do the national–provincial–districts–local governments cooperate to deal with land subsidence?
      b. How important is multilevel governments' cooperation?
      c. What is the procedure of multilevel governments' cooperation?

2. Governments–civil society organization (CSO) cooperation
    a. How important is NGO and local community participation to deal with land subsidence problems?
    b. What is the procedure to adopt the aspiration of CSO into land subsidence mitigations and programs?
3. Governments–private sector cooperation
    a. What are the governments' roles in controlling private sector activities to prevent and to deal with land subsidence problems?

List of questions for NGOs

1. What are the problems associated with dealing with land subsidence?
2. Are there any roles for NGOs in land subsidence management or national/regional development? If so, what are the roles?
3. Does your NGO have programs or actions to prevent and to deal with land subsidence? If so, what are they?
4. Has your NGO participated in government programs to deal with land subsidence (or others: related to environmental and disaster issues)? How did you participate in the programs?
5. Have there been any inappropriate government or private-sector programs or actions that triggered land subsidence? If so, what were the programs/actions?

List of questions for communities

1. What are the problems associated with dealing with land subsidence?
2. Are there any roles for communities in land subsidence management? If so, what are the roles?
3. Do your communities have programs and actions to prevent and to deal with land subsidence? If so, what are the programs/actions?
4. Has your community participated in government programs to deal with land subsidence? If so, how did you participate in the programs?
5. Have there been any inappropriate government or private-sector programs or actions that triggered land subsidence problems? If so, what were the programs/actions?

SUMMARY

Various areas around the world are currently threatened by land subsidence, which results from both the natural activities of nature and anthropogenic factors arising from human interventions. It has severe consequences for people and both the built and the natural environment in different areas, for example, urban, coastal, and peatland areas. Since land subsidence has been happening for so long, it has destroyed buildings, infrastructures, and ecosystems, decreased the value of land, and damaged the source of income of the people affected by subsidence.

Land subsidence must be combatted to avoid more serious consequences in the future. In disaster literature, three concepts—namely awareness, response, and adaptive capacity—are considered crucial factors when dealing with disasters. Enhanced awareness plays an essential role in determining the sense of urgency about the problem, which along with the adaptive capacity might increase the responses and decrease maladaptation. Ample evidence concerning the importance of the awareness and responses of various actors in dealing with disasters has been provided by scholars in the context of rapid-onset or short-term disasters. In contrast, there has been a limited discussion about these aspects regarding such long-term disasters as land subsidence.

Using case studies from Indonesia, this dissertation contributes to a deeper and broader understanding of the characteristics of land subsidence and the responses of affected people and various actors to subsidence. Indonesia was selected as the case study because of the country's vulnerability to multiple hazards. For decades, Indonesia has been one of the world's five countries that suffer the most disasters, including land subsidence. In some areas of Indonesia, the land is sinking faster than in any other country in the world and causing severe physical environment and socioeconomic problems. Although it is clear that the problem must be solved, evidence about the ways different actors should solve it is scarce.

The aim of the present research was translated into a main research question: What exactly is the land subsidence problem and what kinds of measures can help to resolve it? To answer this question, three sub-questions were addressed: 1) What are the characteristics of land subsidence in different geographical settings? 2) What kind of problems does land subsidence generate and how do people respond to those problems? 3) What kinds of measures have been taken by different actors from different levels to solve land subsidence problems and how successful are those measures? Thus, this research can provide evidence for other developing countries as it focused on different localities.

To answer the research questions, three areas that represent urban, coastal, and peatland were studied. A combination of a qualitative and a quantitative approach and various data collecting techniques were utilized, namely desk research, an introductory scoping study, focus group discussions, participatory mapping, and interviews.

The present research shows that in Indonesia, land subsidence has been happening for several decades, as it has been in many other countries. Even worse, the country's capital, Jakarta, is sinking faster than just about any other city in the world. The triggers of the

subsidence are both natural processes—for example, the compaction of alluvium soil and the oxidation of peatland—and anthropogenic-induced processes, such as the overexploitation of groundwater, an increase in surface load, and the expansion of plantations in peatland areas. The situation is exacerbated by the government's failure to introduce policies to stop land subsidence from happening.

Land subsidence is a complex problem that threatens different geographical settings. As a single problem, land subsidence occurs in huge areas over an extended period of time. It slowly endangers affected areas and people through its slow and sometimes undetected movement. The land subsidence issue is becoming more complicated since it is interrelated with other problems that can increase its impacts. For instance, in coastal and peatland areas, subsidence can trigger or be triggered by other problems, such as inundation, coastal erosion, flooding, deforestation, fires, and carbon emissions. Thus, land subsidence can worsen other hazards, and vice versa.

One of the most noticeable results of land subsidence is severe and repeated damage. For affected households, it has become a really serious threat. It affects them in various ways, ranging from physical damage to their land and property, to environmental and socioeconomic problems. Almost three quarters of the affected households covered by the present research have suffered from a combination of direct and indirect impacts. Their assets are sinking continuously, and increasingly so. They are also seriously affected by other interrelated hazards, such as sea level rise, flooding, peat fires, and coastal erosion. What is important to note is that although land subsidence is a severe problem, not all affected people know that it exists and happens on a huge scale.

To deal with land subsidence, some affected households had initiated some measures using their own capacities. However, most had not taken any measures, because they were not aware of the problem, did not have enough money to adapt to land subsidence, or did not know how to respond properly. Their ability to respond to the problem has also decreased, as land subsidence has undermined their source of income. Therefore, the inability of the affected people to fight the problem will leave them vulnerable to land subsidence.

Knowing that the affected people could not deal with land subsidence on their own, various actors from different levels have offered several solutions. The government at various levels, environmental and developmental NGOs, and local communities have tackled the problems using their abilities and resources. The actors' interventions have been diverse, ranging from adaptation to existing problems, to mitigation measures to minimize the drivers to prevent future or worse problems. Some measures have been initiated and taken collaboratively and complementarily among the actors, which has some advantages: The collaboration has increased not only the types but also the quality of responses.

Despite the various responses, there are still some considerable challenges to overcome in order to solve the problem of land subsidence. Some of the challenges are: 1) The solutions offered have been fragmented, and cannot solve such a huge problem; 2) actors pay more attention to fixing the short-term issues than fighting the drivers; 3) the scale of the solutions

offered is often too small to tackle such a huge problem; and 4) the central government and local governments take different approaches, especially when designing and prioritizing solutions.

To conclude, the present research makes a significant contribution to thoroughly understanding the characteristics of land subsidence in different geographical settings and the responses of different actors to it. It shows that land subsidence happens in various areas and often has a huge coverage area and massive impacts. In some affected areas, land subsidence has become a wicked problem and is interrelated with other problems, which exacerbates the issue. Various actors have tried to deal with it. However, only a few of their responses can delay the problem. It seems that land subsidence is not only a sleeping disaster, but also a ticking time bomb that might explode at any moment, creating even more severe impacts. Hence, it is important to adopt a comprehensive approach to the issue, starting by raising the awareness of it among the affected people and other actors by putting the issue at the top of the relevant actors' agendas, then enhancing the adaptive capacity of those people and actors to respond to the issue, using effective measures based on time-scale considerations and acting based on coherent processes and multilevel cooperation among actors.

SAMENVATTING

Verschillende gebieden in de wereld worden bedreigd door bodemdaling. Bodemdaling wordt door zowel natuurlijke als antropogene factoren veroorzaakt. Het heeft ernstige gevolgen voor samenlevingen, en zowel de gebouwde als natuurlijke omgevingen ondervinden omvangrijke hinder van bodemdaling. Stedelijke, kust, en veen-gebieden zijn hier voorbeelden van. De gevolgen van bodemdaling zijn ernstig: het heeft gebouwen, infrastructuren en complete ecosystemen vernietigd; waarden van land verlaagd; en het heeft de inkomstbronnen voor veel mensen negatief beinvloed.

Bodemdaling moet worden bestreden om zwaardere gevolgen in de toekomst te voorkomen. In de rampenliteratuur worden drie concepten - namelijk bewustzijn, reactie en adaptief vermogen - beschouwd als cruciale factoren voor het omgaan met rampen. Verbeterd bewustzijn speelt een essentiële rol bij het bepalen van het gevoel van urgentie over het probleem. Verbeterd bewustzijn kan samen met het adaptief vermogen het gevoel van urgentie stimuleren en maladaptatie verminderen. Wetenschappers hebben voldoende bewijs geleverd met betrekking tot het belang van het bewustzijn en de reacties van verschillende actoren bij het omgaan met rampen met een snel of kortstondig karakter. Aan de andere kant, is er slechts een beperkte discussie geweest over deze aspecten met betrekking tot langdurige rampen zoals bodemdaling.

Aan de hand van casestudy's uit Indonesië draagt dit proefschrift bij tot een meer diepgaand en breder begrip van de kenmerken van bodemdaling en de reacties van getroffen personen en verschillende actoren op bodemdaling. Indonesië werd geselecteerd als case study vanwege de kwetsbaarheid van het land voor verschillende rampen. Al tientallen jaren behoort Indonesië tot een van de top vijf landen ter wereld met de meeste rampen, waaronder bodemdaling. In sommige delen van Indonesië zinkt het land sneller dan in enig ander land ter wereld en veroorzaakt het ernstige fysieke en sociaaleconomische problemen. Hoewel het duidelijk is dat het probleem moet worden opgelost, is er weinig bewijs over de manieren waarop verschillende actoren het moeten oplossen.

Het doel van het huidige onderzoek werd vertaald in een hoofdonderzoeksvraag: wat is precies het probleem van bodemdaling en welke maatregelen kunnen er worden genomen om dit op te lossen? Om deze vraag te beantwoorden, werden drie subvragen gesteld: 1) Wat zijn de kenmerken van bodemdaling in verschillende geografische omgevingen? 2) Wat voor soort problemen worden veroorzaakt door bodemdaling en hoe reageren mensen hierop? 3) Wat voor soorten maatregelen zijn er door verschillende actoren op verschillende niveaus genomen om problemen met betrekking tot bodemdaling op te lossen en hoe succesvol zijn deze maatregelen? Dit onderzoek is ook relevant voor andere ontwikkelingslanden, omdat het zich op verschillende locaties richt.

Om bovenstaande onderzoeksvragen te kunnen beantwoorden, werd er onderzoek gedaan in drie gebieden die gezamenlijk een stedelijke, kust- en veengebieden representeren. Een combinatie van een kwalitatieve en kwantitatieve benadering en verschillende technieken

voor het verzamelen van data werden gebruikt, namelijk deskresearch, een inleidend scopingonderzoek, focusgroepdiscussies, participatieve mapping en interviews.

Dit onderzoek toont aan dat bodemdaling in Indonesië al tientallen jaren voorkomt, net als in veel andere landen in de wereld. Erger nog, de hoofdstad van het land, Jakarta, zinkt sneller dan zowat elke andere stad ter wereld. De triggers van de verzakking zijn zowel natuurlijke processen - bijvoorbeeld de verdichting van alluviumgrond en de oxidatie van veenland - als antropogene geïnduceerde processen, zoals de overexploitatie van grondwater, een toename van de oppervlaktebelasting en de uitbreiding van plantages in veenland gebieden. De huidige situatie wordt verergerd door het falen van overheidsbeleid om bodemdaling tegen te gaan.

Bodemdaling is een complex probleem dat verschillende geografische omgevingen bedreigt. Als een enkel probleem, kan bodemdaling in grote gebieden voorkomen over een lange tijdsperiode. Bodemdaling brengt de getroffen gebieden en mensen langzaam in gevaar vanwege zijn langzame en soms niet-gedetecteerde verschijning. Het probleem van bodemdaling wordt meer gecompliceerd omdat het vaak samen met andere problemen voorkomt die de impact van bodemdaling kunnen verergeren. In kust- en veengebieden kan bodemdaling bijvoorbeeld leiden tot of worden veroorzaakt door andere problemen, zoals inundatie, kusterosie, overstromingen, ontbossing, branden en koolstofemissies. Bodemdaling kan dus andere gevaren verergeren en vice versa.

Een van de meest opvallende resultaten van deze studie is dat bodemdaling vaak ernstige en herhaalde schades veroorzaakt. Voor getroffen huishoudens is het een ernstige bedreiging geworden. Het treft hen op verschillende manieren, variërend van fysieke schade aan hun land en eigendommen tot milieu- en sociaaleconomische problemen. Bijna driekwart van de getroffen huishoudens waarop dit onderzoek betrekking heeft, ondervindt ernstige hinder van een combinatie van directe en indirecte effecten. Hun vermogen zakt steeds verder weg. Ze worden ook ernstig getroffen door andere onderling samenhangende gevaren, zoals zeespiegelstijging, overstromingen, veenbranden en kusterosie. Wat belangrijk is om op te merken, is dat hoewel bodemdaling een ernstig probleem is, niet alle getroffen mensen weten dat het bestaat en op grote schaal voorkomt.

Om de bodemdaling tegen te gaan, hadden sommige getroffen huishoudens maatregelen getroffen met hun eigen capaciteiten. De meeste hadden echter geen maatregelen getroffen, omdat ze zich niet bewust waren van het probleem, niet genoeg geld hadden om te kunnen gaan met de gevolgen van bodemdaling, of niet wisten hoe ze zo goed mogelijk konden reageren op het probleem. Hun vermogen om met het probleem om te gaan is ook afgenomen, aangezien bodemdaling hun bron van inkomsten negatief heeft beinvloed. Daarom zal het onvermogen van de getroffen mensen om het probleem te bestrijden hen nog meer kwetsbaar maken voor bodemdaling.

Wetende dat de getroffen mensen niet alleen met bodemdaling konden omgaan, hebben verschillende actoren van verschillende niveaus meerdere oplossingen aangeboden. Overheden op verschillende niveaus, milieu- en ontwikkelings-NGO's en lokale gemeenschappen hebben

de problemen aangepakt met behulp van hun capaciteiten en middelen. De interventies van de actoren waren divers, en variërend van aanpassing aan bestaande problemen tot mitigatiemaatregelen om de drivers te minimaliseren en om toekomstige of meer ernstige problemen te voorkomen. Sommige maatregelen zijn geïnitieerd en in samenwerking met de actoren genomen, wat een aantal voordelen heeft: de samenwerking heeft niet alleen het type, maar ook de kwaliteit van de reacties verbeterd.

Ondanks de verschillende reacties, moeten er nog een aantal grote uitdagingen worden overwonnen om het probleem van bodemdaling op te lossen. Enkele uitdagingen zijn: 1) De aangeboden oplossingen zijn gefragmenteerd en kunnen een dergelijk ernstig probleem niet oplossen; 2) actoren besteden meer aandacht aan het oplossen van de kortetermijnkwesties dan aan het bestrijden van de zogenheten 'drivers'; 3) de schaal van de aangeboden oplossingen is vaak te klein om zo'n enorm probleem aan te pakken; en 4) de centrale overheid en lokale overheden hanteren verschillende benaderingen, met name bij het ontwerpen en prioriteren van oplossingen.

In conclusie, dit onderzoek levert een belangrijke bijdrage aan de huidige kennis over de kenmerken van bodemdaling in verschillende geografische omgevingen en de reacties van verschillende actoren daarop. Het laat zien dat bodemdaling in verschillende gebieden voorkomt en vaak een enorm dekkingsgebied en enorme gevolgen heeft. In sommige getroffen gebieden is bodemdaling een 'wicked' probleem geworden en hangt het samen met andere problemen, wat het probleem verergert. Verschillende actoren hebben geprobeerd bodemdaling aan te pakken. Slechts enkele van hun strategieën kunnen het probleem echter vertragen. Het lijkt erop dat bodemdaling niet alleen een slapende ramp is, maar ook een tikkende tijdbom die op elk moment kan ontploffen en nog zwaardere gevolgen heeft. Daarom is het belangrijk om een alomvattende benadering, een zogeheten 'comprehensive approach', van het probleem te hanteren. Het verbeteren van de bewustzijn van de getroffen huishoudens en actoren kan worden gerealiseerd door bodemdaling bovenaan de agenda van de relevante actoren te plaatsen. Hierdoor kan het aanpassingsvermogen van de mensen worden vergroot en kan men adequaat op het probleem reageren met behulp van effectieve maatregelen op basis van tijdschaaloverwegingen alsmede op basis van coherente processen en samenwerking op meerdere niveaus tussen actoren.

RINGKASAN

Berbagai lokasi di penjuru dunia sedang berada dibawah ancaman penurunan tanah, yang terjadi secara alami dan disebabkan oleh intervensi manusia. Di berbagai lokasi, misalnya kawasan perkotaan, pesisir, dan lahan gambut, penurunan tanah ini berdampak serius terhadap manusia dan lingkungan, baik itu lingkungan buatan maupun alami. Akibat terdampak penurunan tanah dalam waktu yang lama, sejumlah bangunan, infrastruktur, dan ekosistem mengalami kerusakan, nilai lahan menjadi turun, dan sumber mata pencaharian masyarakat terdampak menjadi rusak.

Untuk menghindari dampak yang lebih serius, permasalahan penurunan tanah ini harus segera diatasi. Di dalam literatur akademik, terdapat tiga konsep yang harus dipahami agar mampu mencegah dampak suatu bencana, yaitu kewaspadaan, respon, dan kapasitas untuk beradaptasi. Kewaspadaan yang tinggi berperan besar dalam menentukan apakah permasalahan tersebut dianggap penting atau tidak. Bersamaan dengan kapasitas untuk beradaptasi, kewaspadaan terhadap suatu bencana akan meningkatkan respon dan mengurangi kemungkinan maladaptasi. Banyak peneliti sudah membuktikan bahwa faktor-faktor tersebut sangat penting untuk mengatasi bencana yang datang secara tiba-tiba atau bencana jangka pendek. Sebaliknya, bukti-bukti yang berkaitan dengan bencana jangka panjang, misalnya penurunan tanah, masih sangat terbatas.

Dengan menggunakan studi kasus dari Indonesia, disertasi ini berkontribusi terhadap pemahaman yang lebih dalam dan luas tentang karakteristik penurunan tanah dan respon masyarakat terdampak dan berbagai aktor terhadap masalah ini. Indonesia dipilih karena Indonesia rentan terhadap beragam bencana. Sejak beberapa dekade terakhir, Indonesia merupakan satu dari lima negara di dunia yang paling banyak terdampak multi-bencana, termasuk penurunan tanah. Di beberapa daerah di Indonesia, penurunan tanah terjadi lebih cepat dibandingkan dengan banyak daerah di negara lain dan telah mengakibatkan munculnya masalah-masalah fisik lingkungan dan sosial ekonomi. Sayangnya, meskipun sudah jelas bahwa masalah ini harus diselesaikan, bukti tentang cara berbagai aktor dalam memecahkan masalah ini masih sangat sedikit.

Tujuan dari penelitian ini diterjemahkan dalam pertanyaan penelitian: Apakah permasalahan sebenarnya penurunan tanah itu dan apa saja metode yang bisa menyelesaikannya? Tiga sub-pertanyaan penelitian digunakan untuk menjawab pertanyaan tersebut, yaitu: 1) Apakah karakteristik penurunan tanah pada lokasi geografis yang berbeda-beda? 2) Apakah masalah yang ditimbulkan oleh penurunan tanah tersebut dan bagaimana orang-orang meresponnya? 3) Apa sajakah cara yang sudah dilakukan oleh beragam aktor pada level yang berbeda-beda dalam upaya untuk menyelesaikan masalah itu dan seberapa sukses usaha tersebut? Jadi, penelitian ini bisa memberikan cukup pembelajaran untuk negara-negara berkembang lainnya, karena penelitian ini fokus pada lokasi yang berbeda-beda.

Untuk menjawab pertanyaan-pertanyaan tersebut, dilakukan penelitian di tiga lokasi yang merepresentasikan kawasan perkotaan, pesisir, dan lahan gambut. Kombinasi pendekatan kualitatif dan kuantitatif serta beberapa teknik pengumpulan data digunakan, diantaranya

adalah *desk research*, survei pendahuluan, diskusi kelompok terarah atau FGD, pemetaan partisipatif, dan wawancara.

Penelitian ini menunjukkan bahwa, sebagaimana di banyak negara lain, penurunan tanah di Indonesia sudah berlangsung selama beberapa dekade. Bahkan, kecepatan penurunan tanah di ibukota Indonesia, Jakarta, lebih cepat dibandingkan dengan kota-kota lain di penjuru dunia. Penyebab penurunan tanah di Indonesia adalah proses alamiah, seperti pemadatan tanah aluvium dan oksidasi gambut, dan proses yang disebabkan oleh aktivitas manusia, seperti pengambilan airtanah secara berlebihan, peningkatan beban permukaan tanah, dan ekspansi perkebunan di kawasan gambut. Keadaan ini menjadi semakin serius disebabkan oleh kegagalan kebijakan pemerintah untuk menghentikan laju penurunan tanah.

Penurunan tanah merupakan permasalahan yang kompleks, yang mengancam berbagai daerah pada kondisi geografis yang berbeda-beda. Penurunan tanah terjadi pada area yang sangat luas dalam jangka waktu lama. Penurunan tanah secara perlahan membahayakan kawasan dan masyarakat yang terdampak melalui pergerakannya yang lambat dan terkadang tidak terdeteksi. Permasalahan ini menjadi lebih rumit dikarenakan keterkaitan masalah ini dengan masalah lainnya yang dapat menyebabkan dampak penurunan tanah lebih besar dan berbahaya. Contohnya, di kawasan pesisir dan lahan gambut, penurunan tanah dapat menjadi penyebab atau disebabkan oleh permasalahan lainnya, seperti genangan air laut, erosi pantai, banjir, deforestasi, kebakaran lahan dan hutan, dan emisi karbon. Semua permasalahan tersebut dapat memperburuk status dan dampak masing-masing persoalan.

Salah satu hasil dari penelitian ini yang harus menjadi perhatian dan ditegaskan adalah bahwa penurunan tanah merupakan masalah yang serius dan terjadi secara terus-menerus. Hal ini benar-benar menjadi ancaman yang sangat serius bagi masyarakat yang terdampak. Penurunan tanah ini menyebabkan berbagai permasalahan, mulai dari merusak lahan dan properti hingga menyebabkan masalah lingkungan dan sosial ekonomi. Berdasarkan penelitian ini, hampir tiga perempat dari jumlah rumah tangga di daerah penelitian mengalami dampak penurunan tanah, baik secara langsung maupun tidak langsung. Banyak aset dari masyarakat tersebut yang mengalami penurunan kualitas, yang terjadi secara terus menerus. Disamping itu, mereka juga terdampak oleh masalah lain yang saling berkaitan, yaitu kenaikan muka air laut, banjir, kebakaran lahan gambut, dan erosi pantai. Satu hal yang menjadi catatan yaitu meskipun penurunan tanah merupakan masalah yang serius, tidak semua masyarakat terdampak mengerti apa itu penurunan tanah dan juga mereka tidak paham bahwa penurunan tanah tersebut benar-benar terjadi, dan skalanya sangat besar.

Untuk menghadapi masalah tersebut, beberapa rumah tangga terdampak sudah berusaha untuk merespon, yang disesuaikan dengan kapasitas masing-masing. Namun demikian, dari seluruh rumah tangga terdampak, sebagian besar belum melakukan usaha apapun yang dikarenakan oleh beberapa alasan, yaitu: mereka tidak mengerti tentang permasalahan yang sedang dihadapi, mereka tidak memiliki cukup dana untuk beradaptasi, atau mereka tidak tahu cara yang efektif untuk merespon permasalahan tersebut. Disamping itu, kemampuan mereka untuk merespon menjadi berkurang karena rusaknya sumber-sumber mata pencaharian mereka yang diakibatkan oleh penurunan tanah tersebut. Sehingga, dapat dikatakan bahwa

ketidakmampuan masyarakat terdampak untuk mengatasi konsekuensi dari penurunan tanah tersebut akan menyebabkan mereka tetap rawan terhadap permasalahan ini.

Setelah mengetahui bahwa masyarakat terdampak tidak mampu untuk menyelesaikan masalah tersebut, berbagai aktor dari berbagai level menawarkan beragam solusi. Aktor-aktor seperti pemerintah dari berbagai level, LSM-LSM lingkungan dan pembangunan, serta komunitas-komunitas lokal, sudah berusaha untuk membantu menyelesaikan permasalahan tersebut dengan mengerahkan kemampuan dan sumberdayanya. Intervensi mereka beragam, mulai dari menawarkan program dan kegiatan adaptasi terhadap permasalahan yang sedang terjadi, hingga program dan aksi mitigasi untuk meminimalisir penyebab-penyebab penurunan tanah--yang bertujuan untuk mencegah agar permasalahan tersebut tidak muncul lagi di kemudian hari dan agar permasalahan yang ada tidak bertambah runyam. Beberapa aksi dilakukan berdasarkan prinsip kolaborasi dan saling melengkapi antaraktor, yang menunjukkan beberapa keuntungan: kolaborasi berhasil meningkatkan ragam dan kualitas respon yang mereka lakukan.

Meskipun berbagai aktor sudah merespon permasalahan penurunan tanah dengan berbagai cara, namun masih terdapat berbagai permasalahan untuk bisa menyelesaikan permasalahan ini secara utuh. Permasalahan tersebut diantaranya adalah: 1) Solusi-solusi yang ditawarkan terfragmentasi, tidak komprehensif, dan cenderung tidak saling terkait dan berkelanjutan, sehingga tidak mampu menyelesaikan masalah dalam skala besar, 2) para aktor lebih memilih untuk menyelesaikan permasalahan yang ada, bukan mencegah faktor-faktor penyebabnya, 3) skala berbagai solusi yang ditawarkan terlalu kecil untuk mampu menyelesaikan permasalahan yang skalanya sangat besar, dan 4) ridak sinkronnya pendekatan yang diambil oleh pemerintah pusat dan daerah dalam merancang dan memprioritaskan solusi untuk penurunan tanah.

Sebagai kesimpulan, penelitian ini memberikan kontribusi penting untuk memahami karakteristik penurunan tanah, secara sistematis, di lokasi geografis yang berbeda-beda, dan mengetahui respon beragam aktor dalam menghadapi permasalahan tersebut. Penelitian ini menunjukkan bahwa penurunan tanah terjadi di banyak lokasi dan seringkali terjadi pada skala yang sangat besar dan menimbulkan dampak yang sangat serius. Di beberapa lokasi terdampak, penurunan tanah menjadi permasalahan yang pelik dan berhubungan erat dengan permasalahan lainnya, yang pada akhirnya akan memperburuk dampak masalah secara keseluruhan. Sudah banyak aktor yang berusaha untuk menyelesaikan permasalahan ini, namun hanya sedikit yang mampu untuk bahkan hanya memperlambat penurunan tanah. Berkaca dari hal ini, penurunan tanah jelas tidak hanya sebuah bencana yang terselubung, namun bisa diibaratkan sebagai sebuah bom waktu bencana yang dapat meledak kapanpun dan bisa berdampak lebih serius. Oleh karena itu, perlu adanya pendekatan yang komprehensif untuk menyelesaikan permasalahan ini, yang dimulai dari meningkatkan kewaspadaan masyarakat terdampak dan aktor-aktor yang relevan, dengan terlebih dahulu menempatkan isu penurunan tanah pada agenda utama mereka, meningkatkan kemampuan beradaptasi masyarakat terdampak dan para aktor terhadap permasalahan penurunan tanah, menggunakan cara-cara yang efektif berdasarkan pertimbangan skala waktu, dan melakukan kegiatan-kegiatan yang saling koheren dan lintas level diantara berbagai aktor.

CURRICULUM VITAE

Erlis Saputra was born on 1 October 1980 in Pekanbaru, Riau province, Indonesia. He completed his Bachelor's and Master's degrees in Geography from Universitas Gadjah Mada Indonesia, *cum laude* and *summa cum laude* respectively, with a focus on regional development and planning. Since 2007, he has been a lecturer in the Department of Development Geography, Faculty of Geography, Universitas Gadjah Mada, Indonesia, where he focuses on and teaches urban geography, spatial theory, small city and archipelago development, and spatial and regional planning.

His passionate interest in issues of human geography, development, and planning means that working only on campus is not enough for him, so in 2005, he co-founded a development NGO: the Institute for Regional Development Studies (IReDS). This organization has allowed him to combine theoretical perspectives mostly developed in the academic environment, with empirical work in the field. His interest continues to grow in line with several issues he came across during his research on tourism geography. Thus, in 2012 he co-founded a tourism-based NGO, namely Indonesia Tourism Watch (ITW). The combination of his position as a lecturer, his growing interests, and his activities in NGOs has led to many opportunities to work in projects and on research with, for instance, the central and local governments of Indonesia, private sectors in development and resources exploration fields, international, national, and local NGOs, and local communities.

To enhance his knowledge, in September 2014 Erlis joined the International Development Studies (IDS) research group in the Department of Human Geography and Planning, University of Utrecht, the Netherlands, as a PhD researcher. During his study, he attended several conferences, meetings, and workshops organized by, for instance, the Association of European Schools of Planning (AESOP), LANDac – The Netherlands Land Academy, Ghent University, Utrecht University, and many more. He also supervised and helped an IDS Master's student to complete his internship in Indonesia. He broadens his experience and contributes to social and academic life by being an active member of the Netherlands Chapter of the Alumni Association of Universitas Gadjah Mada (Kagama Belanda), the Indonesian Student Association of Utrecht (PPI Utrecht), and Stichting Generasi Baru (SGB) Utrecht. More importantly, he has contributed to several book chapters and conference proceedings, namely *Filsafat Sains Geografi* / Philosophy of Geography Science (2008), Challenges of Urbanization in the 21st Century (2011), and Sustainable Megacities: Vulnerability, Diversity, and Livability (2015), and published various articles in peer-reviewed journals, including Land, Journal of Environmental Protection, American Journal of Climate Change, and Geografia-Malaysian Journal of Society and Space.

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