ASSESSMENT AND ROADMAP

Towards Adapting and Mitigating Land Subsidence in Central Java Province

MAY 2021

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Disclaimer

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All images are credited to the Water Dialogue Consortium and Rafii Bisatya Rahmat, except stated otherwise.

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Assessment and Roadmap towards Adapting and Mitigating Land Subsidence Central Java Province

Chapter

Acronyms and Abbreviations

Bappeda	Badan Perencanaan Pembangunan Daerah, Development Planning Agency
Bappenas	Badan Perencanaan Pembangunan Nasional, Ministry of National Development Planning of the Republic of Indonesia
BIG	Badan Informasi Geospasial
BNPB	Badan Nasional Penanggulangan Bencana
BPBD	Badan Penanggulangan Bencana Daerah
DLHK	Dinas Lingkungan Hidup dan Kehutanan
DKP	Dinas Kelautan dan Perikanan
ESDM	Dinas Energi dan Sumber Daya Mineral
ICZM	Integrated Coastal Zone Management
InSAR	Interferometric synthetic aperture radar
GPS	Global positioning system
Kemenkomarves	Kementerian Koordinator Bidang Kemaritiman dan Investasi
Kementerian ATR	Kementerian Agraria dan Tata Ruang
Kementerian ESDM	Kementerian ESDM Kementerian Energi dan Sumber Daya Mineral
Kementerian PUPR	Kementerian PUPR Kementerian Pekerjaan Umum dan Perumahan Rakyat
KKP	Kementerian Kelautan dan Perikanan
KLHK	Kementerian Lingkungan Hidup dan Kehutanan
PUSDATARU	Dinas Pekerjaan Umum, Sumber Daya Air dan Tata Ruang
PDAM	Perusahaan Daerah Air Minum

CHAPTER 1 INTRODUCTION

1.1 Introduction

The issue of resilience and climate crisis have emerged as important discourse following a significant impact of climate change across the globe. While the impacts are observed globally, some areas are more vulnerable than others. This is the case of many low-lying areas that are prone to various climate-related disasters due to sea-level rise and changing patterns of rainfall while experiencing significant population growth and rapid economic activities at the same time. With the rapid population growth and urbanization, coupled with the impacts from climate change, land subsidence appears as an equally pressing issue as densification of the coastal area is not complemented by proper water management. Water extraction that leads to land subsidence is occurring in many coastal cities, adding up the already existing vulnerabilities such as poverty traps in the community. Consequently, land subsidence in coastal lowlands has threatened the existence of healthy wetlands, increasing the community's vulnerability and risks of disasters (i.e flood, tidal flood and abrasion, coastal erosion, extreme weather, and loss of sources of livelihood).

While generally, the issue of land subsidence occurs across Indonesia's provinces, Semarang Water Management Report (RVO, 2020) reveals that the land subsidence rate in Semarang, the biggest city in Central Java Province, is up to 13 cm/year. A similar situation occurred in other areas along the northern coast of Java Island, including Demak and Pekalongan. Industrial and other commercial activities that use a significant amount of water triggers excessive groundwater extraction and increasing surface load. These two factors significantly contribute to the problem of land subsidence in the Province--thus making this issue an immediate urgency to be addressed by the local government. External factors such as natural soil consolidation and tectonic activities have aggravated the situation which leads to an ever-increasing rate in the near future (RVO, 2020). Currently, in some places in Demak, the phenomenon has stayed permanently -- and was referred to as "the silent killer" by the community. This is, in many ways, quite literal, as the slow onset process of the phenomenon, as well as the economic losses it has caused over the years. To date, the estimated direct and indirect economic losses due to land subsidence, sea-level rise, and tidal floods have reached more than 100 trillion rupiah for Central Java Province and even more for other coastal areas in Indonesia (Deltares, 2021).

Figure 1. ***Deteriorated buildings in Semarang Utara and sinking houses in Sriwulan, Sayung, Demak due to land subsidence in the north coast of Central Java***
Source: Water Dialogue Consortium (Barry Beagen, Rizqa Hidayani), 2020

Measures to adapt and mitigate land subsidence have been made by city governments across Central Java, but the efforts are rather sporadic and uncoordinated. Accordingly, there is a need to encourage more coordination between the National, Provincial, and Local Government as there are different authorities involved in the process. For example, exploration and utilization of groundwater should be based on the Central Java Provincial Regulation No. 3/2018 on Groundwater Management (see chapter 2, provided in Annex I - Compilation of Govt. Regulations). However, the existence of this regional regulation has not been able to reduce the rate of land subsidence significantly as it requires a better mechanism for monitoring and approval for permission. The current circumstances create an urgent call to promote transformative thinking to be more adaptive to address the land subsidence while addressing the impacts of climate change at the same time. This requires the active participation of multiple stakeholders and decentralized decision-making mechanisms in which governance should function as the backbone to escort the process.

The government of Central Java province has started to address this issue with the development of Roadmap towards Adapting and Mitigating Land Subsidence in Semarang and Demak, as a collaborative project between Central Java Province and the support from the Water Dialogue Program to provide a framework for adaptation and mitigation measures to address this issue in Central Java. The Pekalongan - Semarang - Demak coastal corridor as one of the highest risks of subsidence areas along the north coast of Central Java is the main locus for the technical study, as an input to further formulating the roadmap for the Central Java region.

1.2 About the Initiative

The development of the roadmap for adaptation and mitigation of land subsidence in Central Java Province is collaboratively initiated by the Central Java Province with support from the Water Dialogue Program, with technical expertise support from Wetlands International Indonesia, Deltares, Witteveen+Bos, Kota Kita, Diponegoro University, and Institut Teknologi Bandung (ITB). This roadmap will draw all actors' roles in the wider watershed to reduce groundwater extraction, recharge the aquifer and optimize surface water use and recycling.

In addition, this roadmap is in accord with the **national roadmap for mitigation and adaptation of land subsidence in coastal lowlands** (2019). As the national roadmap gives general strategies on how cities should cope with land subsidence, this local level roadmap will be more context-specific to the Semarang and Demak condition as the area with the highest risks of subsidence along the north coast of Central Java.

To align and internalize the strategies with other existing initiatives, the development of this roadmap closely takes into account three previous water-related programs in Semarang and Demak but will shed more light on mitigation and adaptation to land subsidence in Semarang and Demak.

These three programs are Integrated Coastal Zone Management (ICZM) of Central Java, Building with Nature in Demak, and Water as Leverage Semarang. The following figure illustrates the scope of this work and the three ongoing initiatives.

This roadmap will include both short and long-term solutions for implementation by the governments. While on the other hand, this roadmap inscribes the origin causes of land subsidence in coastal protection, thus, will enrich the discourse of land subsidence. By elaborating long-term solutions, hopefully, it can sustain the nature-based solutions proposed by the Building with Nature. Lastly, the roadmap will create a committed roadmap that builds an enabling environment, scenarios that contribute to the Water as Leverage's feasibility studies. On the counterpart, the Water as Leverage initiatives can provide projects and programs that have components to be embedded into the roadmap.

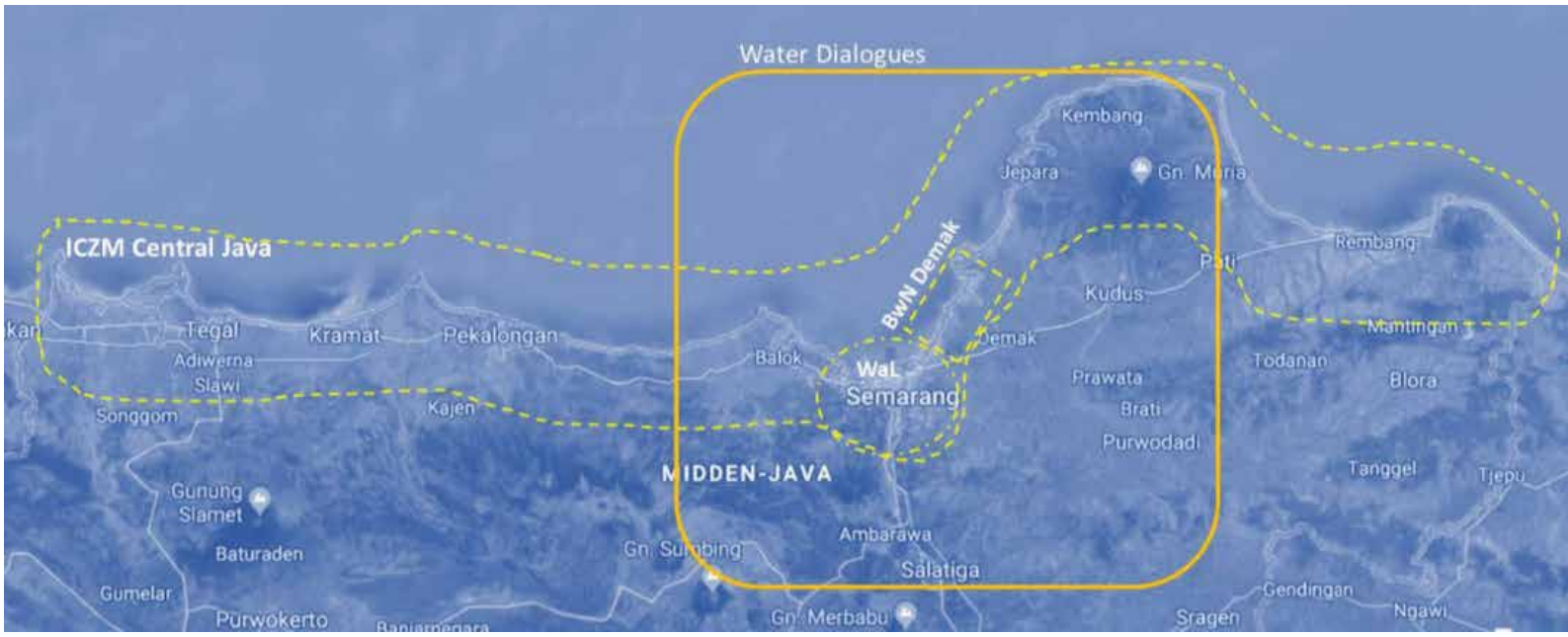

Figure 2. ***The working scope of Water Dialogues and other initiatives in Semarang and Demak***
Source: Author, 2021

Water Dialogue position to other initiatives

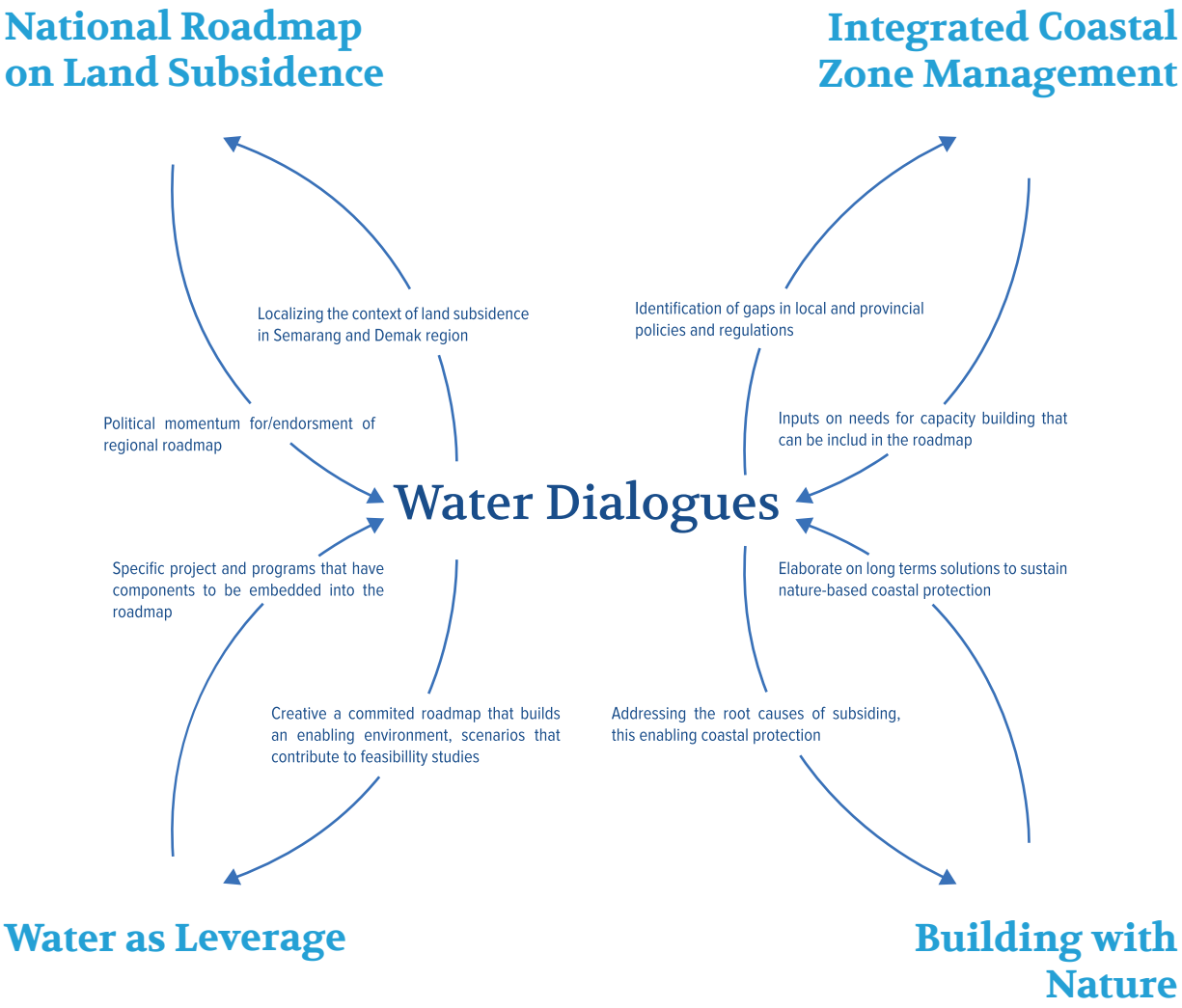

Figure 3. ***Water Dialogue position to other initiatives***
Source: Author, 2021

1.3 Objectives of the Development of the Roadmap

Adaptation and mitigation strategies and measures to address land subsidence in the coastal areas in the north part of Central Java Province, particularly Semarang and Demak, are urgently required. This is due to the impacts to local communities and activities are quite massive, as well as to avoid bigger impacts in the future. This roadmap on mitigation and adaptation to land subsidence is prepared to be used as a reference and serve as a guide for the implementation of mitigation and adaptation programs that involve all relevant stakeholders.

1.4 Scope and Components

SCOPE AREA

As mentioned earlier, the roadmap is intended to address the problem of land subsidence in Central Java Province. However, the study area examined in this roadmap is Semarang and Demak as the area with the highest risks of subsidence along the north coast of Central Java. Using the case of Semarang and Demak, the strategies and measures proposed within this roadmap to adapt and mitigate land subsidence is expected to provide a framework of action for other coastal areas in the province.

TIMEFRAMES

The strategies developed in this roadmap include those with the short-term timeframe of implementation (1-2 years), medium-term (5 years), and long-term (10 years).

COMPONENTS

This roadmap was developed through combinations of several components, including:

Institutional and stakeholder mapping

The first part focuses on the analysis of the actors and institutions involved as well as their roles in the adaptation and mitigation of land subsidence in Semarang and Demak. This also involves a review of the current policy framework on addressing land subsidence in the study area. This part is conducted by Kota Kita and Diponegoro University, as the local team in Central Java.

Development of the roadmap and implementation scenario:

The first part focuses on the analysis of the actors and institutions involved as well as their roles in the adaptation and mitigation of land subsidence in Semarang and Demak. This also involves a review of the current policy framework on addressing land subsidence in the study area. This part is conducted by Kota Kita and Diponegoro University, as the local team in Central Java.

Economic impact assessment

The second component focuses on the economic impact assessment due to land subsidence in Semarang and Demak. The economic impact assessment is conducted under three scenarios: business as usual, reduced subsidence rate by 50% and reduced subsidence rate by 75%. This part is undertaken by Deltares.

Development of the policy framework

Lastly, in order to prompt the proposed strategies towards implementation, recommendation on policy and institutional framework is expected to help local governments to operationalize the roadmap. This part is undertaken by Wetlands International Indonesia.

Identification of adaptation and mitigation measures

This component aims to identify the adaptation and mitigation measures that need to be taken according to the result of the scenarios. This part will also take a look at the prior works on the land subsidence study conducted in Semarang and Demak. This component is primarily developed by Witteveen+Bos.

CHAPTER 2 — ALIGNMENT AND REVIEW OF REGULATORY FRAMEWORK

2.1 National Roadmap on Land Subsidence

In 2019, the Coordinating Ministry of Maritime Affairs and Investment has published the National Roadmap for Land Subsidence Adaptation and Mitigation (provided in Annex XI - Strategies of the National Roadmap for Land Subsidence Adaptation and Mitigation). The mitigation and adaptation measures are urgently needed to avoid a higher potential loss in the future (Andreas et al. 2018; Mazzoti et al. 2009; Sutanta et al. 2005). The roadmap is formulated to be utilized by relevant stakeholders in addressing land subsidence in the coastlines.

The national roadmap of mitigation and adaptation consists of several chapters such as institutional arrangements and policy study, mapping of land subsidence hazard, monitoring on land subsidence, adaptation measure for short term impacts, and comprehensive mitigation measures for long term impacts. The strategies in the roadmap have been formulated to accommodate the short-term period (5 years), medium-term (10 years), and long-term period (>10 years).

2.1.1 Overview of Land Subsidence in Indonesia

Land subsidence occurs in Indonesia's coastal lowlands--affecting more than 20 cities in Indonesia including large coastal cities like Jakarta, Semarang, and Surabaya. Also, coastal areas adjacent to peatlands are very vulnerable to land subsidence, such as coastal areas in Kepulauan Meranti Regency, Riau Province. According to the National Roadmap on Land Subsidence, there are at least 21 provinces and 132 regencies/cities in Indonesia currently indicated to experience subsidence, especially in coastal areas, both on mineral soils or coastal peatlands.

Figure 4 as shown above indicates the areas in Indonesia with land subsidence issues. It indicates that most of the areas on the northern coast of Java (including Semarang, Demak, Pekalongan, and Kendal) and east of Sumatra are prone to land subsidence (including Langsa, Medan, Indragiri, and Palembang). Moreover, some areas in the Borneo island, as well as Papua and West Papua Province, are also prone to land subsidence issues. Due to its coverage across Indonesia, this has urged coordination at the national level to address the problem and paved the way for the National Roadmap on Land Subsidence Adaptation and Mitigation.

According to the National Roadmap, land subsidence in Indonesia generally occurs due to anthropogenic factors or as a result of human activities, such as excessive groundwater extraction, loading effects, exploitation of oil and natural gas, the impact of subsurface mining activities, and peat soil oxidation. Other factors are non-anthropogenic in nature, namely natural compaction and the effect of tectonic subsidence due to the sharpening and movement of the earth's fault. In Indonesia, the two non-anthropogenic factors mentioned above have little effect on land subsidence in comparison to anthropogenic factors.

Figure 4. ***Land subsidence Potentials in Indonesian Cities***
Source: National Roadmap of Mitigation and Adaptation to Land Subsidence, 2019

2.1.2 Summary of the Strategies on the National Roadmapon Land Subsidence

As previously mentioned, the cause of land subsidence in Indonesia derived mainly from anthropogenic activities--and therefore, can be mitigated or prevented to avoid greater loss in the future. The condition serves as the basis for the formulation of the National Roadmap, which aimed to encourage related stakeholder's participation to respond towards the risk of land subsidence and to be used as a reference and guidelines in respective provinces/local governments.The process involves not only government, but also private stakeholders and general public. To that end, the National Roadmap on Land Subsidence outlines seven main strategies as follow (National Roadmap on Land Subsidence, 2019):

1. Establishment of an authorized cross-sectoral institution/coordinator for the implementation of mitigation and adaptation program for land subsidence: The strategy involves coordination processes between sectoral ministries to form a technical institution for the implementation of mitigation and adaptation measures.

2. Development of hazard and risk map of land subsidence: The strategy encourages the development of hazard and risk maps, particularly on the critical groundwater basin and overall in coastal lowlands area.

3. Conduct monitoring of the rate of land subsidence: The strategy consists of various monitoring activities in priority coastal cities, coastal peat areas, and priority peat areas. The strategy invites not only the initiative by the government (central and regional), but also through CSR systems by private sectors (i.e. oil and gas industries, related to the exploitation activities).

4. Implementation of short term measures (adaptation): This strategy incorporates the development of concept and standard operating procedures (SOP) for adaptation measures, including its monitoring activities.

5. Implementation of long term measures (mitigation): This strategy highly emphasizes the prevention measures from anthropogenic activities, such as through spatial planning approach, water management, peat conservation, among others.

6. Carry out education and capacity building efforts: The activity deals with raising awareness among the general public to participate in the monitoring and implementation process of mitigation and adaptation measures.

7. To enforce the law on groundwater utilization and spatial planning: The law enforcement aspect is needed to ensure the policies and regulations are put in place to regulate relevant actors for their compliance on their roles and responsibilities in the implementation of mitigation and adaptation measures to land subsidence.

Strategy 1. Establish an Authorized Cross Sectional Institution/Coordinator for the Implementation of the Mitigation and Adaptation Program for Land Subsidence and Related Disasters (2019-2020)

1.1 Coordinating mechanism between the relevant sector ministries for mitigation and adaptation to land subsidence is in place;
1.2 Technical institutional forms for implementing mitigation and adaptation of land subsidence is agreed;
1.3 Legal basis documents/institutional policies for implementing mitigation and adaptation of land subsidence is developed;
1.4 Technical institutions for the mitigation and adaptation of land subsidence is established and operationalized.

Strategy 2. Develop the Critical Groundwater Basin Map and Map of Land Subsidence Risks in the Coastal Lowlands (2019-2021) -2024

2.1 Land subsidence in coastal lowlands in Indonesia risk's map is developed;
2.2 Land subsidence in coastal lowlands in Indonesia risk map is regularly updated.

Strategy 3. Monitor and Evaluate Critical Groundwater Basins, and Soil Subsidence Rates in Coastal Lowland Cities, Coastal Peat Areas and Coastal Oil and Gas Exploitation Areas (2019-2029)

3.1 Groundwater basin monitoring programs, and land subsidence monitoring in coastal cities are in place by involving the central government, regional government and CSR;
3.2 Land Subsidence monitoring in priority coastal city locations is implemented;
3.3 Land subsidence monitoring in indicated coastal city locations is implemented;
3.4 Land subsidence monitoring programs in coastal peat areas is in place by involving the central government, regional governments, and CSR systems from private parties (HTI companies, oil palm plantations, etc.);
3.5 Land subsidence monitoring in priority peat areas is implemented;
3.6 Land subsidence monitoring in indicated coastal peat is implemented;
3.7 Land subsidence monitoring programs in the oil and gas exploitation area is in place by involving the K35 team through SKK-Migas and or other scenarios such as CSR from the private sector;
3.8 Land subsidence monitoring program in the priority oil and gas exploitation area is implemented.

Strategy 4. Develop Concepts, Standard Operating Procedures (SOPs) and Implement Short-Term Solutions/Adaptations for Disaster of Land Subsidence that have Occurred (2019-2024)

4.1 The concept and SOP of short-term solutions/adaptations of land subsidence disasters are developed and socialized;
4.2 Short-term solutions/adaptations are implemented;
4.3 The implementation of short-term solutions/adaptations are monitored.

Strategy 5. Develop and Implement the Concept of Land Subsidence Prevention (Mitigation) through Spatial Planning Approach, Water Management, Peat Conservation and High-tech Environmentally Friendly Oil and Gas Exploitation Activities (2010-2029)

5.1 Guidelines for the integration of land subsidence into Spatial Planning is developed;
5.2 Priority areas for integration of land subsidence into Spatial Planning are identified;
5.3 Land subsidence is mainstreamed into spatial planning;
5.4 Water management based mitigation program plan is developed;
5.5 Priority areas for water management based mitigation programs are identified;
5.6 Water management based mitigation program is implemented;
5.7 Plans for mitigation of land subsidence based on peatland conservation is developed;
5.8 Priority areas for peatland conservation-based land subsidence mitigation programs are identified;
5.9 Land subsidence mitigation programs based on peatland conservation is implemented;
5.10 Land subsidence mitigation program plans through environmentally friendly and high-tech oil and gas exploitation programs is developed;
5.11 Priority areas for oil and gas exploitation programs that are environmentally friendly and high-tech are identified;
5.12 Oil and gas exploitation programs that are environmentally friendly and high-tech are implemented.

Strategy 6. Conduct Awareness Raising and Capacity Building in Mitigations and Adaptation of Land Subsidence (2019-2029)

Strategy 6. Conduct Awareness Raising and Capacity Building in Mitigations and Adaptation of Land Subsidence (2019-2029)

Strategy 7. Carry out Law Enforcement of Groundwater Extraction and Spatial Planning (2019-2029)

7.1 Regulations and institutions for Law Enforcement related to the Utilization of Groundwater and Spatial Planning are in place;
7.2 Policies and regulations and institutions for Law Enforcement related to the Utilization of Groundwater and Spatial Planning are implemented and operationalized.

Figure 5. ***National Roadmap Mitigation and Adaptation to Land Subsidence***
Source: Kemenkomarves

2.2 Existing Policies on Land Subsidence at the National, Provincial and Local Level

Policies on land subsidence at the national, provincial, and local levels are still limited. Thus, the effort to deal with land subsidence tends to be fragmented and embedded in other relevant sectors i.e. city water provision strategy or groundwater monitoring strategy, by which the responsibility lies in different government institutions. However, just recently in 2020, the national government has considered land subsidence as one of the types of disaster in the draft revision of the Law on Disaster Management (Law No. 24/2007). This provides an opportunity to put more attention to this issue. In addition, the Province of Central Java has enacted several policy architectures addressing this issue. Existing policies on land subsidence at the national level, and particularly in Central Java includes, but not limited to the following regulation and policies:

- Law No. 7/2004 on Water Resources - Annulled (Undang-undang No. 7/2004 tentang Sumberdaya Air)
- Draft Revision of Regulation No.24 / 2007 on Disaster Management (Draft Revisi UU No. 24 Tahun 2007 tentang Penanggulangan Bencana).
- Central Java Governor's Regulation No. 47/2015 on Local Drinking Water Provision System Development Policy and Strategy of Central Java Province
- Local Regulation of Central Java Province No. 3 / 2018 on Groundwater Management (Perda Provinsi Jawa Tengah Nomor 3 Tahun 2018 tentang Pengelolaan Air Tanah).
- Law No. 17/2019 on Water Resources (Undang-undang No. 17/2019 tentang Sumberdaya Air).
- Govt. Regulation No. 5/2021 on Execution of Risk-Based Business Licensing (Peraturan Pemerintah No. 5/2021 tentang Penyelenggaraan Perizinan Berusaha Berbasis Risiko)

Table 1.
Existing Policies related to Land Subsidence Issue in Central Java Province

Existing policies related to land subsidence in Central Java	Review	Relevance and Gaps
Law No. 7/2004 on Water Resources (Annulled) *(Undang-undang No. 7/2004 tentang Sumberdaya Air)*	- Law No. 7/2004 oversees the management of water resources, water use rights, and water venture rights, as well as the authority of stakeholders in the management of water resources. - Annulled by the Constitutional Court in 2015 as it was argued that this law encourages privatization of water rights, that is against the Constitution. - Replaced with the re-enactment of Law No. 11/1974 on Irrigation, and later Law No. 19/2019 on Water Resources.	Land subsidence is considered as one of the water damage potentials along with flood, erosion, sedimentation, among others. The management of water damage potential shall be carried out by means of disaster mitigation.
Draft Revision of Law No.24 / 2007 on Disaster Management *(Draft Revisi UU No. 24 Tahun 2007 tentang Penanggulangan Bencana)** *Under the renewal process	- The Law No. 24 / 2007 classifies disasters into three categories: natural disasters, non-natural disasters and social. - While in the draft revision of regulation, there are four clusters of disasters based on the trigger: (1) geology and volcanology, (2) hydrometeorological disasters I (dry), (3) hydrometeorological disasters II (wet), and (3) non-natural disasters. - Non-natural disasters include four components: waste, land subsidence, epidemic, and technological failure, which include industrial disaster issues.	Land subsidence is included as one of the types of disaster in the regulation. This provides an opportunity to put bigger attention on this issue in the future.
Governor Regulation of Central Java Province No. 47 of 2015 on Local Drinking Water Provision System Development Policy and Strategy of Central Java Province *(Peraturan Gubernur Jawa Tengah Nomor 47 Tahun 2015 tentang Kebijakan dan Strategi Daerah Pengembangan Sistem Penyediaan Air Minum Provinsi Jawa Tengah)*	- The coverage of urban drinking water service in Central Java Province at the end of 2013 only reached 63.99%, consisting of Piping Network 42.76% and Non-Piping Network 21.23%. The coverage of rural drinking water service is 49.13%, consisting of Pipeline 42.76% and Non-Pipeline Network 10.99%. The MDG target to be achieved by the end of 2015 is 75%. - The drinking water service in Central Java Province is currently managed by PDAM of Central Java Province, Regional/City PDAM, and independently by the community. There are 35 Regional/City PDAMs and 1 PDAB in Central Java Province. - IIn Central Java Province, there are 573 IKKs: 427 have been built and 146 have not been built, with an average idle capacity of 3,000 L/s. Currently, the average leakage in the pipeline is 30-40% and it is expected to be 3.10% by the end of 2019 with a plan to reduce leakage by 1% per year.	The city government of Central Java has planned to develop reservoirs to increase the retention capacity to increase the volume of raw water.

Existing policies related to land subsidence in Central Java	Review	Relevance and Gaps
Local Regulation of Central Java Province No. 3 / 2018 on Groundwater Management *(Perda Provinsi Jawa Tengah Nomor 3 Tahun 2018 tentang Pengelolaan Air Tanah)*	- Drilling, excavation, or any other activities within a 200 m radius of the emergence of the spring is prohibited. - Groundwater management affairs are carried out by the head of the institution in charge of energy and natural resources - The holder of groundwater concession permit is required to, among others, provide at least 15% on the use of groundwater discharge limits set out in the permit for the fulfillment of basic daily needs of the local community; to operate monitoring wells for every five well or for an extraction discharge rate of 50 L/s or more from one or more wells in the area less than 10 hectares. - The provincial regulation mandates the development of a groundwater conservation zone map as well as a groundwater information system, serving as a basis to determine the groundwater protection and utilization area - The implementation of groundwater management is financed by the APBD of Central Java and/or other legal and not binding sources.	There is already a lead institution for monitoring groundwater extraction (the Department of Energy and Natural Resources). However, the capacity mechanism of monitoring needs to be increased.
Law No. 17/2019 on Water Resources *(Undang-undang No. 17/2019 tentang Sumberdaya Air)*	- Replaced the previous Law No. 11/1974 on Irrigation (and the annulled Law No. 7/2004 on Water Resources). - Reaffirmed the state control on water rigths. Prescribes clear hierarchy of water utilization: guaranteed fulfilment by the government (basic daily needs, public agricultural activities, drinking water supply system), non-commercial purposes, and commercial purposes (subject to license). The law emphasizes that water utilization for specific (commercial purpose) can only be done if the above hierarchy is met. - Water resources management plans include the management of transnational river basins, inter-provincial river basins, and nationally strategic river basins, including groundwater basins in these river basins. - Currently there are no derivative regulations at the national and sub-national levels.	- Land subsidence is considered as one of the water damage potential along with flood, erosion, sedimentation, among others. The management of water damage potential shall be carried out by means of disaster mitigation. - Stipulates the authorization of groundwater basins as part of the river basins. - This will affect the institutional arrangement of ground water affairs at the sub-national level (once the derivative regulations are already in place).
Govt. Regulation No. 5/2021 on Execution of Risk-Based Business Licensing *(Peraturan Pemerintah No. 5/2021 tentang Penyelenggaraan Perizinan Berusaha Berbasis Risiko)*	- Derivative regulation of Job Creation Act (Law No. 11/2020) which specifically stipulates many affairs on business licensing across sectors. - Stipulates the norms and criteria for business in water resources as one of the sub-sector.	- Stipulates the strict duties of business in water resources to be responsible for negative impacts/risks associated with their business. - List hierarchies of licensing activities for business in water resources. - Encourage better utilization of water resources by the private entities.

Source: Various regulations as stated in the Table

2.3 Current Institutional Framework

Institutionalization becomes one of the important aspects for the implementation of mitigation and adaptation of land subsidence in the coastal areas of Central Java Province. Strategy for overseeing the issue cannot be done partially, rather it is necessary to have a synergy of governance across sectors as well as jurisdictions of the national and local governments. Optimizing the effectiveness of land subsidence mitigation and adaptation also needs to be supported by a comprehensive synergy of policies and programs from upstream to downstream areas.

In Indonesia, the institutional aspect for handling land subsidence has been initiated since early 2020 as a follow-up to the preparation of the national road map for mitigation and adaptation of land subsidence in the coastal area of Indonesia that was prepared in 2019. The institutional aspect is the first step in efforts to deal with land subsidence. Therefore, in Central Java Province, efforts to establish an institution for the management of mitigation and adaptation of land subsidence in the coastal areas are also important to be implemented immediately. The following table gives an overview of the current institutional framework conditions related to land subsidence at the National, Central Java, and City / Regency levels.

Table 2.
Overview of Current Institutional Framework Regarding the Land Subsidence

Current Conditions	Problems/GAP	Relevance and Gaps
National Government		
Has the authority to formulate policies and programs at the national scale	- Land subsidence has not been part of the disaster category in Indonesia. - A national program such as PAMSIMAS (a national program of water provision that uses groundwater) contributes to land subsidence.	The establishment of policies and programs that encourage mitigation and adaptation of land subsidence in Provincial and City/ Regency.
Already have a working group on mitigation and adaptation of land subsidence by the end of 2020	The role of the working group in implementing mitigation actions and adaptation of land subsidence has not been optimal due to the budgeting mechanism.	The working group for mitigation and adaptation of land subsidence at the national level could be a role model for local governments.
Central Java Province Government		
Has the authorities related to: - Groundwater management in Central Java Province (Regulation of Central Java Province No.3 / 2018 concerning Groundwater Management) - Management of coastal areas as far as 0-12 miles from the shoreline (Law No. 1/2014 concerning on Amendments to Law No. 27/2007 concerning on Management of Coastal Areas and Small Islands) - The institutional framework for mitigation and adaptation of land subsidence has not been established yet. The existing institutions carry out the programs related to land subsidence sporadically, based on the main functions and tasks of each stakeholder - The stakeholders involved in handling land subsidence issues are still dominated by the government and academia.	- An institution that specifically handles land subsidence which is integrated among the national, provincial, and city/district governments has not been established yet. - The comprehensive, as well as integrated programs and policies (across regions and sectors) regarding the land subsidence, has not been developed yet. - Lack of involvement and active participation of more integrated stakeholders, both government and non-government.	- An authorized institution for the mitigation and adaptation of land subsidence with a clear legal and policy basis is established. The institution has an integrated communication and coordination mechanism from the national, provincial to city/regency levels. - The compilation of integrated and comprehensive programs for the mitigation and adaptation of land subsidence with clear regulations and budgeting mechanisms. - The establishment of an inclusive collaboration of all stakeholders (both government and non government) to optimize efforts to mitigate and adapt to land subsidence in Central Java Province.

City/ Regency Government		
- Has the authority to develop the program as well as land utilization and management at City/ Regency level. - The institutionalization for mitigation and adaptation of land subsidence has not been established yet. The existing institutions carry out the programs related to land subsidence sporadically, based on the main functions and tasks of each stakeholder - The stakeholders involved in handling land subsidence issues are still dominated by the government and academia.		

The identification of the institutional framework in Central Java Province related to the mitigation and adaptation of land subsidence is identified through two (2) aspects, namely authority as well as main tasks and functions (tupoksi). The information on these two aspects are as follow:

2.3.1 Authority

Strategy for handling the land subsidence issue should be carried out in an integrated collaboration and cooperation from the central to regional governments. Authority is one of the important aspects as well as becomes a challenge in the implementation of land subsidence mitigation and adaptation programs in Indonesia. The management of lowland and coastal areas cannot be separated by jurisdiction.

The provincial government has the authority to manage coastal areas as well as groundwater which is one of the triggers for land subsidence. Meanwhile, land-use factors also play a major role in land subsidence which coincides with massive exploitation of groundwater. Land management and utilization are under the authority of the City / Regency government. At the national level, the central government has the authority to formulate policies for local governments in efforts to handle the land subsidence. The policy is an important aspect that acts as a reference and umbrella for local governments.

Policies at the national level are important, considering that land subsidence has not been categorized as a disaster category. It has implications for policies and programs developed in handling land subsidies in the lower level of governments because there is no policy at the national level that can be used as a reference. On the other hand, one of the national programs, namely PAMSIMAS, as an effort on water provision using groundwater becomes another trigger on land subsidence. This is a separate focus that needs to be considered in optimizing the handling of land subsidence. Consistency, integration, and synergy between the central and local governments are important factors in reducing land subsidence.

2.3.2 Main Duties and Function (Tupoksi)

Currently, the programs for handling the land subsidence are still being implemented partially and sporadically based on certain cases. Governments, both at the provincial and city /district levels have implemented programs for land subsidence management following their main duties and functions. To optimize the efforts to deal with land subsidence, cross-sectoral integration, and coordination, as well as a comprehensive strategy, are important to be implemented immediately. Henceforth, the coordination mechanism needs to be established under the institutional framework which focuses on the mitigation and adaptation of land subsidence in Central Java Province.

The coordination mechanism for land subsidence in Central Java is under the authority of the Central Java Provincial Government. In Central Java Province itself, there's no institution specifically addressing the issue of land subsidence. The following are the key institutions that should be involved in the institutional process related to land subsidence in Central Java Province.

Table 3.
Key Institutions that should be Involved in the Institutional Process Regarding Land Subsidence in Central Java Province

Government Organization	Roles and Functions
Central Java Province Government	
Dinas Pekerjaan Umum Sumber Daya Air dan Penataan Ruang (PUSDATARU)/ Public Works Agency of Water Resources and Spatial Planning	- PUSDATARU has the main task of carrying out government affairs in the field of public works, sub-affairs of water resources, and spatial planning. - Function: carry out the formulation, implementation, monitoring, evaluation, and reporting of policies in the fields of development and technical guidance, irrigation, and raw water, rivers, dams, and beaches as well as spatial planning. (Source: Central Java Provincial Governor Regulation Number 60/2016)
Dinas Energi dan Sumber Daya Mineral Provinsi Jawa Tengah (Dinas ESDM)/ Energy and Mineral Resources Agency	- ESDM Agency has the main task related to government affairs in the energy and mineral resources sector. - Function: carry out the formulation, implementation, monitoring, evaluation, and reporting of policies in the fields of geology and groundwater, minerals and coal, electricity, and renewable energy. (Source: Central Java Governor Regulation Number 27/2018)
Badan Perencanaan Pembangunan Daerah (BAPPEDA)/ Development Planning Agency	- BAPPEDA has the main task of carrying out governmental affairs and socio-cultural affairs; economy; infrastructure and regional development; programming, monitoring and evaluation of development; research and development; and innovation and technology. - Function: carry out the formulation, implementation, and monitoring, evaluation, and reporting of policies in the planning, research, and development sectors.
Badan Penanggulangan Bencana Daerah (BPBD) / Disaster Management Agency	- BPBD has the main task of carrying out the formulation and implementation of regional policies in the area of disaster management. - Functions: carry out the formulation, implementation, and monitoring, evaluation, and reporting of policies in the area of disaster management. (Source: Central Java Governor Regulation Number 101 /2008)
Dinas Lingkungan Hidup dan Kehutanan (DLHK)/ Environmental and Forestry Agency	- DLHK has the main task of carrying out government affairs in the environmental and forestry sector. - Function: carry out the formulation, implementation, and monitoring process, as well as evaluation and reporting of policies in the field of structuring, impact assessment and capacity building of the environment, waste management, toxic hazardous waste, control of environmental pollution and damage, forest management and utilization, regional management on river and Natural Resources conservation, counseling, environmental law enforcement, and forest protection.

Government Organization	Roles and Functions
Central Java Province Government	
Dinas Kelautan dan Perikanaan (DKP)/ Department of Marine Affairs and Fisheries	- The Office of Marine Affairs and Fisheries has the main task of carrying out government affairs in the maritime and fisheries sector. - Function: carry out the policies formulation and implementation as well as evaluating and reporting in the fields of aquaculture, capture fisheries, coastal marine and supervision, extension, and fisheries marine business. (Source: Central Java Governor Regulation Number 75/2016)
Biro Infrastruktur dan Sumber Daya Alam Sekretariat Daerah (Biro ISDA Setda)/ Bureau of Infrastructure and Natural Resources, Regional Secretariat	- ISDA Bureau of the Regional Secretariat of Central Java Province has the task of coordinating the formulation of regional policies, coordinating the implementation of regional apparatus duties, monitoring and evaluating the implementation of regional policies, administrative services, and fostering human resources in the fields of infrastructure, environment, forestry, and energy mineral resources, food security, marine, fisheries, and agriculture. - Functions: a) coordinating the formulation of regional policies, b) coordinating the implementation of regional apparatus duties, c) monitoring and evaluating the implementation of policies, and d) implementing administrative services and fostering civil servant resources in the fields of infrastructure, environment, forestry, and energy mineral resources, food security, marine, fisheries and agriculture; and e) the implementation of other functions assigned by the Economic and Development Assistant.
Local Governments in Coastal Area of Central Java Province: Local government has main duties and functions in the areas of spatial planning, water management, environmental, disaster issue, and coastal management such as BAPPEDA, Spatial Planning Agency, Public Works Agency, Environmental Agency, Disaster Management Agency, and Department of Marine Affairs and Fisheries.	

Furthermore, this institutional aspect requires the active role of more stakeholders. Referring to institutions at the national level, the governance process is carried out by clustering (grouping) based on the implementation function for land subsidence mitigation and adaptation programs. Stakeholder identification is carried out to map the stakeholders who have the potential involvement to participate in land subsidence adaptation and mitigation efforts. Later, the results of stakeholder identification (grouping) according to the work fields above play a role in the establishment of institutions related to land subsidence in Central Java Province (will be explained further in the road map strategy section in next chapter). The following is a schematic overview of the main areas and the role of the potential institutions for the adaptation and mitigation of land subsidence in Central Java Province.

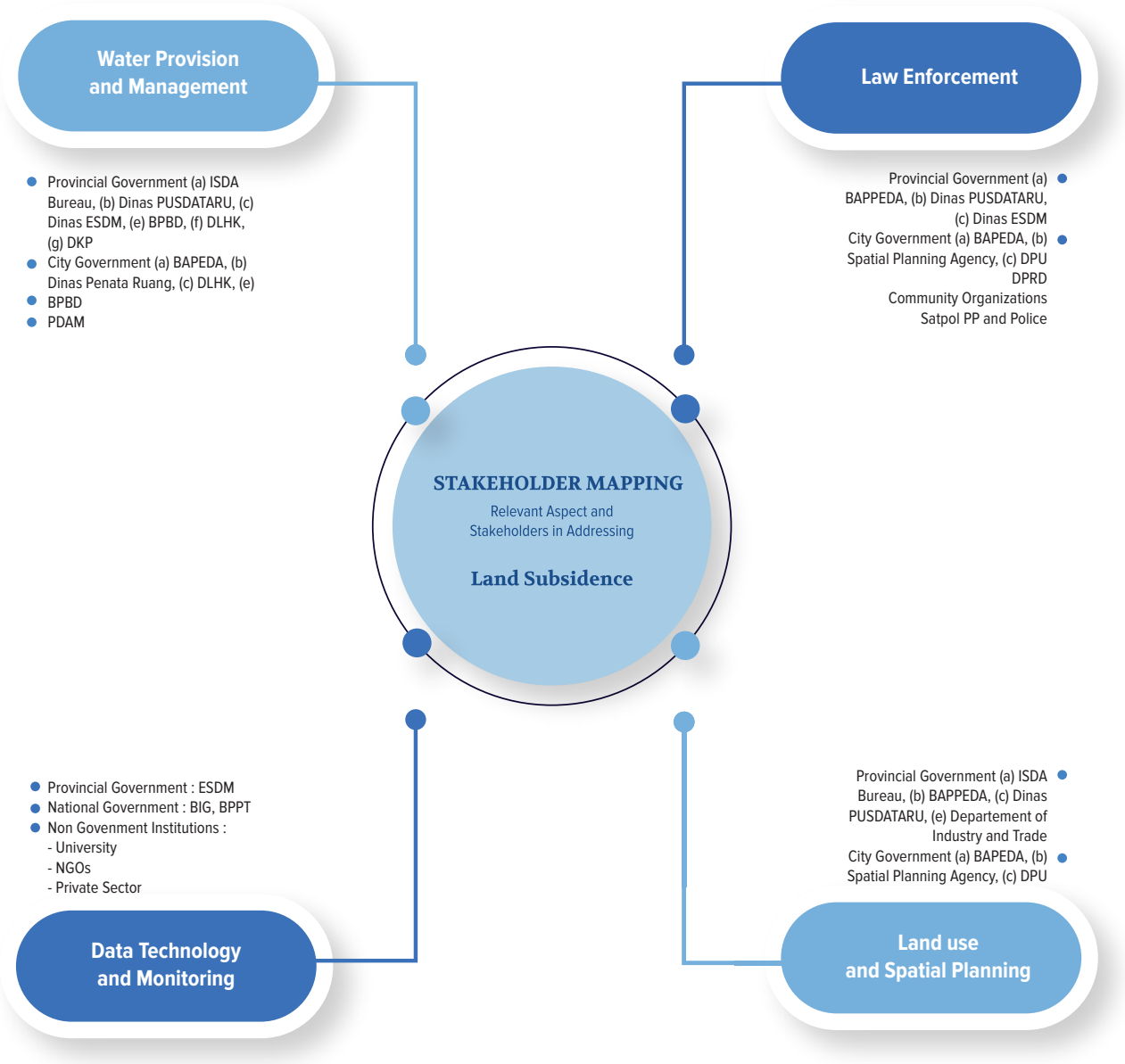

Figure 6. ***Stakeholder Mapping: Relevant Aspects and Key Institutions that should be Involved in the Institutional Process Regarding Mitigation and Adaptation to Land Subsidence in Central Java Province***

2.4 Existing Initiatives in Semarang and Demak

To address the issue of land subsidence, the local governments have initiated various measures by partnering with different stakeholders. Currently, there are several initiatives that are underway in the north coast of Central Java Province, particularly Semarang and Demak, that might not directly address land subsidence issues, but contribute to mitigating and adapting to land subsidence

Integrated Coastal Zone Management of Central Java

Integrated Coastal Zone Management (ICZM) is a provincial government initiative to look at the whole coast from Brebes to Rembang, where some parts of it are being supported by the Netherland technical assistance with varied scope (one in Pekalongan and one in Brebes). The provincial government has formed a team made up of the different departments which serve as a task force to develop the plan and the primary stakeholder interfacing with the international assistance. ICZM is officially listed as a program under the national mid-term plan RPJMN 2020-2025, as well as provincial RPJMD 2020-2025.

The technical assistance in Pekalongan is funded by Nuffic and OKP, heavily focusing on research and knowledge building analyzing challenges and opportunities for the coastal city. This also supported the creation of the ICZM center in UNDIP which has ambitions to be the main knowledge hub for the province. Meanwhile, the technical assistance in Brebes is funded by RVO under Partnership for Water. The program covers training programs for the province, as well as a pilot for master planning of Brebes.

Building with Nature in Demak

The "Building with Nature" initiative aims to build stable coastlines with reduced erosion risk through a unique integration of mangrove restoration, small-scale hard-engineering, and sustainable land use. The five-year program (2015-2020) focuses on the shoreline in Demak where sea level rise is projected to cause flooding 6 km inland by 2100, inundating 14,700 hectares affecting over 70,000 people and the loss of 6000 hectares of aquaculture ponds. To date, the program has enhanced coastal security for 70.000 vulnerable people by avoiding further coastal flooding and erosion in Central Java and providing them with a long-term perspective for sustainable economic development. The project was able to slow down or halt erosion Locally and in the short term, and even some mangroves be restored. However, due to the severity of subsidence in the area, not all restoration targets of the "Building with nature" project can be achieved, unless subsidence is significantly reduced.

Figure 7. ***Building with Nature Strategies***
Source: Wetlands Indonesia, 2016

Water as Leverage
Semarang

Water as Leverage is a cooperation program between the Netherland Enterprise Agency (RVO.nl) and the City of Semarang to develop innovative, bankable, and implementable design proposals to tackle water-related problems in the city. The challenge is to match long-term comprehensive urban planning with short-term innovative transformations; ambitious climate adaptation plans with bankable projects; the development of more knowledge on water systems with the construction of more resilient cities; research, design, and implementation with inclusive urban alliances.

During the first and second phase of the Water as Leverage Program (2018-2019), the design teams collaboratively developed five strategic programs from upland to coast that tackle pressing water-problem in Semarang including water supply, land subsidence, flooding, and sea-level rise, under one comprehensive and holistic approach. In the third phase of the program (2020), the team has worked closely with the city government of Semarang to develop a roadmap of Water as Leverage initiatives, focusing on programs that can be aligned with city programs, including three main programmatic ideas: Resilient Kampung, Rechanneling the City, and Spongy mountain terrace, as well as developing guidelines that serve as a toolkit for implementing the concepts.

Figure 8. ***Water as Leverage Outcome: Comprehensive Strategies to Tackle Water Issue in Semarang***
Source: Water as Leverage, 2019

CHAPTER 3 COASTAL SUBSIDENCE IN CENTRAL JAVA

CASE STUDY: SEMARANG AND DEMAK

While the issue of land subsidence generally occurs across coastal regions in the country, the north coast of Central Java is highly prone to subsidence and therefore is more at stake. This part will provide an overview of land subsidence issues in Central Java, with a specific focus on Semarang - Demak as the main locus for this technical study, followed by an economic assessment of subsidence impact and proposed adaptation and mitigation measures.

3.1 Overview of Land Subsidence Issue in Central Java

3.1.1 Land Subsidence Issue in Central Java

As mentioned earlier, the issue of land subsidence has not gained serious attention from the government. Especially in the coastal cities of Central Java such as Semarang, Demak, Pekalongan, Brebes, and Tegal the issue was poorly managed considering the vulnerabilities of these cities. According to previous studies, the rates of land subsidence in the forth-mentioned cities are quite varied. In Semarang, the land subsidence rate varies from 1 to 15 centimeters per year, while in Demak the rate varies from 1 to 10 centimeters per year. In Pekalongan, the rate is between 1 to 15 centimeters, but in some parts, it reaches 20 centimeters per year. Meanwhile, in the Brebes and Tegal, there are no specific measurements yet, however, there are signs of land subsidence.

As previously mentioned, like many other Indonesian cities, land subsidence in Central Java occurs mainly due to anthropogenic factors or as a result of human activities, such as excessive groundwater extraction, loading effects, exploitation of oil and natural gas, the impact of subsurface mining activities, and peat soil oxidation. Meanwhile, the non-anthropogenic factors like natural compaction and the effect of tectonic subsidence have little effect in comparison to anthropogenic factors.

3.1.2 Impacts of Land Subsidence in Central Java

Land subsidence resulted in a "slow onset disaster" in the coastal lowlands area in the form of tidal /coastal flooding or locally known as ‘rob’, infrastructure damage, expansion of the flood-prone areas, environmental degradation, etc. The northern coast of Central Java, however, is one of the areas with significant and visible impacts of land subsidence. Table x shows the extent of areas that have experienced tidal/coastal flooding, coastal abrasion, and sedimentation in Pekalongan, Batang, Kendal, Semarang, and Demak.

Figure 9. ***Tidal flood in Pekalongan and Semarang***
Source: Antaranews.com, Detik.com

Table 4.
City / Regency in the North Coast of Java with coastal flooding, abrasion, and sedimentation

No	City / Regency in North Coast of Central Java	Total area with sedimentation (ha)	Total area with coastal abrasion (ha)	Total area with coastal flooding (rob) (hektar)
1	Pekalongan	427,5	77,3	4.500,8
2	Batang	-	-	11,0
3	Kendal	1.005,8	317,4	258,9
4	Semarang	318,7	342,6	1.157,8
5	Pekalongan	-		3.221,0

Source: Andreas et al. (2016); Budianto (2012); Pribadi dan Helmi (2012).

Based on the data, Pekalongan and Demak were the two most affected cities by tidal floods in terms of the total affected area, which reached more than thousands of hectares. Some of these areas were experiencing frequent coastal flooding which, in some part, has led to the loss of aquaculture and land. In some parts of Demak, land subsidence and frequent coastal flooding have also led to the displacement of local communities due to loss of livelihood.

3.2 Overview: Land subsidence in Semarang and Demak

Semarang and Demak are a city and a regency, respectively, located on the northern coast of Java. Like many other coastal cities along Java's northern coast, these cities are facing complex and inter-related urban challenges: sinking, flooding, and rapid growth. Semarang's coastal zone is sinking at a rate of 4 to 16 cm per year, a result of a combination of its treacherous geology, uncontrolled groundwater extraction, and increasing building mass. This is worsened by the global sea-level rise that is projected to reach the rate of 4 mm per year due to climate change (IPCC, 2013).

3.2.1 Subsidence Rates

Several investigations for the prediction and modeling of land subsidence in Semarang have been done by various researchers using various methods and approaches. As cited in Deltares (2021), most of the researchers found that subsidence rates are highest in the northern part of Semarang especially in the northeastern region (Kuehn, et al., 2010; Putranto & Rude, Groundwater Problems in Semarang Demak Urban Area, 2011; Abidin, Andreas, Gumilar, Sidiq, & Fukuda, 2012; Islam, Yudo, & Sudarsono, 2017; Ismanto, Wirasatriya, Helmi, Hartoko, & Prayogi, 2009). Unlike Semarang, subsidence study in Demak is still lacking. The study from Yuwono et al., 2019 using DInSAR method indicates that subsidence in Demak varied in time and space, with the highest rate in Sayung District. In Demak, Sayung district has a subsidence rate of up to 13 cm/year in 2017 (Yuwono et al., 2019).

Table 5.
Subsidence rate in Semarang from different authors and methods

Method	Year	Reference	Genuk [cm/year]	Harbour [cm/year	Tawang [cm/year]	Marina [cm/year	Airport [cm/year]
Levelling	2000-2001	(Murdohardono, Sudrajat, Wirakusumah, Kuhn, & Mulyasari, 2009)	4-8	8-20	6-8	4-8	2-4
Levelling	1999-2003	Centre of Environmental Geology	>6	>8	6-8	4-8	2-4
	2009-2011 2008-2016	(Abidin, Andreas, Gumilar, Sidiq, & Fukuda, 2012; Andreas H. , et al., 2019)	9-15	6-9	3-7	6-9	3-6
Insar	Until 2019	(Ellipsis, 2020)	>10	6-10	6-8	3-6	0-4
SPN	2002-2006	(Kuehn, et al., 2010)	>7	>7	6-7	>7	5-6
DInSAR	2015-2016	(Islam, Yudo, & Sudarsono, 2017)	10	8-15	8	4-6	4-6
Modeling with Plaxis and Terzaghi	2015-2016	(Sarah, Syahbana, Lubis, & Mulyono, 2011)	-	-	3-7	-	-
Bench mark elevation and field measurement with DGPS	2009	(Ismanto, Wirasatriya, Helmi, Hartoko, & Prayogi, 2009)	>8.1	8.1-12	4.1-8	4.1-8	1.1-4
Microgravity	2002-2005	(Supriyadi, 2008)	<6.5	8-9.5	5-8	15	<6.5

Source: Deltares, 2021

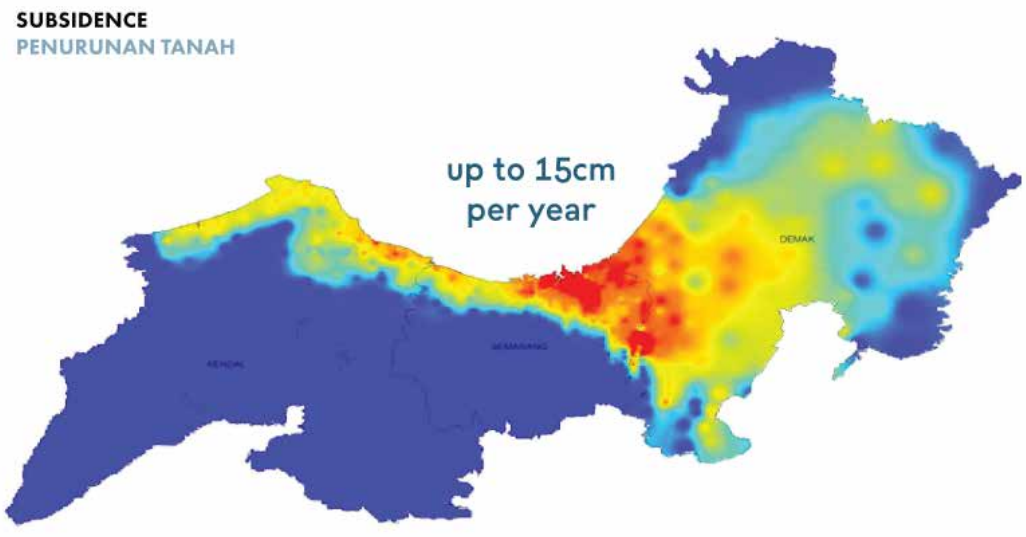

Figure 10. ***Subsidence rate in cm per year in Semarang and Demak***
Source: Andreas, Heri (2017)

3.2.2 Aspects Relevant to Land Subsidence in Semarang and Demak

Several aspects that are considered relevant, or otherwise serve as a necessary background on the land subsidence in Semarang and Demak are documented in the following.

Population Growth

Population growth is one of the main factors that contribute to the increasing demand and needs for water supply. According to BPS data from 2003 to 2019, the population of Semarang is increasing every year, The following figure illustrates the population growth from 2003 to 2017. On average the population growth in Semarang is increasing around 1.89% per year. High population growth began at 2.09% in 2003 and generally fluctuated with a decreasing trend, to 0.5-1% growth this past decade. However, there was a high surge of 3% increase in population from 2017 to 2018 observed. The growth of domestic water demand in Semarang can be predicted with a similar trend. The increase is also projected, although growth possibly slower as indicated.

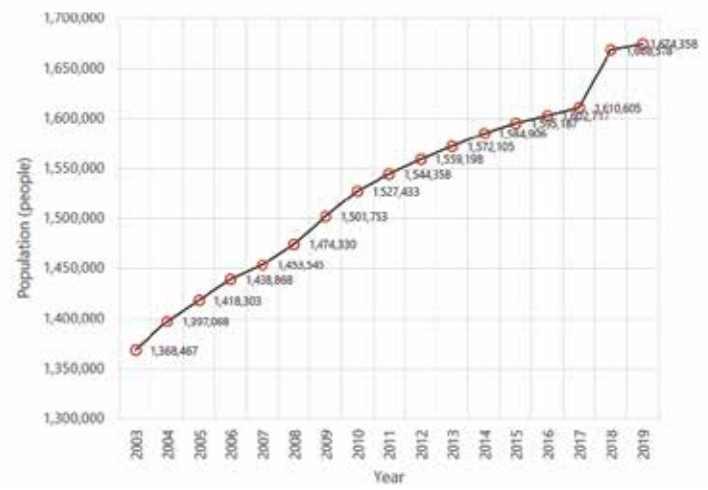

Figure 11. ***Population of Semarang***
Source: Witteveen Bos

As compared to Semarang, the population of Demak from 2005 - 2019 fluctuated slightly in the first five years - but overall shares an upward trend. As illustrated in the figure above, the population growth rate from 2005 - 2010 was quite irregular. According to BPS, the highest rate was observed in 2007 with 2,88%. After that point, the number dropped abruptly to 0,35%. However, in the following years, the rate was averaging around 1-1,25% up until 2019 - with a consistent rising trend.

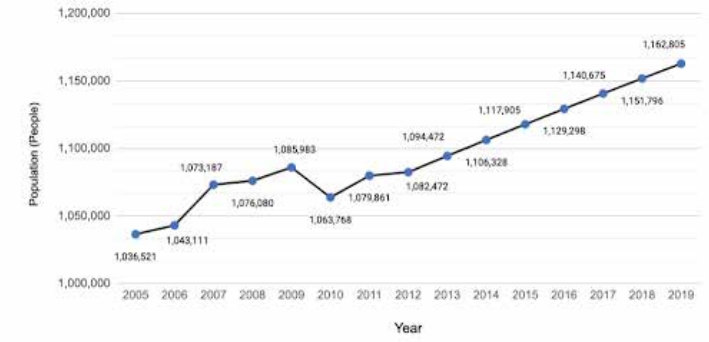

Figure 12. ***Population of Demak***
Source: BPS Kabupaten Demak, 2021

Current Condition of Water Supply in Semarang and Demak

The condition of water supply in a city determines the use of groundwater both by the industrial sector and household. Both Semarang and Demak have become an industrial epicenter in Indonesia, housing 783 large-scale industries and more than 35000 small-scale industries as of 2018 (Central Java Statistics Indonesia, 2020). In 2019, the industrial sector has contributed 27.22% and 30.84% of the GDP of Semarang and Demak respectively. The population, fuelled by economic development, has grown from 1.3 million in 1995 to 1.8 million in 2018 in Semarang, and from 0.9 million to 1.2 million in Demak (Central Java Statistics Indonesia, 2020). As a result, water demand has risen from 48.5 million m3 in 1999 and increased to 68.5 million m3 in 2005. With the growing urbanization, the projected Semarang water demand is expected to be 336 million m3 in 2030 (Central Java Government, 2020). However, the local drinking water company in Semarang and Demak, PDAM (Perusahaan Daerah Air Minum), only covers 61.2% and 23.68% of the administrative boundaries in Semarang and Demak respectively (Association of Indonesian Drinking Water Companies Central Java, 2020). Due to this inadequate clean water provision, 24% of clean water demand in Semarang is fulfilled by means of groundwater extraction and industrial activities rely more on groundwater sources (Valentino, 2013). Based on 2011 and 2012 data, 53% of groundwater extraction permits were issued for industry and the rest was for domestic use. The deep groundwater extraction has led to significant subsidence in the area, with rates ranging from 0-2 cm to >10 cm per year. The most notable consequences in the area include damage to buildings and infrastructure and a high coastal flooding hazard.

Table 6.
Summary Water Supply Condition in Semarang and Demak

Semarang	Demak
- The PDAM pipe network serves 59% of the water needs of the citizens of Semarang. - Enforcement of regulation to limit groundwater extraction in Northern Semarang (Kec. Tugu, Smg Barat, Smg Tengah, Smg Selatan, Smg Timur, Genuk, Pedurungan, and Gayamsari) - Economic loss due to land subsidence 28,724 IDR billion (1,9 billion USD) (Water as Leverage, 2019)	- PDAM service 30% of households in Demak connected to PDAM service as their main water source. The current main PDAM water sources are the Rowopening reservoir and the Kedungombo dam. - Groundwater serves as the main water source for households, as PDAM coverage is still low. The quality of groundwater is considered better than PDAM water. - PAMSIMAS service133 out of 243 villages in Demak has now been served by a community-based water supply and sanitation program (PAMSIMAS) which uses groundwater as its source. Water services are available through the PDAM pipe network which serves 8 from 14 districts (need to clarify) - PAMSIMAS (communal water provision using groundwater source) become an alternative source of water that serves the area without PDAM service. - There is a regulation on groundwater extraction (revoked in 2018 - need to clarify): limiting groundwater extraction and priority use of groundwater. - Demak catchment: Jratun Seluna watershed

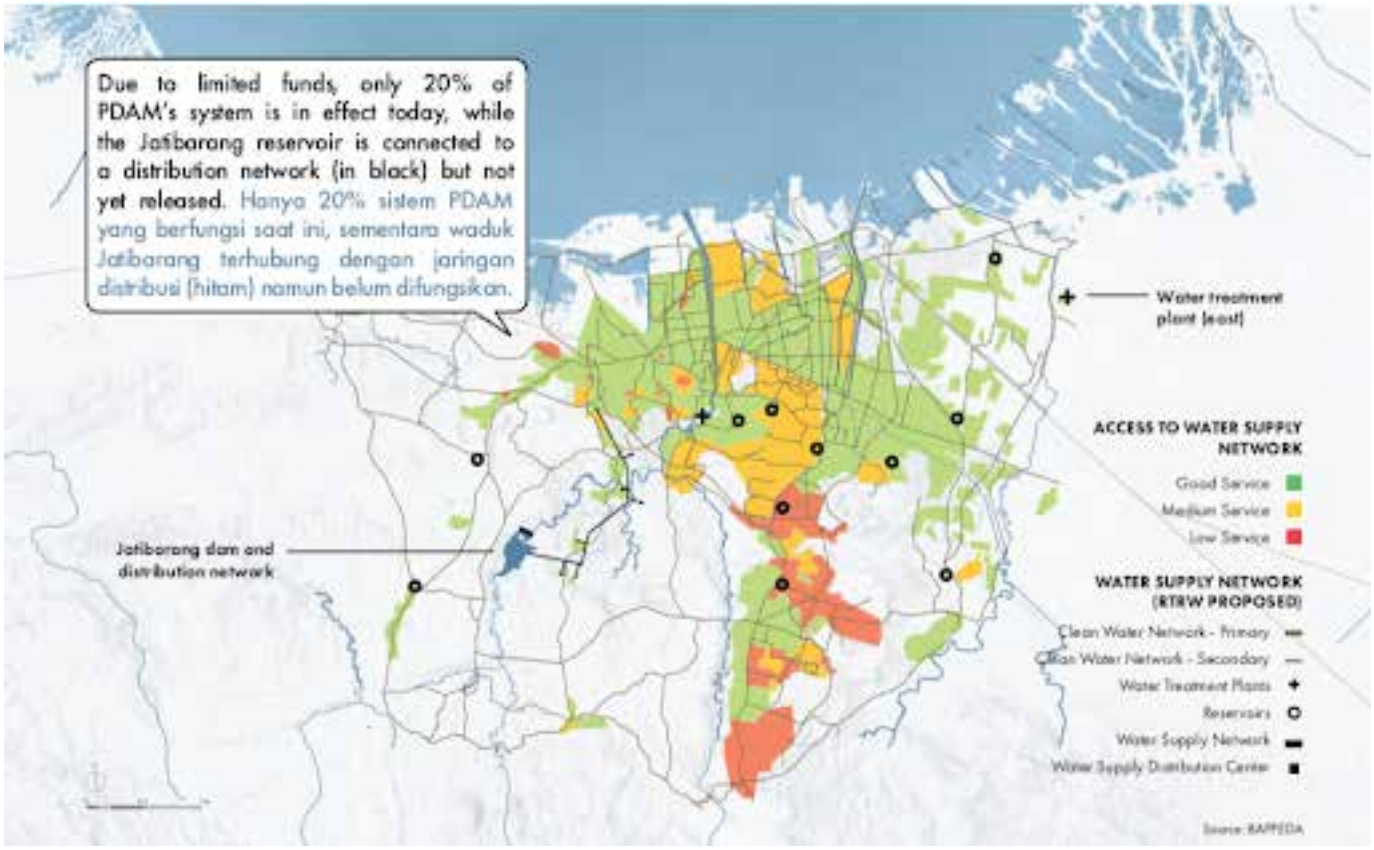

Figure 13. ***Access to Water Supply Network in Semarang***
Source: Water as Leverage, 2019

Land use and Spatial Planning (Rencana Tata Ruang Wilayah/RTRW)

Land use is particularly valuable to gain insight into the degree of development in the area. Information regarding land use and spatial planning plays an important role in supporting the effectiveness of mitigation and adaptation efforts to land subsidence. Land utilization in coastal areas also contributes to increasing the level of land subsidence. According to the Geological Agency of the Ministry of Energy and Mineral Resources (Badan Geologi Kementerian Energi dan Sumber Daya Mineral/ ESDM), there are three (3) factors that contribute to land subsidence, namely: (1) the higher ground load due to the buildings on it, (2) groundwater exploitation, and 3) land consolidation or stabilization (Petriella, 2019). Therefore, to obtain optimal benefits in the implementation of mitigation and adaptation efforts to land subsidence, it must be supported and in line with the spatial plan. The following is an overview of land use and spatial planning in the coastal areas of Semarang City and Demak Regency:

Semarang City

Northern Semarang is of higher population density used primarily as a business/office district and settlement. Whereas the southern area is primarily open space and wetland. Referring to the Semarang City Regulation Number 14/2011 concerning on Spatial Planning of Semarang City In 2011 - 2031, the coastal area or coastal border of Semarang City has an area of ± 175 Ha, located in four (4) sub-districts and consists of 13 Kelurahan. The area includes:

1. Genuk District: Kelurahan Terboyo Kulon
2. West Semarang District: Kelurahan Tambakharjo, Tawangsari, dan Tawangma
3. North Semarang District: Kelurahan Panggung Lor, Bandarharjo, dan Tanjung Mas
4. Tugu District: Kelurahan Mangunharjo, Mangkang Wetan, Mangkang KUlon, Randugarut, Karanganyar, dan Tugurejo

The coastal areas of Semarang City are prone to tidal flood, flash flood, and abrasion. The efforts to control tidal flooding are carried out by constructing a coastal embankment, as well as a water storage in North Semarang District. As an effort to prevent abrasion, protected areas, mangrove conservations are implemented in Genuk and Tugu Districts. In addition to residential areas, the coastal area of Semarang City is also designated for industrial areas, both bonded industries, warehousing, small and household industries. Optimization of land subsidence mitigation and adaptation efforts must be implemented and supported with the suitability of the spatial plan designation because land use will affect the rate of land subsidence. The following is Figure 11 which shows the RTRW for Semarang City 2011-2031.

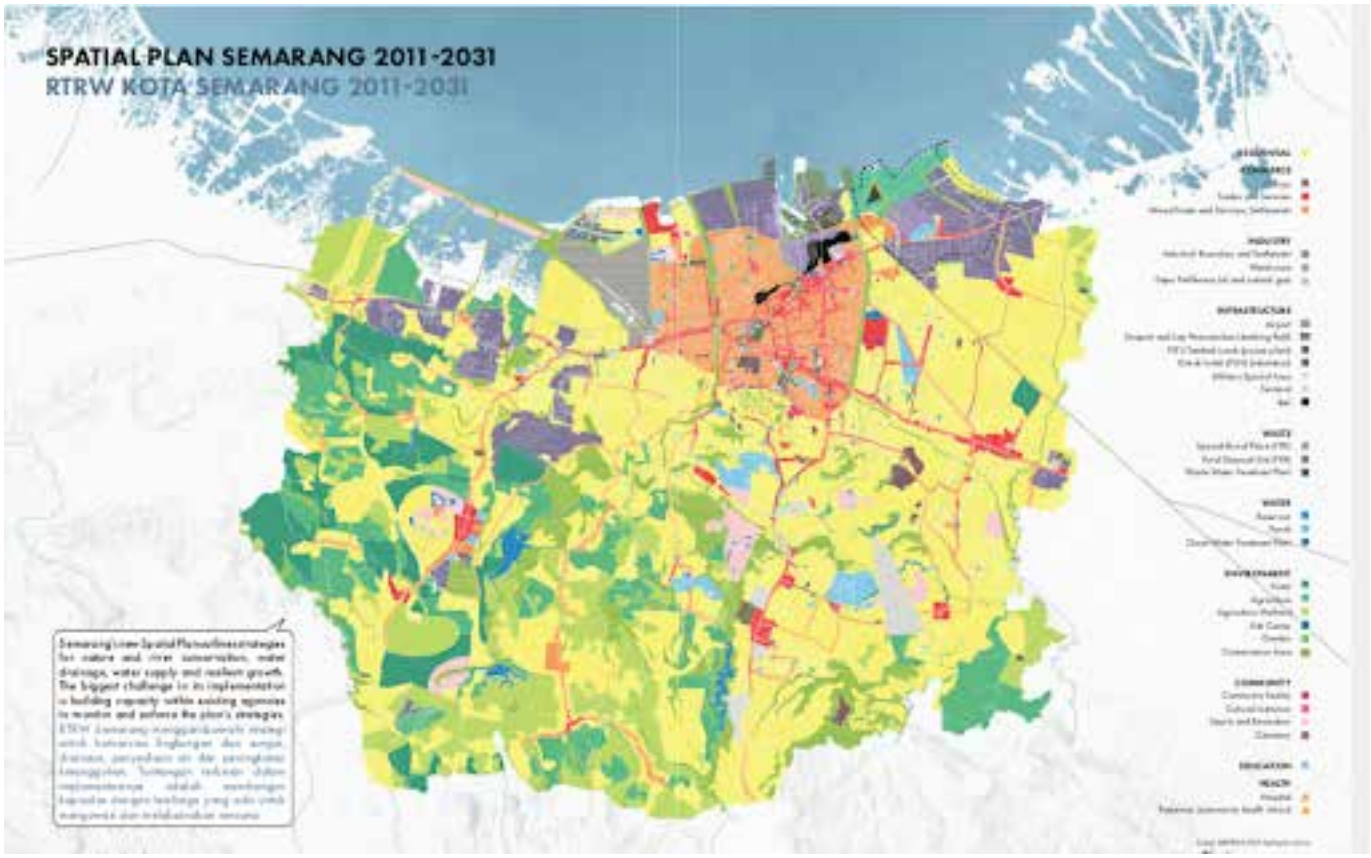

Figure 14. ***Spatial Plan of Semarang***
Source: Water as Leverage, 2019

Figure 15. ***Industrial Area in Semarang and the surrounding Regions (Demak and Kendal)***
Source: Water as Leverage, 2019

Demak Regency

The coastal area of Demak Regency includes four (4) Districts, namely Sayung, Karangtengah, Bonang, and Wedung. According to the Demak Regency Regional Regulation No.1 / 2020 concerning Amendments to the Demak Regency Regional Regulation No. 6 of 2011 concerning the Spatial Planning (RTRW) of Demak Regency in 2011-2031, the four regions are included in the urban structure as the Activity Service Center (Pusat Pelayanan Kegiatan/ PPK) areas. As a protected area, Demak Regency has a mangrove ecosystem area of 701 hectares with the highest area in Wedung District covering 608 hectares. The coastal area of Demak Regency is designated as a residential area for urban, rural, fishery cultivation, food crops, horticulture, and industry. The industrial area in four sub-districts of the coastal area of Demak Regency reaches 6,722 hectares. The industrial area is larger than urban and rural settlements in the four districts (4,313 hectares). It is a challenge for Demak Regency. The large industrial area in Demak Regency will certainly contribute to land subsidence because the majority of these industries still use groundwater as a source of raw water. The coast of Demak Regency is a flood-prone area. The integration between spatial planning as well as mitigation and adaptation efforts of land subsidence is expected to contribute to addressing land subsidence and other related disasters.

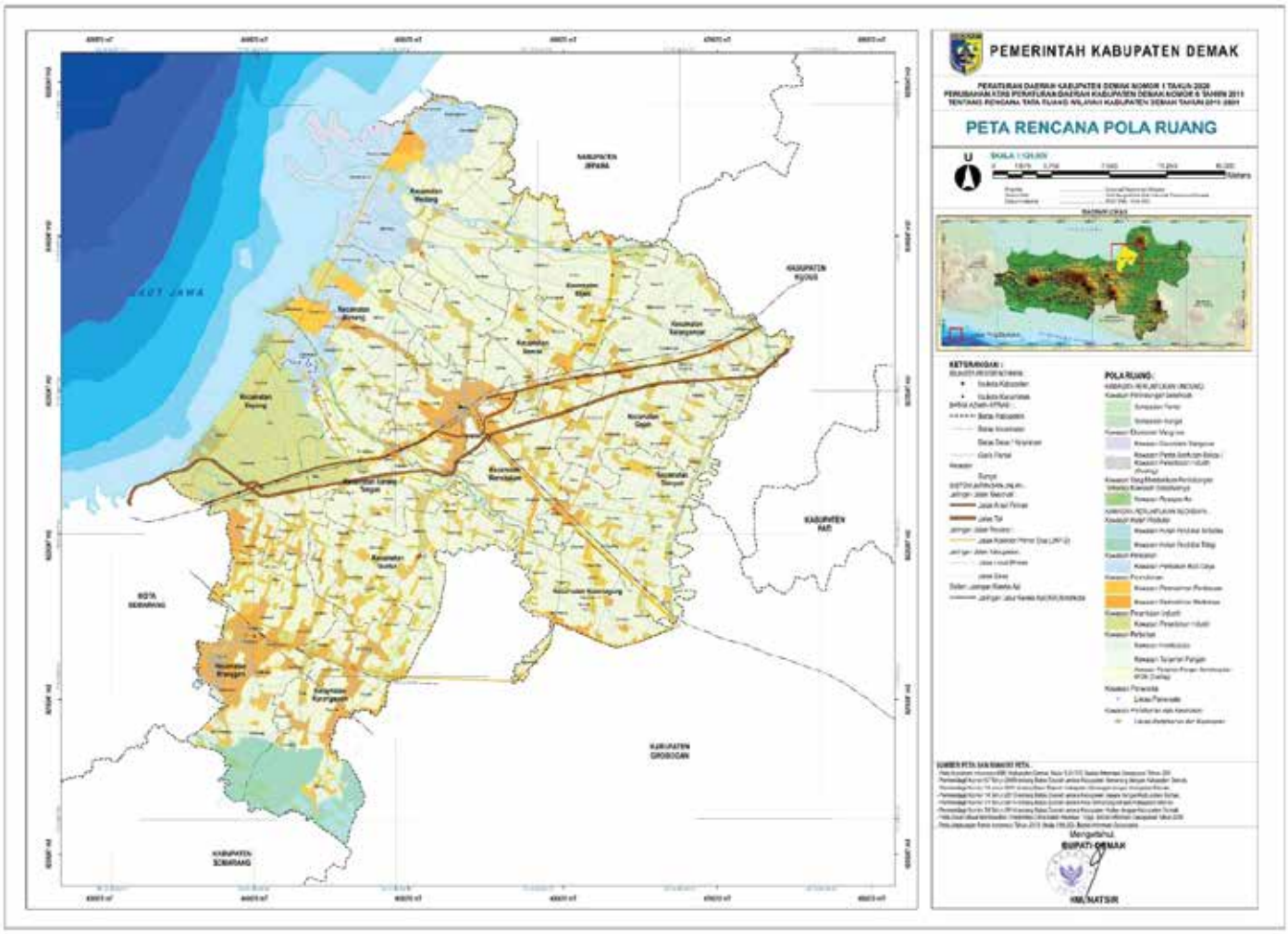

Figure 16. ***Spatial Plan of Demak Regency***
Source: Water as Leverage, 2019

3.2.3 Land Subsidence Causes and Effects in Semarang and Demak

Many studies have suggested that the causes of subsidence in the urban areas in northern Java, including Semarang and Demak are a mix of natural and anthropogenic activities (Witteveen+Bos, 2020; Sarah et al., 2015, Abidin et al., 2013). On top of natural consolidation and tectonic activities, additional load due to construction and groundwater extraction are the main factors that contribute to this problem - and the area where we can intervene. The prominence of subsidence in Northern Java is due to its physiographic setting and increased water demand following population growth and economic development.

Excessive groundwater extraction

The subsidence due to groundwater extraction is induced by the seepage due to the water head lowering from pumping. The dissipation of the pore water pressure will in turn increase the effective stress thus causing subsidence of land surface. However, in nature, there is no aquitard that is purely impermeable. This occurrence will cause the dissipation to also occur in the clay layer which is more prone to consolidation settlement due to seepage. Likewise, there is no aquifer layer that is fully made up of granular material.

In Semarang, groundwater has been exploited as a natural resource since 1841 (Putranto & Rude, 2016). Based on Semarang groundwater extraction data from different studies, groundwater extraction has increased substantially since 1980. Groundwater extraction rate in 1980 was less than 5 million m3/year. While in 1990, the extraction rate was increased to approximately 20 million m3/year. Only 10 years later in 2000, the extraction amount was drastically increased reaching almost 40 m3/year. Even though the absolute values differ between different datasets (Figure A-1), the overall patterns are similar, which shows the reliability of the data.

Additional load due construction

Additional load due to construction can cause compaction in the topsoil layer which causes land subsidence. Natural subsidence rates rarely exceed 1 cm/year, whereas man-induced subsidence can reach 50 cm/year and even more (Dolan & Grant, 1986).
Compaction of the soil increases its density and reduces its pore spaces. Soils are elastic material to only a limited extent. Soil compaction which goes beyond the elastic deformation results in plastic deformation and will not rebound even if the cause of compaction is removed (Suripin, 2012).

Box 1.Anthropogenic Factors of Land Subsidence

- Excessive groundwater extraction will cause compaction in aquifers (underground layers that contain water and can drain water), resulting in a response on the surface in the form of subsidence events.
- Additional load due to construction can cause compaction in the topsoil layer which causes land subsidence.
  Subsurface mining activities will result in reduced formation pressure in the surrounding rock layer, resulting in a subsidence response above it.
- In peat soils, the process of draining the peat through the construction of canals causes the peat soil to compact and experience subsidence accompanied by oxidation of the organic matter that makes up the peat.

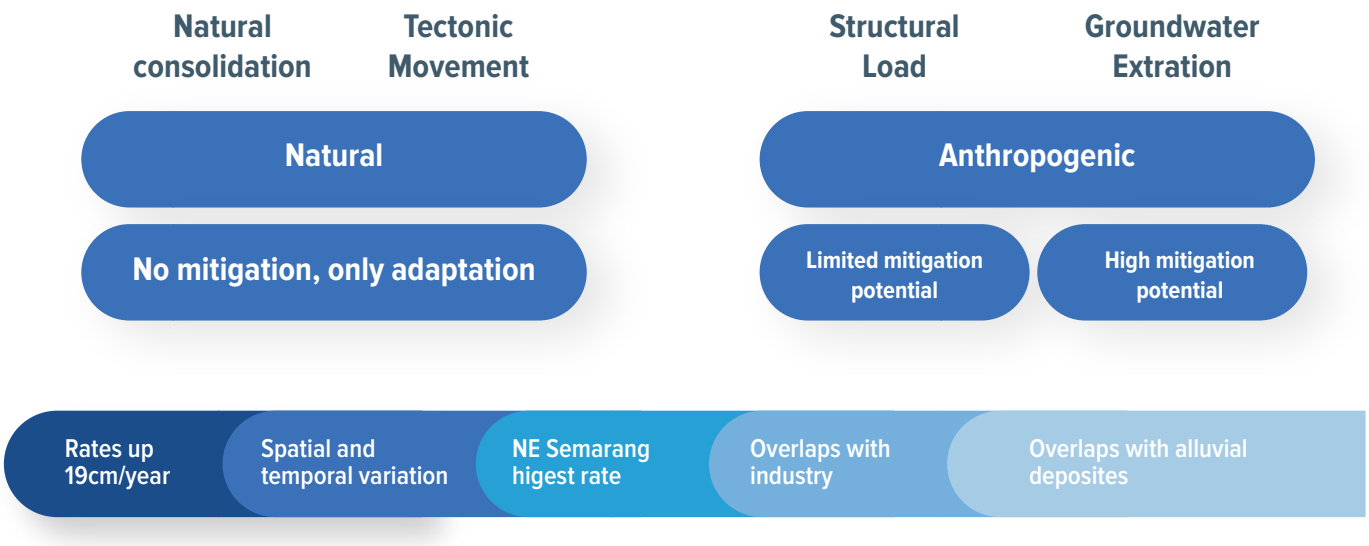

Figure 17. ***Land Subsidence Causes and Effects***
Source: Deltares, 2021

3.2.4 Risks and Opportunities

To understand the risk and opportunities in addressing land subsidence in Semarang and Demak, a SWOT analysis was conducted related to the major causes of land subsidence in both areas. The causes are related to various issues, such as water management, groundwater extraction, spatial planning, among others. The table below elaborates the SWOT analysis for both cities.

SWOT analysis Semarang

STRENGTH	WEAKNESSES
- Basic water service exists through the PDAM pipe network which connects to 62.4% of households in Semarang and is projected to increase the coverage. - Existing regulations related to groundwater management (i.e. Mayoral Decree on Moratorium for groundwater extraction & Local Govt. of CJP Regulation No. 3/2018 on groundwater management - which defines a conservation zone for groundwater extraction). - Strong community initiatives for flood management both in coastal areas (polder system & mangrove) and upstream areas (restoration activity).	- Unintegrated programs and siloed process of institutional arrangement (e.g. PAMSIMAS is using groundwater as the main source of water supply, unintegrated mangrove restoration program). - Limited technical capacity by the local governments (e.g. no adequate SOP in monitoring and to enforce regulation on groundwater extraction). Lack of mainstreamed urgency of land subsidence to wider audiences, particularly the private sector. - Geographical challenges (e.g hilly topography of Semarang affecting the distribution of water).
OPPORTUNITY	**THREAT**
- Lesson-learned from other cities and countries are available (e.g. public spaces, green open spaces, and coastal management). - Various opportunities for water conservation (e.g. rainwater harvesting & recycling system, and artificial recharge). Collaboration for public-private partnership (i.e. improve water services of PDAM and pipe-water service and effective land-use). - Development of water-neutral industrial zones.	- Rapid urban development in Semarang (i.e. new industrial zones). The polder system is highly dependent on the capacity and power of the pump. When there is a problem with the pump, the area is prone to flooding. - The sustainability of mangrove areas in the future depends on the current land owner (private developer. - If land subsidence is not stopped, the problem of flooding in coastal areas will not only continue, but the impact will also be greater. The risks will be higher and the O&M costs will continue to

SWOT analysis Demak

STRENGTH	WEAKNESSES
- Water services are available through the PDAM pipe network which serves 8 from 14 districts. - PAMSIMAS (communal water provision using groundwater source) become an alternative source of water that serves the area without PDAM service. - Several government regulations on groundwater extraction coastal protection. Existing Demak catchment areas: Jratun Seluna watershed.	- Limited sources / availability of clean water during the dry season. - The distribution of clean water services has not been optimal, especially in coastal areas. - Lack of attention and regulation enforcement on groundwater use and overall land subsidence.
OPPORTUNITY	**THREAT**
- Optimization of reservoirs to improve clean water services in Demak. - There are many large rivers pass through the Demak area (Jragung watershed, Tuntang, Serang-Lusi) - Opportunity to use alternative water sources such as rainwater harvesting systems. - Collaboration with the private sector to improve water services delivery and management effective use of land while preserving the ecological functions of the coastal zone. - Opportunity to develop a water-neutral industrial zone, environmentally-friendly toll road and tourism activity that also serve as coastal protection.	- Major threat from tidal flooding (rob) and coastal abrasion that continues to erode the coastal area of Demak. - industrial clusters development (6,600 ha in Sayung) and toll roads in coastal areas. - The availability of surface water is not sufficient for projected needs. There is no adequate system for monitoring groundwater use and land subsidence. - If there is no improvement in PDAM water services or there is no innovation in using alternative water sources, groundwater extraction continues and so does land subsidence, resulting in investment losses.

3.3 Economic Assessment of Subsidence Impact

An assessment of the economic impacts of subsidence can help increase the awareness and sense of urgency of addressing the subsidence problem. Furthermore, economic impact assessment can provide the economic rationale of implementing mitigative measures, and support decision making in this context. By comparing economic impacts of subsidence under business as usual (no additional measures taken) with economic impacts under alternative scenarios (additional measures taken), the benefits of taking action are identified and quantified. This section provides a short summary of the economic assessment of the subsidence impact in Semarang and Demak. The detailed elaboration of the assessment is provided in a separate document titled Economic assessment of subsidence in Semarang and Demak, Indonesia, as part of the Water Dialogue Program, that serves as a complement to this Roadmap document.

3.3.1 Subsidence scenarios

The economic impact of subsidence in the Semarang-Demak region is assessed under three scenarios:

Business as Usual (100% of current subsidence rate)

In BAU, the subsidence rate will remain constant over time. Currently planned measures that address groundwater extraction are assumed to either be ineffective in significantly reducing the subsidence rate or will not take effect until after 2040. With ongoing economic growth, the number of assets exposed to subsidence and aggravated coastal flooding will be higher: to address this, we use the land use map of 2030. Although economic growth will likely also increase groundwater demand and consequent subsidence, this relationship is a knowledge gap and cannot be quantified: we, therefore, assume the current subsidence rate will continue but not increase in the future.

Scenario A (Subsidence rate reduced by 50%)

Experiences from other countries indicate that with full effort in minimizing subsidence, the process can be significantly reduced over the span of 10 years after measures have been taken (Sato, Haga, & Nishino, 2006). Building on this, we assume that the subsidence rate will remain constant in the first 10 years (2020-2030), and then be reduced by 50% as a result of efforts to mitigate subsidence.

Scenario B (Subsidence rate reduced by 75%)

We assume that in scenario B the subsidence rate will remain constant in the first 10 years 2020-2030), and then reduce by 75% as a result of efforts to mitigate subsidence.

This assessment will provide valuable insight into the economic damage that can be avoided by stopping or reducing groundwater extraction (the main driver of subsidence) in the area, and in providing economic justification of investment in mitigative measures. Policy alternatives and their investment costs are not included in this study.

3.3.2 Economic valuation

The economic assessment is undertaken by assessing the economic damage of subsidence of two direct impacts (damage to infrastructure and to buildings), and two indirect impacts (land loss and increased flood risk). Other impacts that cannot be quantified due to data and time limitations, such as adverse health impacts, loss in landscape quality, and social disruption, will be described qualitatively. Those impacts that do not have a direct reflection in a real market, are not addressed in this assessment as there is no good way to assess these impacts without elaborate local data collection.
Figure 18 shows a schematic overview of the methodology. To arrive at an economic value for subsidence effects, we use a risk approach to make the link between the hazard (subsidence or flood risk) and the exposed assets, such as roads and buildings, and people.

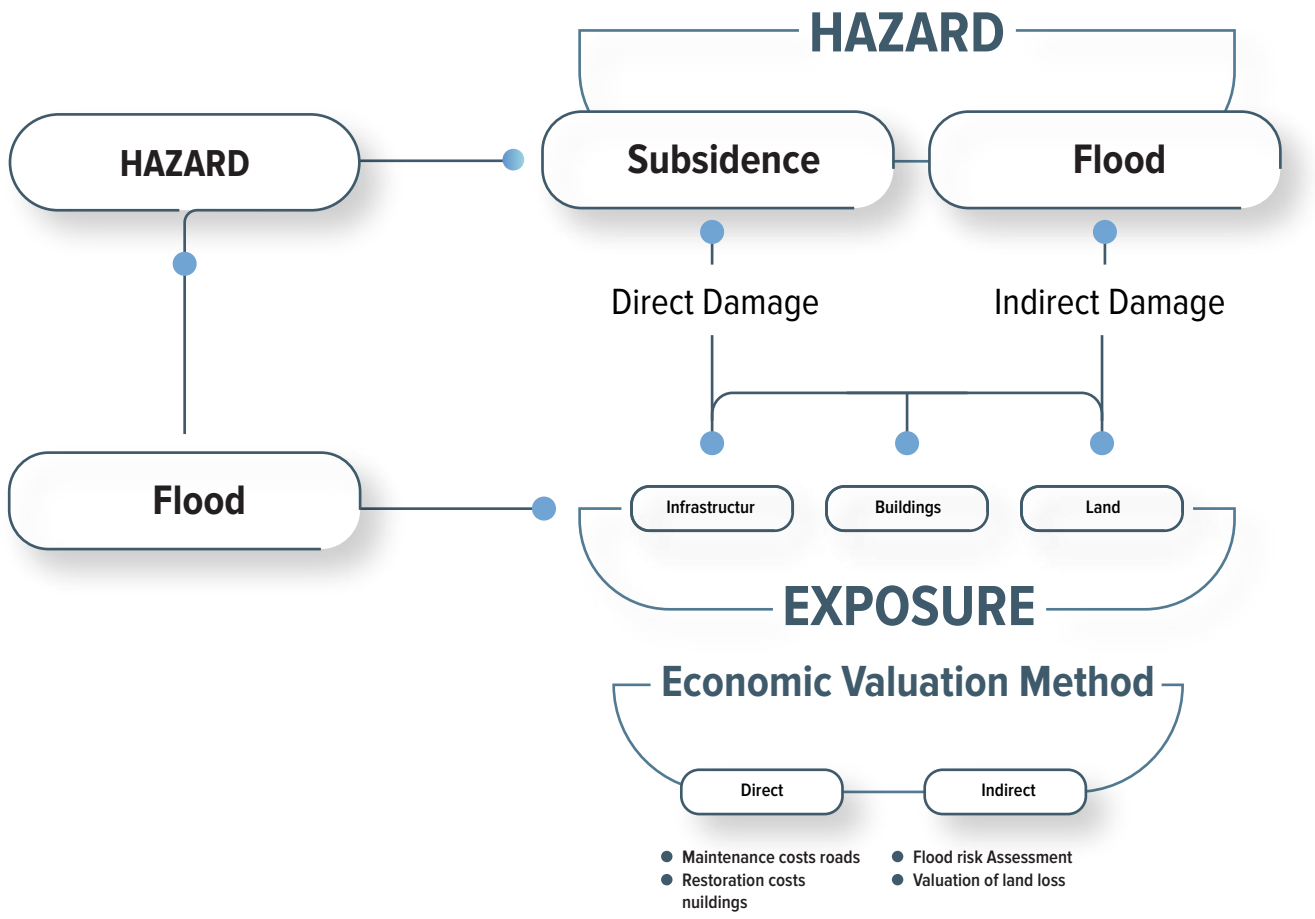

Figure 18. ***Schematic representation of the relationship between the drivers of subsidence (green), the hazards (red), exposure (grey blue) and the economic valuation methods used.***
Source: Deltares, 2021

This assessment examines the impact of subsidence directly, and the impact on flood risk. As the land sinks below the sea level (Clark, 2013) more areas will be susceptible to coastal flooding. Pluvial and fluvial flooding may also increase as inundation depths become larger, and the changing elevation complicates the discharge of water from the drainage system to rivers, and from the river to the sea, but these hazards are not quantified due to data limitations.

Exposure is the amount and type of assets exposed to the hazard. In this study, the assets under consideration include the land use type, infrastructure, and buildings exposed to subsidence and coastal flooding.

Table 7 gives an overview of the approach used for each quantified effect, based on a combination of hazard and exposure information and the value or price of damage. The following sections (listed in the last column of the figure) will provide more background and underlying assumptions for estimating damage for each of these effects.

Impacts of subsidence were calculated for 20 years in the future, for the period of 2020 to 2040. We assume damage will increase over time with average inflation over 2010-2020 4,65% (Central Bank of Indonesia, 2020). Building on recommendations from the ADB for Asia, we use a social discount rate of 10%. All values in this study are at the price level of 2020. Results will be presented for Semarang and Demak separately, as well as together, as these have distinct jurisdictional mandates (local governments).

Table 7
Overview of the different evaluation approaches for each type of damage. The evaluation approach is explained in detail in the shown sections.

Potential Damage	Evaluation approach
Direct damage	
Damage to infrastructure: roads	Additional costs in road maintenance = # m2/road type/subsidence category * additional costs (IDR)/m2/road type/ subsidence category
Damage to buildings	Damage to buildings due to subsidence = # buildings/ subsidence category * estimate restoration costs (IDR)/building/subsidence category
Indirect damage	
Increased coastal flood risk	Increased coastal flood risk = ∫#ha per land-use newly exposed to coastal flooding * damage-effect relationship (f(inundation depth, land use, return period)
Loss of land near water bodies	Economic value of land loss = #ha/land use type below MSL (Scenario A/B)*land price/ha/land use type (IDR)

3.3.3 Result of Economic Assessment of Subsidence Impact

Direct subsidence damage

Road Infrastructure

Based on overlaying the subsidence map and road map in GIS, the amount of km road impacted per subsidence class was calculated, presented in Table 8.

Table 8.
Overview of # road (in km) impacted per subsidence rate

Subsidence (cm/year)	# Road Impacted (km)			
	Road		Arterial Road	
	Semarang	Demak		
0-2	1.202	160	125	0
2 to 4	127	744	5	91
4 to 6	149		12	
6 to 8	153		15	
8 to 10	229	138	26	23
> 10	125		8	

Table 9.
Assumed additional maintenance costs due to subsidence in IDR/year/m2 road

Subsidence rate	Assumed additional maintenance costs in IDR/year	
	Arterial road	Regular road
0-2 cm / year	16. 080	10.720
0-4 cm / year	20.100	13.400
>4 cm / year	24.120	16.080

Based on these quantities and the prices (for additional maintenance) presented in Table 9, the annual costs of additional road maintenance due to subsidence amount to 128 billion IDR/year in Semarang and 80 billion IDR/year in Demak for regular roads, and 72 billion IDR/year and 55 billion IDR/year respectively for arterial roads.

Under BAU, in which subsidence is expected to continue at the same rate, this amounts to 4,307 billion IDR in present value. For scenario A, in which the subsidence rate is halved after 10 years when measures come into effect, this amounts to 3,456 billion IDR. For Scenario B this amounts to 3,030 billion IDR.

Figure 19. ***Damaged infrastructures in Sriwulan, Demak***
Source: Left: Rafii Bisatya (2021), Water Dialogue Consortium - Rizqa Hidayani (2020)

Damage to buildings

Based on overlaying the subsidence map and building data from Openstreet-map, the number of buildings impacted per subsidence class was calculated (Table 10).

Table 10.
Number of buildings affected by subsidence

Subsidence (cm/year)	# Road Impacted (km)			
	Road		Arterial Road	
	Semarang	Demak		
0-2	1.202	160	125	0
2 to 4	127	744	5	91
4 to 6	149		12	
6 to 8	153		15	
8 to 10	229	138	26	23
> 10	125		8	

Based on these quantities and the prices for the restoration of damage presented in Table 11, we calculate the damage to buildings due to subsidence (cracks, damage to windows, etc).

Table 11.
Assumed demage restoration costs for buildings affected subsidence

Subsidence rate	Assumed additional maintenance costs in IDR/year	
	Arterial road	Regular road
0-2 cm / year	16. 080	10.720
0-4 cm / year	20.100	13.400
>4 cm / year	24.120	16.080

In scenario BAU in Semarang, the present value of damage to buildings amounts to IDR 66 billion, and in Demak IDR 6 billion. In Scenario A, the damage is respectively IDR 53 billion and IDR 8 billion. In Scenario B, the damage is respectively IDR 47 and 4 billion.

In scenario BAU in Semarang, the present value of damage to buildings amounts to IDR 66 billion, and in Demak IDR 6 billion. In Scenario A, the damage is respectively IDR 53 billion and IDR 8 billion. In Scenario B, the damage is respectively IDR 47 and 4 billion.

Figure 14. ***Up left and right: Damaged buildings in Sriwulan, Demak, Down-left: Sinking building in the coast of Sriwulan. Down-right: Raised buildings to adapt with land subsidence in Sriwulan, Demak.***
Source: Rafii Bisatya (2021)

Other

Aside from damage to roads and buildings, there are many other physical assets that may be damaged by subsidence and thus lead to restoration costs/ higher maintenance, or lower service levels. These include damage to drinking water and water management infrastructure (sewage pipes, drainage channels, pumping stations, dikes), transport infrastructure (railway, ports, airports), and telecommunication and energy infrastructure (e.g. oil and gas pipes, cables). It was not possible to monetize these impacts, but there is already evidence these assets are subject to damage from subsidence in the area (illustrations in B): it can be expected this will continue in the future.

Indirect subsidence damage

Increased coastal flood risk

To calculate the increase in coastal flooding relative to the current condition due to subsidence, the increase in areas exposed to inundation are calculated for Semarang and Demak under subsidence scenario A and B. Land that becomes permanently inundated is deemed lost (see following section on loss of land). Both for Semarang and Demak, inundation depths are exceeding 1,5 m. In Semarang, mostly residential and industrial areas become subject to inundation, while in Demak the inundated areas are mostly agricultural areas.

In Semarang, 249 hectares will become subject to inundation under BAU (additional to current flood extent in 2020); 456 hectares under scenario A, and 327 hectares under scenario B. The difference between scenarios A and B and BAU is explained as under BAU more land will be permanently lost instead of just subject to additional flooding.

In Demak, 765 hectares will become subject to inundation under scenario BAU (and also a significant amount of land will be permanently lost, see next section 5.2.2). Under scenario A, less land will become subject to flooding than in BAU. Scenario B has the highest increase in total hectares flooded. These results might seem counter initiative as Scenario B presumes the lowest subsidence rate. However, scenario B has the highest flood extent because scenarios A and BAU have high loss of land. Thus, more area under scenario B becomes subject to flooding instead of being completely lost (Table 12).

Table 12.
Additional inundated area under BAU, scenario A and B in 2040, as compared to the current situation (2020) in Semarang and Demak

Area	Additional flood risk area addition under scenario A (hectares)	Additional flood risk area addition under scenario B (hectares)	Additional flood risk area under BAU (hectares)
Semarang	456	327	249
Demak	597	886	765

In present value, the overall increased flood risk due to subsidence over 2020-2040 amounts to 390 billion IDR in BAU, 392 billion IDR in scenario A, and 158 billion IDR in scenario B.

Table 13.
Damage from coastal flooding in Semarang and Demak relative to current condition for different land-use types (present value, in IDR x billion)

Land Use	A	B	BAU
Semarang			
Residential	164	132	140
Industrial	136	216	108
Agriculture	0	0	0
Aquaculture	0	0	0
Total	**300**	**348**	**248**
Demak			
Residential	25	46	54
Industrial	121	135	88
Agriculture	0	0	0
Aquaculture	0	0	0
Total	**146**	**181**	**142**

Loss of land

As can be seen in Figure 21, already in the current situation quite some land has been lost to the sea in the past decades (in grey). If land subsidence continues unabated (BAU) further loss of land will be significant (in green); if subsidence can be halved (scenario A) much land loss will be prevented (in blue), and almost all can be prevented in scenario B with quartered subsidence rate (in black).

Economic damage due to loss of land is calculated as the product of lost area and its land value. Although overall less land is lost in Semarang, the damage is relatively high as compared to Demak due to the higher land value, as most industrial and residential land is lost (Table 14). Total economic damage under BAU is IDR 113 trillion, IDR 83 trillion in scenario A, and IDR 37 trillion in scenario B.

Table 14.
Damage from land loss in Semarang and Demak relative to current condition for different land-use types (present value, in IDR x billion)

Land Use	A	B	BAU
Semarang			
Residential	45002	11628	6242
Industrial	10727	207	13714
Agriculture	23	60	25
Aquaculture	1	1	1
Total	**55753**	**13764**	**76168**
Demak			
Residential	16328	14100	23325
Industrial	3509	2892	5252
Agriculture	7254	6204	8481
Aquaculture	66	68	108
Total	**27157**	**23263**	**37166**

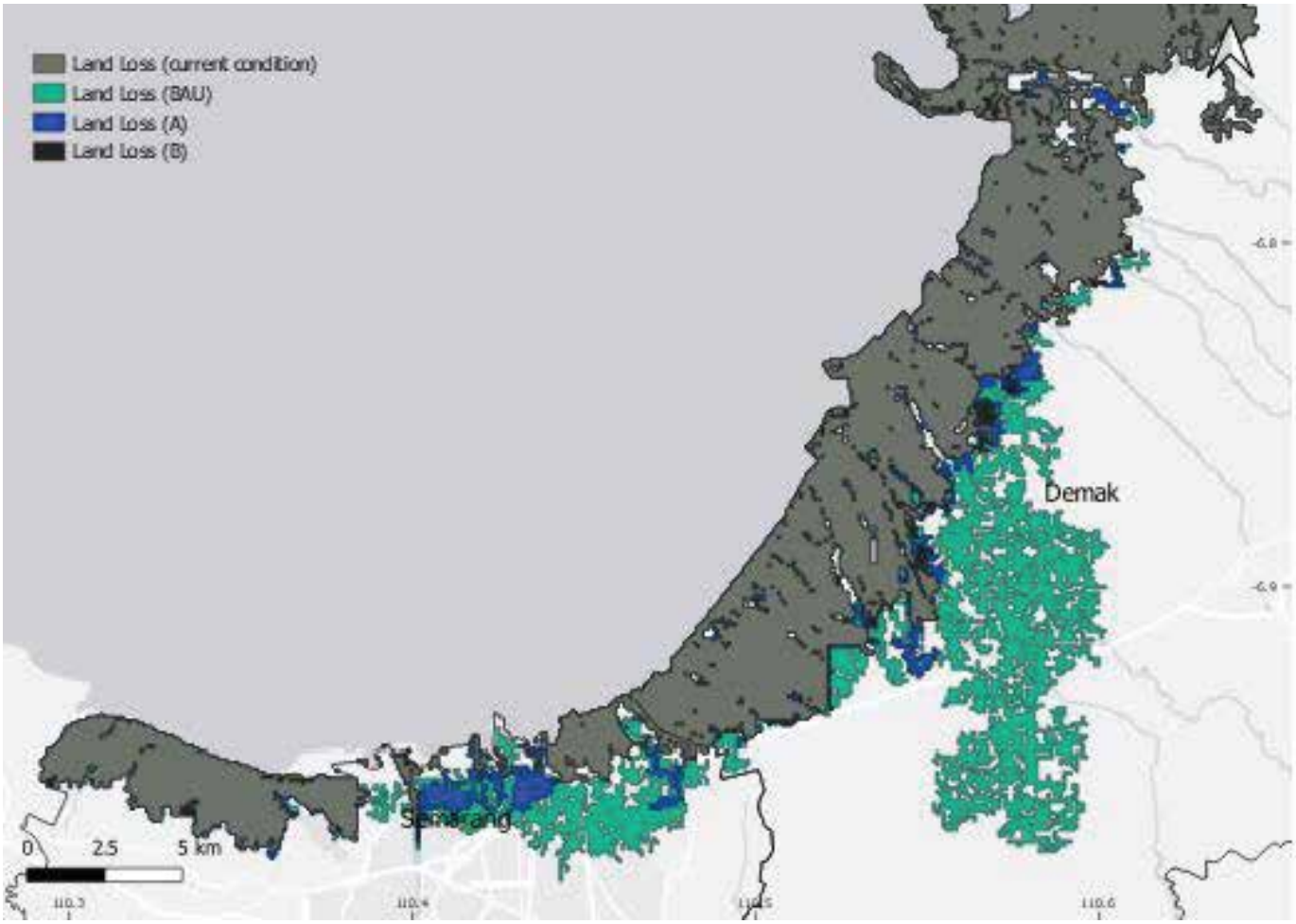

Figure 21. ***Loss of land under the different scenarios and current conditions***
Source: Deltares, 2021

Other

Aside from increased coastal flood risk and land lost permanently to the sea, subsidence also increases pluvial and fluvial flood risk. As the hydrodynamic structure of the land changes, it will become increasingly difficult for rivers to discharge to the sea, leading to high water levels at the river mouth and farther inland. Furthermore, it will become increasingly difficult to drain (rain)water from quickly subsiding areas, leading to inundation during rain events. The high (shallow) groundwater tables and increasing salinization of groundwater in the area will also negatively affect agricultural yields (aside from flooding).

Overall, the increasing flood risk and land loss, lower yields of agriculture, and lower quality and/ or higher costs for upkeep of buildings and infrastructures will reduce the attractiveness of the entire area for businesses: as illustrated by the recent decision in Jakarta to relocate administrative functions elsewhere.

For the population, all these impacts – increasing flood risk, damage to infrastructure, lower agricultural yields, and negative implications for the business climate, reduce the quality of life in general.

3.3.4 Summary of the economic impact of subsidence in Semarang and Demak

The assessment identified the following key economic impacts of subsidence: damage to infrastructure (e.g. roads, railway, drinking water, water management), damage to buildings, increased flood risk and eventual land loss, reduced the attractiveness of the business climate, lower agricultural production, and decreased quality of life for the population. Of these measures, damage to roads and buildings, coastal flood risk, and land loss have been monetized. Other impacts, in particular damage to other types of infrastructure (e.g. water management, sewage), fluvial and pluvial flood risk, and reduced attraction of the business climate are likely also significant in terms of economic impact but could not be quantified due to time and data limitations.

Table 15 shows the overview of economic impacts of subsidence under BAU, scenario A and B over 2020-2040, in billion IDR. The most significant impact of subsidence by far is land loss, followed by increased costs for maintenance of roads and arterial roads, and increased coastal flood risk.

If there is no new policy adopted (BAU), the total order of magnitude of impacts monetized in this study is around IDR 76 trillion for Semarang, and IDR 37 billion for Demak, corresponding to approximately $5,4 billion and $2,6 billion. By reducing subsidence with 50 % (Scenario A) or 75 % (Scenario B) after 10 years, respectively 30 and 66% of this damage can be prevented.
These results do not give a full picture of the extent of damage (prevented) under different subsidence scenarios, as not all effects could be quantified. However, the results indicate that damage from subsidence in Semarang and Demak is very significant, particularly in relation to land loss, direct damage to buildings and infrastructure is significant as well for individual home owners and infrastructure owners. In terms of economic impact, particular increased pluvial and fluvial flood risk may be expected to significantly increase with land subsidence. Other infrastructures beside roads will likely also have significantly higher life cycle costs due to subsidence. Furthermore, consequences of subsidence may lead to a reduced attractiveness of the business climate, possibly lower agricultural yields and an overall lower quality of the life for the population. The extent of flood risk and land loss, and the long duration before measures could take effect (10 years), demonstrate a high urgency to act in the short term.

Table 15.
Overview of economic impacts of subsidence under BAU, scenario A and B over 2020-2040, in billion ID

Effect	Damage in Semarang (billion IDR)			Damage in Demak (billion IDR)		
	A	B	BAU	A	B	BAU
Direct						
Increased road maintenance	1346	1180	1677	798	700	994
Increased arterial road maintenance	764	670	951	549	481	684
Increased road maintenance	53	47	66	5	4	66
Increased road maintenance	PM	PM	PM	PM	PM	PM
Indirect						
Land Loss	55753	13764	76168	27157	23263	37166
Increased Coastal Flood risk	300	348	248	146	181	142
Increased road maintenance	PM	PM	PM	PM	PM	PM
Increased road maintenance	PM	PM	PM	PM	PM	PM
Total (present value in billion IDR)	**58216**	**16009**	**79110**	**28655**	**24629**	**39052**

3.4 Proposed Adaptation and Mitigation Measures

Addressing land subsidence in the coastal areas has proven to be challenging, as it presents complex technical and societal issues involving many stakeholders with wide-ranging interests. With an understanding of the cause and impact of subsidence in the north coast of Central Java Province, using the case of Semarang and Demak, a combination of mitigation and adaptation measures is required to address the issue both in the short term and long term.

On a conceptual level, **mitigation strategies** focus on how to minimize the rate of land subsidence by addressing its cause. Therefore, the effort to mitigate land subsidence in Central Java Province should be targeted to significantly reduce the groundwater extraction by (1) **Accelerating the improvement of water provision and conservation** in critical areas by maximizing the non-groundwater sources, (2) **Improving enforcement, compliance and monitoring** of groundwater extraction activities, and (3) **Improving land-use management**, by integrating the issue of land subsidence into spatial planning and making sure the effective enforcement.

Currently, there are several mitigation measures implemented in Central Java Province, particularly Semarang and Demak, for example, the provincial government has been developing a drinking water masterplan to significantly improve the water supply for the region. While in Semarang, the Spatial plan of Semarang City 2011-203 has planned improvement of the water supply system, with development of four large and 19 smaller drinking water reservoirs. On a smaller scale, the local government has been promoting the rainwater harvesting system in several neighbourhoods throughout the city. City government of Semarang already has regulations that restrict groundwater extraction in Tugu District, West Semaran District, North Semarang District, Central Semarang District, South Semarang, however, enforcement of the regulation and monitoring still become challenges.

On the land use management, there were a good example of pilot project in Sukorejo on land arrangement models, which provide guidance and information to the public about the role of land arrangements in minimizing the disaster by developing conservation model i.e. conservation of plants, planting patterns direction and terrace, creating catchment wells, bio pores, and greening in order to minimize erosion disasters, drought, and floods. However, this example needs to be escalated at the city level, and strictly implemented, particularly in the critical areas. This should be followed by improvement on enforcement, compliance and monitoring of groundwater extraction activities, which are currently still limited.

The following table provides a list of the proposed mitigation measures that can be taken to mitigate land subsidence in Central Java Province. Further description of the list is provided separately in another document that serves as a complement to this roadmap.

Table 16.
Proposed Mitigation Measures

Accelerating the improvement of water provision and water conservation in critical areas by maximizing the non-groundwater source			
1	Artificial recharge of aquifers	Infrastructure	The main purpose of artificial aquifer recharge is to store excess water by recharging the aquifer. Artificial recharge can be done through injection of water through wells. This method often is applied to recharge deep aquifers where the natural groundwater is not effective at recharging these aquifers.
2	Improve water supply coverage through conveyance pipe network	Infrastructure	Expanding the coverage of piped water service particularly in the critical area with no access to the service is one way to reduce the use of groundwater. In Semarang and Demak, some of the coastal neighbourhoods with high land subsidence rate (i.e in Kecamatan Genuk) do not have access to PDAM water. In fact, coverage in the city level (in Semarang) is quite low (only 59 %), with a quite high water loss rate (37%).
3	Water treatment (e.g. recovery of freshwater)	Infrastructure	Improve water availability and reduce consequences of variability. The reclaimed water can be used for urban, agriculture, industrial, recreational, or environmental purposes. The potability of the water depends on the treatment process, but it can be maximized for non-driking purpose.
4	Water desalination	Infrastructure	Desalination is a process to remove the minerals and salts from saline water. Saltwater is desalinated to produce a safely-used water for urban, agricultural, and even potable uses.
5	Construction of water reservoirs	Infrastructure	Water reservoir is an artificial lake that is used to store a large supply of water. The main use of this artificial water body is to collect and store excess water from rainfall, river, or surface run-off. The stored water is essential for supplying water supply for households and industrial uses. The water can be piped through gravity and generate hydroelectricity using turbines to downstream areas. Reservoir helps to control flooding as well by limiting the amount of water allowed to continue downstream.

Accelerating the improvement of water provision and water conservation in critical areas by maximizing the non-groundwater source			
6	Water neutral industry (+urban) programme	Infrastructure	Water neutral industry is a program to develop an industry to capture, treat and reuse water locally so no ground water extraction. This program is a step towards stopping groundwater extraction and reducing land subsidence while simultaneously promoting sustainable and circular economic growth by creating incentives to optimize water supply and management systems based on rain water harvesting, storage, conveyance, reuse and recycling. This program is an integration of several measures to store and reuse more water. In the future, it will also create an eco-friendly zone.
7	Rainwater harvesting (RWH)	Infrastructure	Rainwater harvesting (RWH) is a method to collect the run-off from a surface or other impervious surface in order to store it for later use. There are some techniques that can be used for RWH, such as surface runoff harvesting, roof-top rainwater harvesting (RRH), dams, underground tanks, rain saucer, barrage, slopes, trenches, or rain barrels. The harvested water can be used for agriculture, industry, or domestic uses. Water purifier needs to be installed to produce potable water.
8	Infiltration basin	Infrastructure	Infiltration basin is an artificial pond that is designed to infiltrate surface run-off through permeable soils into the groundwater aquiver. It is different from a water reservoir or retention basin, which is designed to store excess water in a permanent pool of water. The infiltration basins may be less effective in areas with high groundwater levels, compacted soils, high levels of sediment in stormwater, or high clay soil content (ASCE, Urban Runoff Quality Management, 1998). However, infiltration basins must not be built nearby industrial sites where spills of toxic material may occur.
9	Conjunctive use of surface water and groundwater as water source	Regulation	The increasing water scarcity problems requires the adoption of a double approach of water supply management. The conjunctive use of both surface and groundwater is one of the strategies of water supply management. This method has to be considered to optimize the water resource development, management, and conservation. It helps to consider the water resource as a one system and would avoid a water resource development approach focused only on surface water. Since the surface water has poorer-quality compared to the groundwater, it still may require extensive water treatment.

Improving enforcement, compliance and monitoring of groundwater extraction activities			
10	Groundwater extraction policy and policy enforcement	Policy instrument	Groundwater policy is an essential instrument to reduce groundwater extraction. There are some examples of groundwater policy, such as tax procedure for private companies who use groundwater source, restriction policy for groundwater extraction, and groundwater use restriction by zoning. The groundwater policy needs to be assessed with policy reinforcement to ensure compliance with the procedures. Policy reinforcement can be implemented by monitoring the policy implementation and giving incentives to the people.
11	Land Subsidence Monitoring	Data and regulation	Monitoring land subsidence is an essential step to track the land subsidence rate in an area. The aim of this measure is to improve understanding of the processes responsible for changes in the elevation of the land's surface. Monitoring the land subsidence could be measured from land surface elevations, aquiver-system compaction, and water levels. The most frequent techniques to measure elevation-change are interferometric synthetic aperture radar (InSAR), continuous GPS (CGPS) measurements, campaign global positioning system (GPS) surveying and spirit-leveling surveying. While for the aquifer-system compaction is measured by using extensometers. The extensometers make the measurement at a specific depth of interest possible. The most precise measurements tend to be made using spirit-leveling surveys and extensometers, while the least precise are using GPS surveying.
Improving land-use management			
12	Land-use management (clustering/zoning)	Regulation	Land-use has a close linkage with groundwater extraction. The land-use change can have long lasting and irreversible impacts on aquiver. Some land-use that influences groundwater extractions are open-cast mining, deforestation, and urbanization. Applying special protection in special zones, defined by hydrogeological criteria, is needed to provide better socio-economic and environmental returns. This is a better approach compared to treating all land equally. There are different types of groundwater conservation and protection, which require the definition of land-surface zones at varying geographical scales. Groundwater zoning can be classified into three types; Groundwater resource conservations, groundwater and soil salinization control, and groundwater quality production. The zoning depends on the principal objectives and severity of the groundwater condition in the area.

Meanwhile, adaptation strategies focus on how to deal with the risks caused by the impacts of land subsidence (i.e. measures dealing with the increasing flood risk). This involves a wide range of measures from the development of dyke, pumping station, polder system, building codes, adaptive housing design, etc. However, adaptation measures can not be seen as a long term solution, but rather a short term action to adapt to and minimize the risk of land subsidence. And since significant land subsidence keeps happening and worsening by the sea level which continues to rise.

Currently, there are several small-scale adaptation measures implemented by the local governments and individuals in Semarang and Demak, aiming to reduce the damages of subsidence and risk of flooding, such as elevation of roads, buildings and bridges; construction of dikes and a polder system along floodway canal and shoreline; construction of pumping stations; construction of floodway to reduce fluvial flooding, development of drainage master plan and water resource management plan, and mangrove restoration (Andreas et al., 2017).

The following table provides a list of the proposed adaptation measures that can be taken to adapt to land subsidence in Central Java Province. Further description of the list is provided separately in another document that serves as a complement to this roadmap.

Table 17.
Adaptation Measures

No	Measure	Category	Short Description
1	Construction of dikes	Infrastructure	Dike is an artificial structure along the river bank or low lying coast to prevent water from flooding into the land area. As the land subsides, the water level, at the river or sea, will become higher than the land level. As a consequence, the water will be able to flood the land area. Dike construction will temporarily prevent this tragedy from occurring.
2	Construction of polder system	Infrastructure	Polder is a low lying area enclosed by flood defenses that require drainage systems to control the water levels inside the system (Lendering, 2015). As the land subsides, the water level will be higher than the land area. Polder system prevents the surrounding water from entering the land area. It must be noted that this type of structure lies below the surrounding water level. Both the investment cost and the flood risk are determined by the flood defense level. To control the water level inside the polder, it is necessary to install drainage systems.
3	Raising grades for railroads and roads	Infrastructure	The land subsidence produces impacts to tidal inundation. The straightforward strategy to prevent the flood entering the land is by raising grades for roads and railroads. As a consequence, the houses and buildings will be located below the road level. Heavy rainfall will jeopardize the civilization, since the surface run-off tends to flow inside the houses and buildings. Cost to raise the road is also relatively higher compared to constructing dikes.

No	Measure	Category	Short Description
4	Integrated Coastal Zone Management	Governance and regulation	Integrated Coastal Zone Management (ICZM) is a planning and coordinating process for the management of the coast using an integrated approach, with respect to all sectors. The main goals of ICZM are maintaining the functional integrity of the coastal resource systems, reducing resource-use conflicts, maintaining the health of the environment, and facilitating the progress of multisectoral development (Thia-Eng, 1993). There are several types of integration that occur within ICZM; integration among sectors (e.g. tourism, fisheries, port companies), between land and water element of the coastal zone, among level of government, between nations, and among disciplines (scientific, cultural, traditional, political, and local expertise) (Cicin-Sain, 1993). The involvement of all parties of interest is the main distinguishment of this measure.
5	Construction and development of public blue-green infrastructure	Infrastructure	Blue-green infrastructure (BGI) can be defined as a network of green spaces that provides multiple water-related ecosystem services (Kuei-Hsian Liao, 2019). It is an implementation of socio-ecological practice in the urban area. BGI consists of the green spaces; such as parks, urban forests, wetlands or green yards, and water areas; such as waterways, bioretention swales, bioretention basins, or sediment basins. These aquatic green spaces are mainly used for controlling flood, storing the surface run-off, improving the water quality, and supplying the water. BGI also plays a key role in improving ecological connection and mitigating urban heat island effects (UHIE) (Žuvela, 2016).
6	Building and infrastructure codes	Regulation; Awareness Raising	Building and infrastructure codes are a set of regulations that define the standards for constructed structures. The objective of building and infrastructure codes is to prevent the effect of land subsidence in the structures, so the land subsidence rate should be taken into account for the construction.
6	Awareness raising in dealing with land subsidence	Awareness Raising; Governance	Awareness raising is some activities to inform and educate people regarding an issue with the aim of influencing their behaviors and beliefs to achieve a goal. These activities include workshops, pamphlet distribution, and dissemination of information via website (JICA, 2019). Awareness raising could be implemented with a top-down strategy, starting from government organizations, stakeholders, to residents.
6	Construction of retention basin	Infrastructure	Retention basin is a permanent artificial pool of water. The main uses of the retention basin is to manage flooding and downstream erosion. It is also able to improve the water quality in an adjacent river, lake, or bay. Retention basin is often landscaped with a variety of vegetation. It helps to provide water quality benefits by removing soluble nutrients through uptake. (UFCD, 2009). Retention basin differs from an infiltration basin which is designed to infiltrate stormwater through permeable soils. By integrating it with a water treatment plant, the contained water can be used as an alternative water supply.

CHAPTER 4 — ROADMAP OF STRATEGIES

4.1 General Framework of the Roadmap

Addressing land subsidence in the coastal areas has proven to be challenging, as it presents complex technical and societal issues involving many stakeholders with wide-range of interests. Generally, land subsidence is a slowly progressing, hidden threat, often not leading to a sense of urgency. In many cases, technical options to mitigate and adapt to subsidence are readily available, but formulating a subsidence strategy is difficult, let alone implementing its strategic measures. Thus, formulation of a Roadmap of adaptation and mitigation to land subsidence in Central Java Province is a crucial first step towards a more coordinated effort in minimizing risk of land subsidence and the associated impacts in a clear targeted time frame.

A description of the roadmap's general framework for Central Java Province is shown in Figure 22. The general framework provides an overview regarding current conditions of land subsidence disaster in Central Java along with mitigation and adaptation measures that are currently underway. The general framework also indicates that a land subsidence disaster risk and hazard map remains absent in Central Java Province to date, including the monitoring model, which can also be considered unavailable. As a matter of fact, land subsidence disasters are currently an ongoing phenomenon, yet adaptation and mitigation efforts have not been taken optimally. This is indicated with the unavailability of risk and hazard maps as well as sketches of land subsidence monitoring. Accordingly, strategies for implementing land subsidence adaptation and mitigation efforts are required in order to achieve the expected targets and conditions. Nine (9) implementation strategies is outlined in the roadmap document in order to achieve the goals of land subsidence disaster adaptation and mitigation in Central Java Province, namely:

1. Establishment of a designated institution / governance platform to coordinate and oversee the development and implementation of adaptation and mitigation measures,
2. Formulation of necessary regulations,
3. Development of programs and budget,
4. Development of a monitoring system,
5. Development of an early warning system,
6. Development of land subsidence disaster risk and hazard maps,
7. Implementation of short term measures (adaptation),
8. Implementation of long term measures (mitigation),
9. Carry out education and capacity building efforts.

The establishment of an institution and legal basis for policy is one of the key priorities among the land subsidence disaster adaptation and mitigation strategies in Central Java. This strategy must be accomplished swiftly, within a period of one year (2022) at the latest. Following institutional establishment, the next key strategy is the drafting of regulations that serve as the basis in creating programs and budgeting. Implementation of adaptation and mitigation should also be supported by adequate information and database, which, accordingly, leads to the need for a monitoring system, early warning system, and the formulation of land subsidence disaster risk and hazard maps. These are some key strategies in the implementation of land subsidence adaptation and mitigation that needs to be executed urgently.

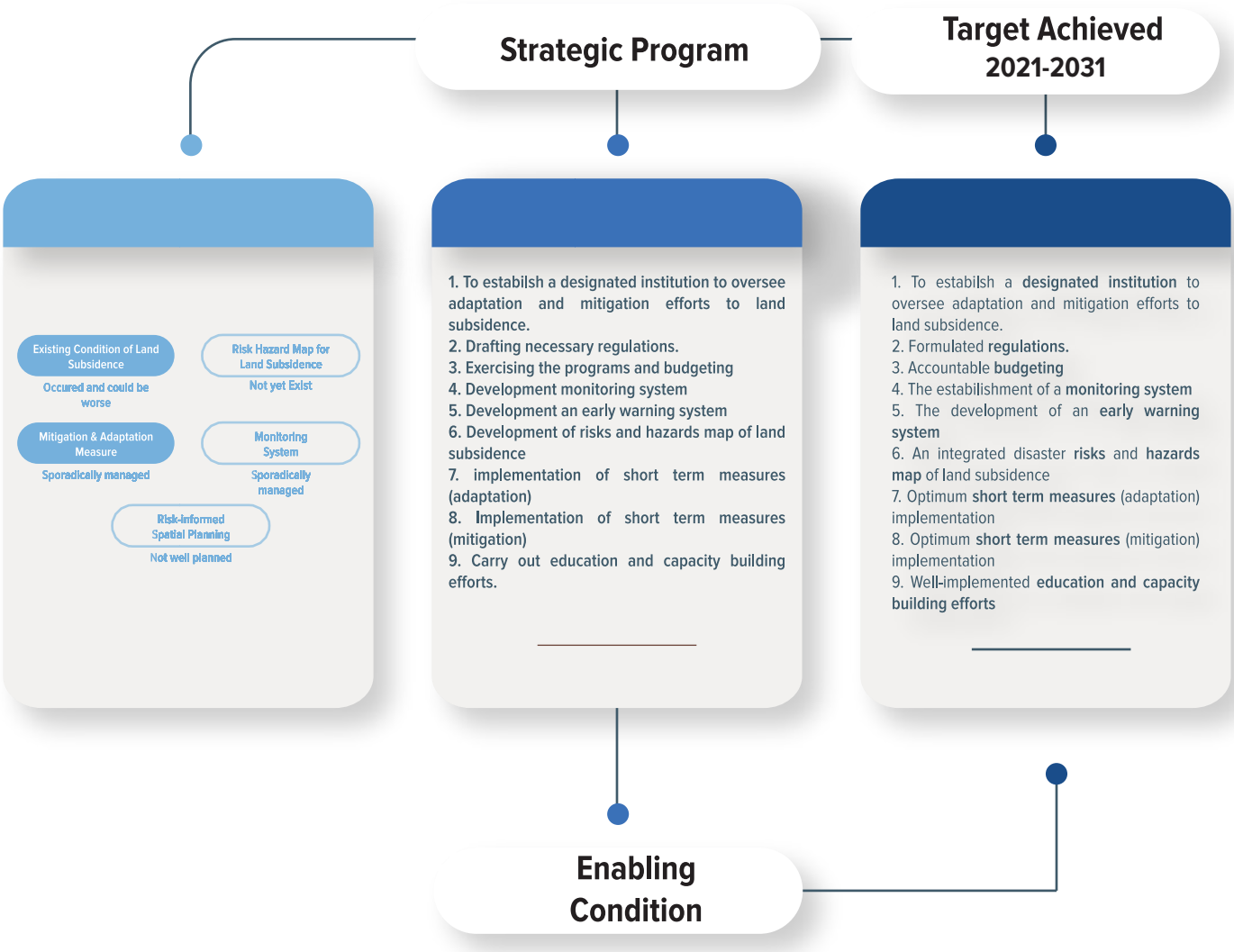

Figure 22. ***General framework of the roadmap for adaptation and mitigation of land subsidence and relevant disasters in Central Java***

4.2 Timeline of Roadmap

Based on lessons-learnt from other metropolitan cities (i.e Tokyo, Shanghai, Osaka, and others) it will take at least 10 years to carry out efforts to overcome land subsidence. These efforts are presented in the roadmap, including its timeline. With an optimistic scenario, efforts to address land subsidence in Central Java can be achieved within a similar period. The roadmap is thus used as a reference in the implementation of land subsidence adaptation and mitigation. The following figure provides information regarding the implementation timeline of the land subsidence adaptation and mitigation strategies in Central Java.

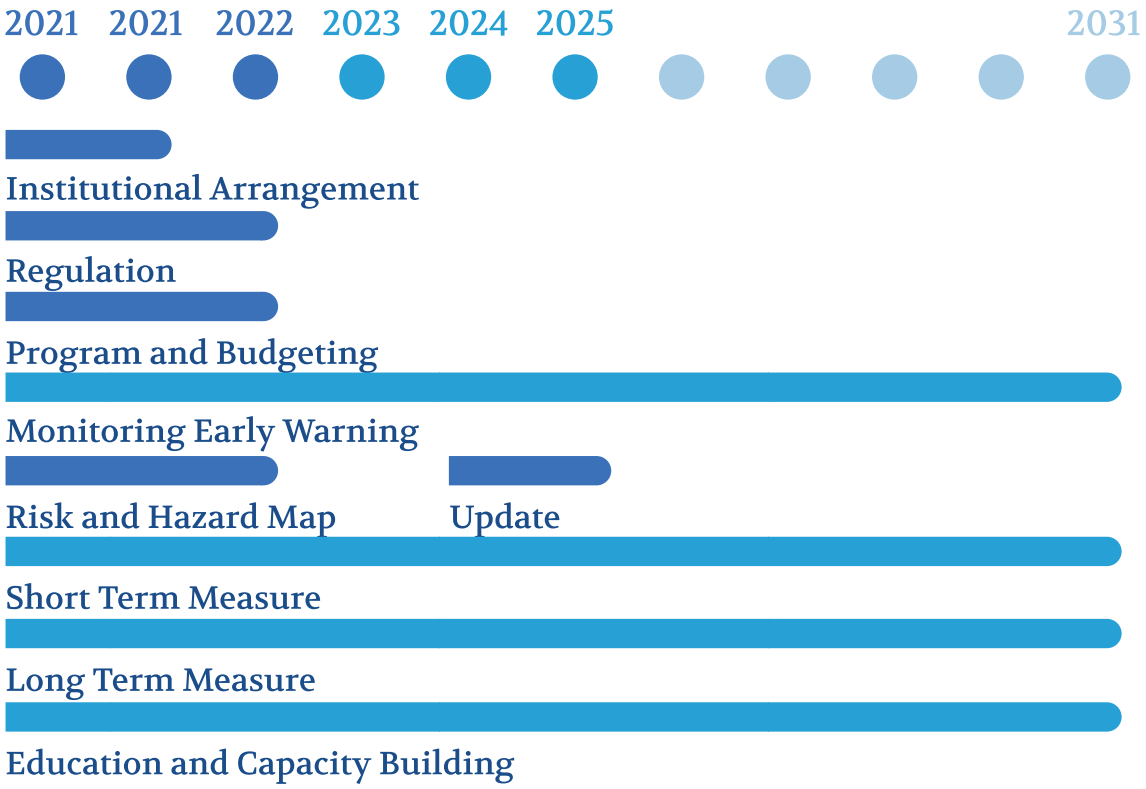

Figure 23. ***Timeline of the Roadmap for Adaptation and Mitigation of Land Subsidence and Relevant Disasters in Central Java***

The establishment of a designated institution or governance platform is the first step to be performed in the roadmap timeline. An institution or governance platform should be established as early as 2022, or at the very least it should be in an ad hoc form so that adaptation and mitigation efforts can be better executed. With a designated institution, the next strategy is to formulate necessary regulations. As a matter of fact, currently a comprehensive regulation is yet to be produced. Regulation is an absolute component on creating programs and budgets as it serves as the legal basis for the program and budgeting process. In an attempt to understand the phenomenon of land subsidence along with the potential disasters it may generate, it is necessary to conduct monitoring activities and development of an early warning system. Data and information obtained from the early warning and monitoring system will serve as input parameters utilized to create a map of land subsidence risks. The lack of mapping, early warning, and monitoring systems will, consequently affect the accuracy to assess land subsidence.

As land subsidence is occurring regularly, accordingly, adaptation efforts or short term measures such as building embankments, elevating infrastructures, and so forth should, immediately, be implemented and to be maintained continuously. These efforts are expected to be accomplished by 2025. On the other hand, some key efforts to prevent increasingly massive land subsidence can be done through mitigation efforts such as water management, disaster risk based land management or spatial arrangement. These efforts can be carried out henceforth until 2031.

By conducting a proper implementation and measurement of land subsidence mitigation in Central Java, the issue of land subsidence is expected to be significantly reduced by the end of 2031. With an optimistic scenario, by 2031 the issue of high land subsidence rate in Central Java could be reduced significantly. The phenomenon of land subsidence and the impacts it contributed up to the disaster phase should not be made available for only a small group of population, or even just the government. All elements of the society must be aware of the information related to land subsidence as the implementation of mitigation and adaptation measures will involve all elements including the community. Therefore, to ensure the dissemination of information education and capacity building plays an important part in the roadmap.

4.3 Roadmap Implementation Action Plan and Strategies

As already mentioned in section 4.2, from lessons learned in great metropolitans such as Tokyo, Shanghai, Osaka, and others, it will take at least 10 years to address land subsidence issues. It is expected that the same period of 10 years serves as the target in Indonesia and, particularly, in Central Java. This is potentially achievable given the clear way forward and implementation pathway in the short and long-term which manifested in the roadmap. Provided in the following are elaborations for the respective land subsidence adaptation and mitigation strategies in Central

4.3.1 Strategy 1: Development of a designated institution to oversee adaptation and mitigation measures to land subsidence

The establishment of a designated institution or governance platform is a crucial first step in addressing the issue of land subsidence since the adaptation and mitigation activities will, ideally, be undertaken and coordinated under the responsibility and authority of a certain institution or platform. In addition, adaptation and mitigation measures to address land subsidence in Indonesia, particularly in the Central Java area, remain overlooked due to the absence of a designated-coordinating institution. This clearly underlines the need to form such an institution. Subsequently, the established institution can be in the form of a Centre, Board, Working Group, or any other forms that is deemed appropriate to have a robust mechanism in addressing the issue.

As a lesson for Indonesia, the management of land subsidence in other countries was taken more seriously in the respective countries (i.e through the establishment of a designated institution such as a key laboratory to monitor the rate of land subsidence, or even a museum on land subsidence in Shanghai) (Figure 24). The United Nations through UNESCO has also formed a specific working group addressing land subsidence. This signifies the importance to address this issue seriously as its impacts are destructive and will cause substantial damage to the overall sustainable development agenda.

Figure 24. ***Key laboratory of and subsidence monitoring and prevention Shanghai and museum of land subsidence in Shanghai***

The designated institution or governance platform should have the overall function of overseeing the issue of land subsidence in Central Java. Specifically, some major divisions in the institution must have the function of monitoring and early warning systems, to carry out or coordinate adaptation measures, mitigation measures, education and capacity building functions as well as law enforcement.

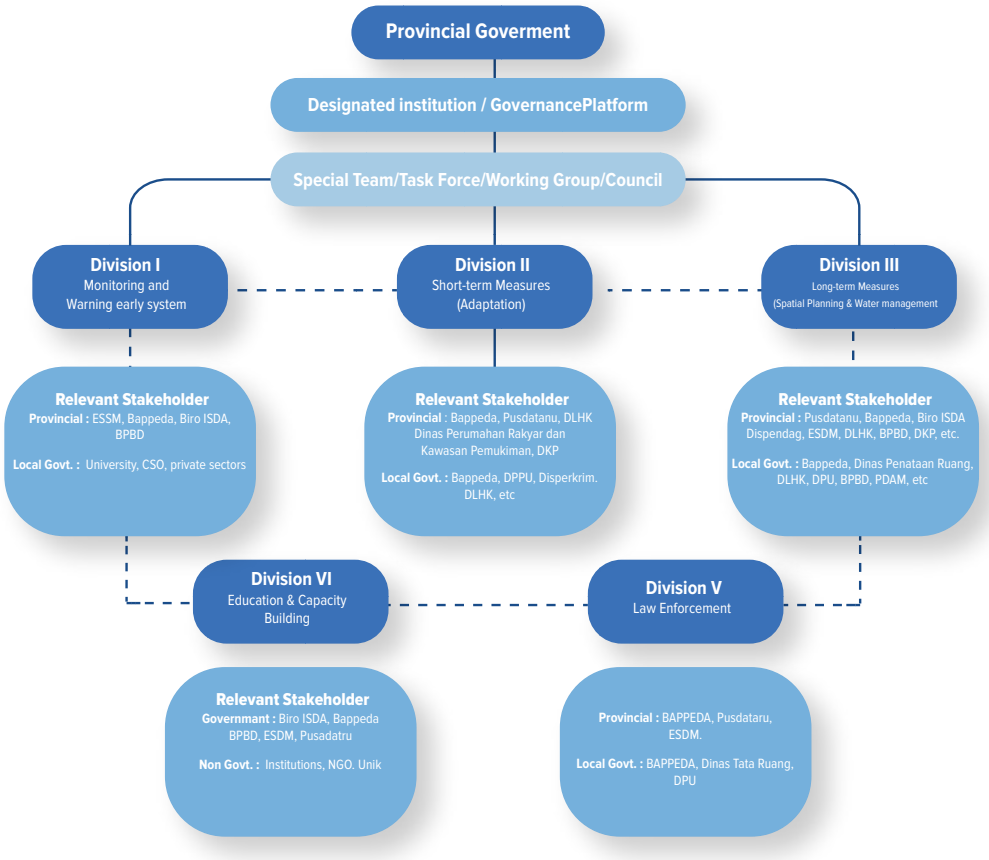

Figure 25. ***Visualization of the Proposed Arrangement of the Institution***

The establishment of the coordinating institution or governance platform in addressing land subsidence is primarily aimed at optimizing and integrating the inter-sectoral efforts to mitigate and adapt to land subsidence in a more coordinated manner, with a clear target and responsible institutions for each set of interventions. Meanwhile, the form of the institution could be the form of a new institution or by optimizing existing institutions or platforms at the provincial level. This is in line with the President Joko Widodo's vision on bureaucratic reforms and institutional streamlining. The identified stakeholders based on its sectoral activities (i.e technology and monitoring, water management, spatial planning and infrastructure, and law enforcement) in the previous section could be used as a reference for work division as illustrated in Figure 25.

Based on the coordination process conducted with local governments in the Central Java Province through FGD and local workshops, there are some insights on the designated institutions, or platform, to oversee and coordinate adaptation and mitigation efforts to land subsidence. In the context of Central Java Province, as there are already existing structures in the local government, the structure of the institution can manifest as a Working Group (Kelompok Kerja), a Council, or a Forum of Stakeholders. This will accommodate the coordination process between different structures in the local government.

It must be noted that the establishment of the designated institutions or governance platform must refer to the structure at the national level. For example, in the area of water resources, there is a Water Resources Council (Dewan SDA Nasional) at the national level designated to be the coordination platform for water resources management between national stakeholders. This council is a non-structural institution that directly reports to the President. The establishment of a designated institution at the local level should model the same approach at the national level, and must strictly refer to the mandates/legal reference at the national level (i.e. through Presidential Decree or Ministerial Regulation). The legal reference at the national level will assist in the easier development of programs and budgets in implementing the adaptation and mitigation measures, as there will be a clear budget channel at the higher level.

The proposed institutional framework above (Figure 25) is prepared by adapting the existing structure at the national level Working Group on Land Subsidence. With the existence of institutional alignment at the central and provincial levels, it is hoped that the coordination and synergy to cope with land subsidence handling can be implemented optimally. Later, the implementation of the land subsidence mitigation and adaptation program can be carried out more intensively by each sector at the central and provincial levels. Also, inclusive collaborations involving non-governmental organizations/institutions such as academics, the private sector, NGOs, and community organizations also need to be encouraged to optimize the implementation of mitigation actions and land subsidence adaptation in the Lowlands of Central Java Province.

Further description of the roadmap and timeline for the development of institutional framework is provided in ANNEX II.1.

4.3.2 Strategy 2: Formulation of Necessary Regulations

The second strategy following institutional arrangement is the formulation of regulatory framework. To date, there is no specific regulation concerning comprehensive management of land subsidence both at the national and regional levels. Regulation is a crucial component in creating programs and budgeting as it serves as the basis of implementation. The first priority should be given to the amendment of Law 24/2007 on Disaster Management to include land subsidence, which is currently being revised. At the moment land subsidence nomenclature remains excluded from the disaster category in the law.

Once the land subsidence nomenclature is included in the disaster category, it will be easier for policymakers to follow up with programs and budgets relating to land subsidence. Subsequently, once normative regulation is in place, it should be followed up by drafting technical regulations concerning land subsidence, including Regional and Local Regulations. Further description of the roadmap and timeline for the formulation of supporting regulations, which is a vital part of the roadmap, is provided in ANNEX II.2.

4.3.3 Strategy 3: Development of Programs and Budget

According to the existing regulation, programs and budgeting process cannot take place if the base regulation is not in place. Therefore, any effort to address this issue will remain unregulatory--hence, not sustainable in the long term. In Central Java, programs for land subsidence disaster risk mapping, early warning, monitoring, and others remain unavailable. Accordingly, once the process of formulation of regulation is done, activities to develop programs and budget must be conducted immediately.

Some of the proposed schemes for the program development could adopt a penta-helix or bottom-up approach. With a penta-helix or bottom-up approach, the local government and, most importantly, the community could be encouraged to be more proactive in addressing the issue of land subsidence on the ground. At the same time, this scheme could also accommodate more community participation on this issue, so more stakeholders could be involved.

On budget related issues, the permission for land utilization in subsidence prone areas should take into account the financing process for risks associated with land subsidence. Activities that are permitted in the area should have financing components that can be used as a blended finance for adaptation and mitigation measures to land subsidence. This is in line with the function of the roadmap to accommodate more involvement from the broader stakeholders, primarily private sectors in addressing the challenges of land subsidence.

Further description of the roadmap and timeline for the development of programs and budget is provided in ANNEX II.3.

4.3.4 Strategy 4: Monitoring of Land Subsidence

As briefly explained in section 4.2, in order to understand the phenomenon of land subsidence and the potential disaster it may cause, monitoring of areas that experience land subsidence needs to be done. Data and information obtained from early warning and monitoring processes serve as input parameters in creating a land subsidence risk map--which can be used by related stakeholders for different purposes. Provided below are documentation of land subsidence monitoring activities using GNSS in the northern coast of Java. In the following years, a more advanced monitoring device (i.e. extensometer in Shanghai) could also be installed to perform monitoring activity. This can also be a reference for setting up a monitoring system in the Central Java area.

An extensive description of the roadmap and timeline for monitoring land subsidence, is provided in ANNEX V.

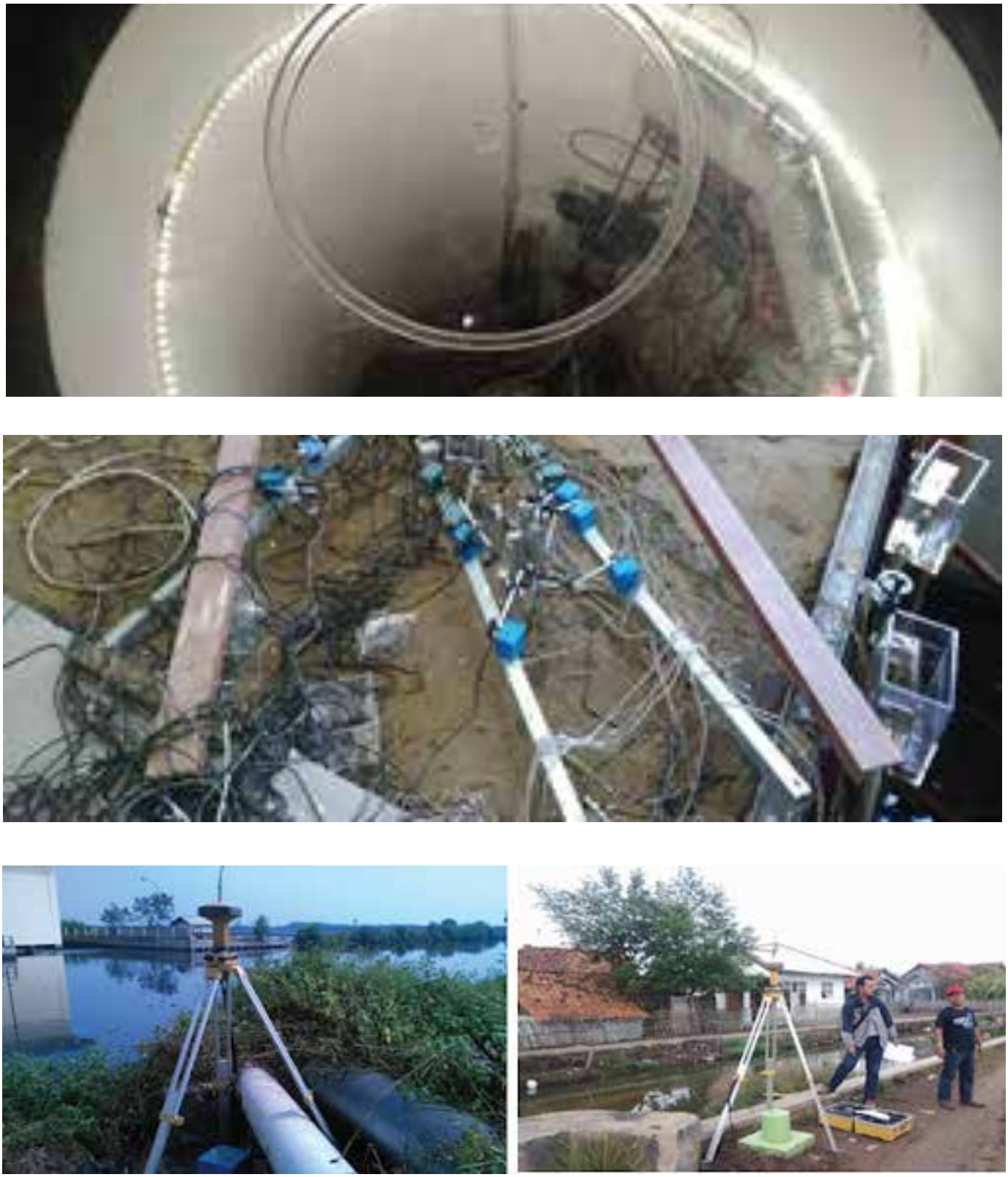

Figure 26. ***Documentation of land subsidence monitoring operation using GNSS in the northern coast of Java and land subsidence monitoring device in the city of Shanghai.***

4.3.5 Strategy 5: Development of an Early Warning System

As already explained in section 4.2, an early warning system (EWS) should be developed in order to understand the phenomenon of land subsidence and the disaster potential it may cause. The system is a development of the monitoring system that operates in real time. Provided below is an illustration of a land subsidence disaster early warning system that is currently being developed in Jakarta. As mentioned above, this system is a development of a continuous monitoring system. The illustration of the currently developed early warning system in Jakarta can serve as a reference for developing an early warning system in the Central Java area.

Further description of the roadmap and timeline for developing an early warning system, which is a substantial part of the roadmap, is provided in ANNEX II.5.

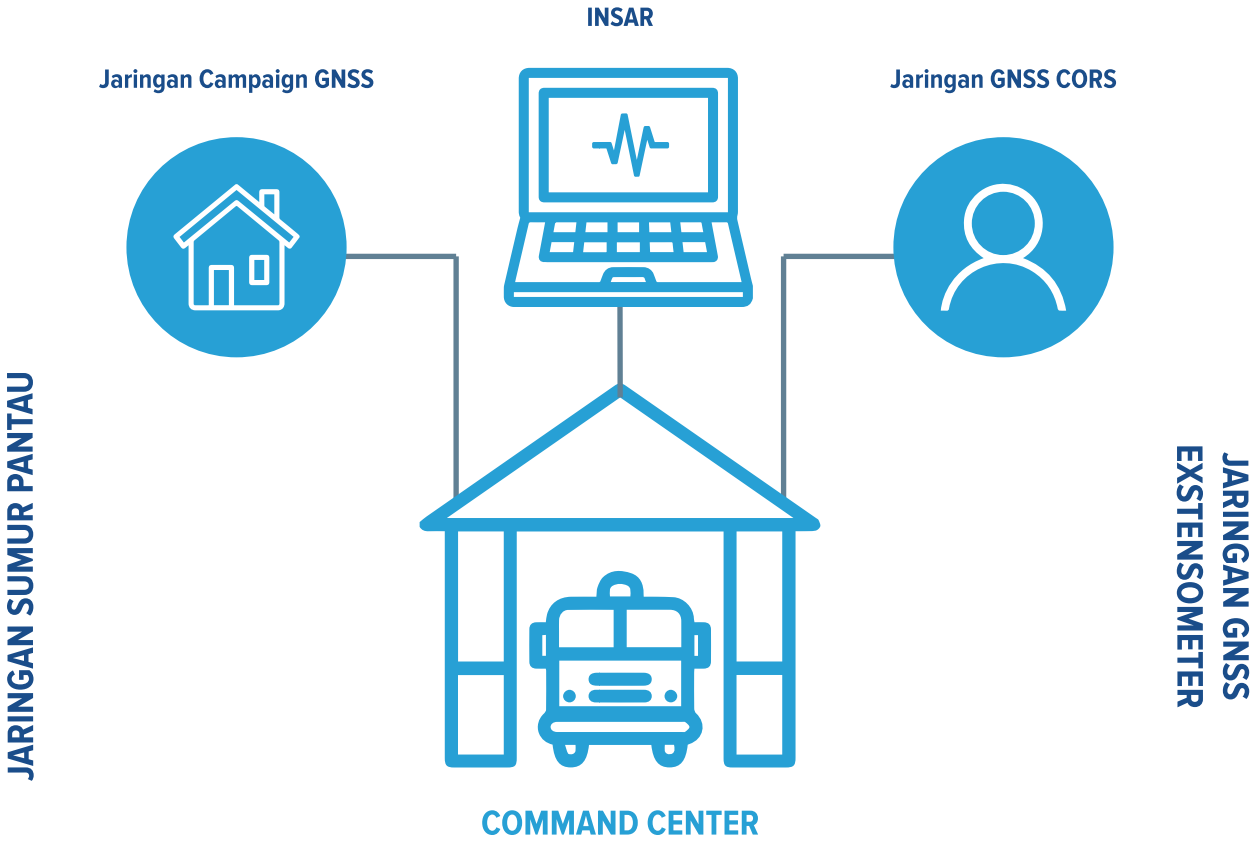

Figure 27. ***Illustration of land subsidence disaster risk early warning system currently developed in Jakarta. In the future, this system is expected to be developed in Central Java areas experiencing land subsidence.***

4.3.6 Strategy 6: Development of Land Subsidence Risk and Hazards Map

Data and information obtained from early warning and monitoring results serve as input parameters in creating a land subsidence risk map. Having land subsidence risks mapped out and analyzed will lead to proper understanding of the phenomenon of land subsidence and its disaster potential. Mapping will spatially show which areas are experiencing land subsidence and its disaster potential. Land subsidence risk map and analysis are, accordingly, used to, effectively and efficiently, plan and implement land subsidence adaptation and mitigation efforts in the Central Java area.

Provided below is an example of a hazard map of land subsidence occurring in Semarang. It is apparent that the northeast area of Semarang is burdened by land subsidence occurrences. The rate of land subsidence can reach 10 – 15 centimeters per annum in this area. Consequently, due attention should be focused, among others, on such areas. As already mentioned above, mapping will, spatially, indicate which areas are experiencing land subsidence and its disaster potential. The illustration below on the current state in Semarang can be used as a reference for planning and implementing land subsidence disaster adaptation and mitigation in the Central Java area.

Further description of the roadmap and timeline for creating and analyzing land subsidence risk and hazards map is provided in ANNEX II.6.

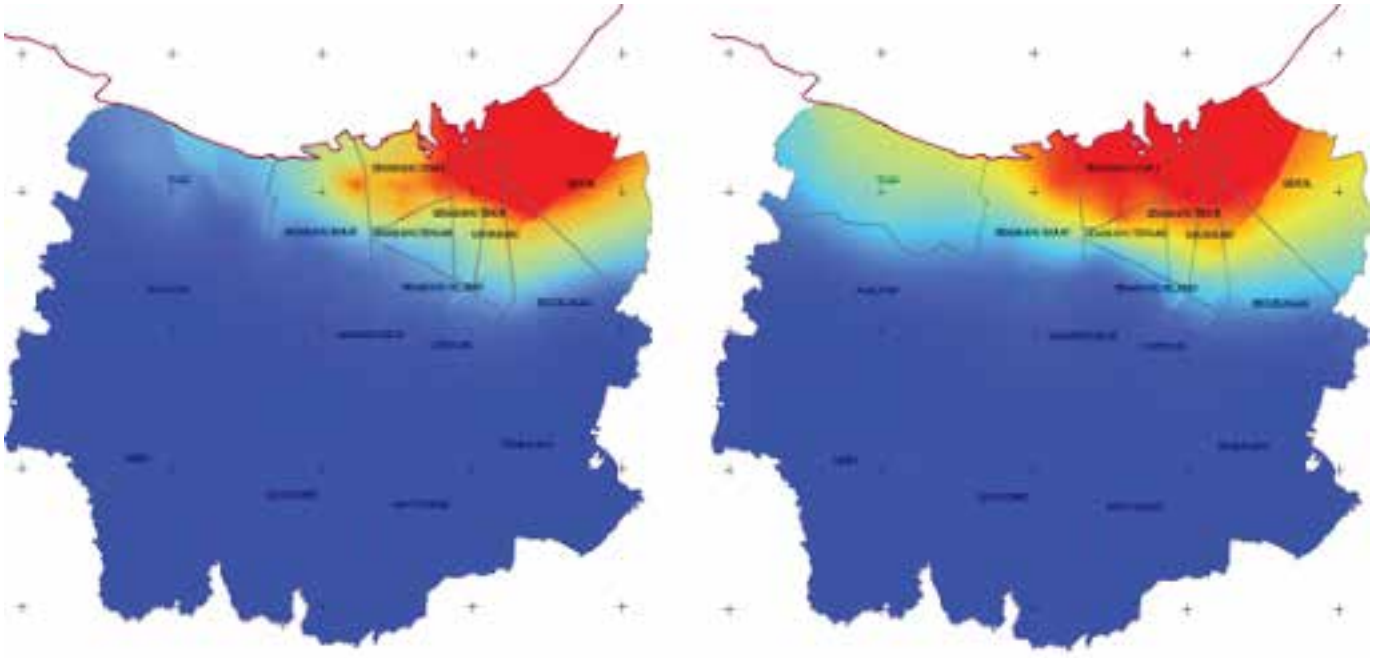

Figure 28. ***Examples of land subsidence hazard map (in the Semarang area) that can be used to create and analyze land subsidence risks***

4.3.7 Strategy 7: Implementation of Adaptation Measures (Short Term Measures)

Adaptation efforts are important as there are impacts of land subsidence that are currently taking place. Efforts in the short-term to respond towards the hazards include construction of embankments, elevating high-risk infrastructures, construction of polder systems, among others. Currently in Semarang, Pekalongan, and some areas in Demak, some measures are being carried out under adaptation, and are expected to be completed by 2025. However, a continuous maintenance of this short-term measure must be performed to ensure the longevity of the short-term structure (i.e. deteriorating of embankments).

Examples of cases in Semarang, Demak, and Pekalongan show that several infrastructures, including buildings, have been elevated two to three times, some even more. This means that adaptation efforts are merely temporary. Long term land subsidence mitigation efforts are, hence, required to restore the impacted areas.

On another note, although some of the adaptation measures are already undertaken, a more environmentally friendly approach is needed, i.e. development of blue-green infrastructure such as parks, urban forest wetlands, etc to improve flood management by storing surface run-off while at the same time providing co-benefits in improving ecological connection, mitigating urban heat island, and provide open space for community. As for adaptation for building and housing, technological advancement is strongly needed by local government and local communities, for a more sustainable and cost-effective approach in building houses in the at-risk areas (e.g. the concept of affordable floating house should be further explored). In addition, building designs that are more adaptive to the risks associated with land subsidence could be incorporated into risk-based building guidelines that serve as a guide and permit for construction of new buildings in land subsidence prone areas.

Further examples of adaptation measures can be found in section 3.4 on Proposed Adaptation and Mitigation Measures. Meanwhile, further description of the roadmap and timeline for implementing adaptation or short term measures, is provided in ANNEX II.7.

Figure 29. Construction of embankment along the coast to prevent tidal flooding caused by land subsidence in Jakarta

4.3.8 Strategy 8: Implementing Mitigation (Long Term Measures): Water and Land Management

Water and land management has been proven as a solution for land subsidence disaster globally. This is done by halting the extraction of groundwater, wherein water management was previously carried out by building surface water infrastructure and paying attention to land management. Land subsidence can be stopped by managing the water and the land. Such land subsidence disaster mitigation efforts must be implemented for the Central Java area and articulated into more detailed actions. Mitigation efforts must begin as soon as possible or it should be effectively implemented by next year at the latest. Provided that there are properly implemented and measured land subsidence mitigation efforts in Central Java, land subsidence issues are expected to be resolved by the end of 2029.

Correlation between land subsidence and water table dynamics are shown in the graph below. It is apparent that the water table recovers as a result of ground water exploitation being halted, thereby stopping land subsidence. This illustration can be used as a reference for implementing mitigation in the Central Java area. As an additional information, ground water consumption remains highly significant in Central Java, including Semarang, Demak, and Pekalongan.

The following are proposed mitigation measures that can be taken by the Central Java Province. Further elaboration of this table is provided in section 3.4 on Proposed Adaptation and Mitigation Measures.

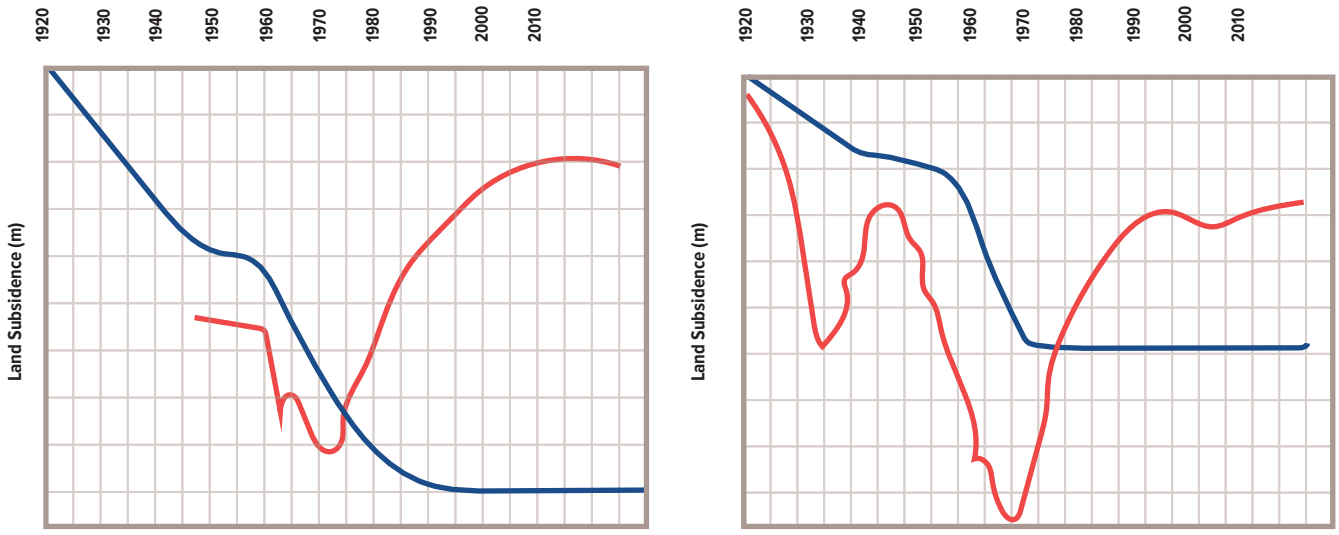

Figure 30. Examples of correlation chart between land subsidence and water table dynamics

Table 18.
Summary of Proposed Mitigation Measures for Central Java Province

	Measure	Category	Short description
Accelerating the improvement of water provision and water conservation in critical areas by maximizing the non-groundwater source			
1	Artificial recharge of aquifers	Infrastructure	The main purpose of artificial aquifer recharge is to store excess water by recharging the aquifer.
2	Improve water supply coverage through conveyance pipe network	Infrastructure	Expanding the coverage of piped water service particularly in the critical area with no access to the service is one way to reduce the use of groundwater.
3	Water treatment (e.g. recovery of freshwater)	Infrastructure	Improve water availability and reduce consequences of variability. The reclaimed water can be used for urban, agriculture, industrial, recreational, or environmental purposes.
4	Water desalination	Infrastructure	Desalination is one alternative for water provision by removing the minerals and salts from saline water. This option is relatively costly but could be one option for critical areas.
5	Construction of water reservoirs	Infrastructure	The main use of this artificial water body is to collect and store excess water from rainfall, river, or surface run-off, for supplying water for households and industrial uses.
6	Water neutral industry (+urban) programme	Infrastructure	Water neutral industry is a program to develop an industry to capture, treat and reuse water locally so no ground water extraction.
7	Rainwater harvesting (RWH)	Infrastructure	Rainwater harvesting (RWH) is a method to collect the run-off from a surface or other impervious surface in order to store it for later use. This could be useful for the community and household level.
8	Infiltration basin	Infrastructure	Infiltration basin is an artificial pond that is designed to infiltrate surface run-off through permeable soils into the groundwater aquiver.

9	Conjunctive use of surface water and groundwater as water source	Regulation	The increasing water scarcity problems requires the adoption of a double approach of water supply management. The conjunctive use of both surface and groundwater is one of the strategies of water supply management.
Improving enforcement, compliance and monitoring of groundwater extraction activities			
1	Groundwater extraction policy and policy enforcement	Policy instrument	Some examples of groundwater policy, such as tax procedure for private companies who use groundwater source, restriction policy for groundwater extraction, and groundwater use restriction by zoning.
2	Land Subsidence Monitoring	Data and regulation	Monitoring land subsidence is an essential step to track the land subsidence rate in an area. The aim of this measure is to improve understanding of the processes responsible for changes in the elevation of the land's surface.
Improving land-use management			
1	Land-use management (clustering/-zoning)	Regulation	Land-use has a close linkage with groundwater extraction. The land-use change can have long lasting and irreversible impacts on aquiver. Some land-use that influences groundwater extractions are open-cast mining, deforestation, and urbanization. Applying special protection in special zones, defined by hydrogeological criteria, is needed to provide better socio-economic and environmental returns.

4.3.9 Strategy 9: Education and Capacity Building

The information related to the rate of land subsidence and its potential impact is a crucial aspect of a long-term mitigation strategy. Therefore, this kind of information must be disseminated and delivered to the public in general to create a public understanding and thus encourage more participation of related stakeholders.. As the success of adaptation and mitigation will depend on the involvement of all stakeholders. This is why education and capacity building play a part in the roadmap that is of no less importance and should be implemented within the arranged timeline.

The engagement of relevant stakeholders has implications on implementing capacity building and education efforts, which can then be properly programmed and planned. By referring to a scale of priority, such effort should be immediately executed in Semarang, Pekalongan, and Demak, which currently suffer from a highly significant level of subsidence. Subsequently, capacity building and education efforts must be conducted in other locations with a high risk of land subsidence.

Further description of the roadmap and timeline for education and capacity building is provided in ANNEX X.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Land subsidence in Indonesia, particularly in Central Java has become one of the most pressing issues in the region, and is expected to intensify in the coming years. As many studies suggest, the main cause of the issue in Central Java province is mainly due to human activities or anthropogenic activities. This includes poor water management and provision, spatial planning, and unintegrated policy and institutional framework. If not addressed appropriately, this issue will threaten and result in significant losses for the community both in tangible and intangible manners.

In Business as Usual (BAU) projection, it is expected that the magnitude of impacts of land subsidence in the region will result in an economic loss of IDR 75 trillion and IDR 37 billion for Semarang and Demak respectively. The economic losses entail various direct and indirect losses, such as damage to vital infrastructure, land loss for the communities, relocation, increased coastal, pluvial, and fluvial flood risk, which eventually result in lower quality of life in the community. This lossed signifies the urgency to address land subsidence in Semarang and Demak appropriately and swiftly in a very short term.

Efforts in adaptation and mitigation to land subsidence to lessen the impacts are crucial. Some initiatives are currently underway to address this situation, including the development of a roadmap on adaptation and mitigation to land subsidence and related disasters in the Central Java area. The roadmap is expected to encourage measures in mitigating and adapting to the impacts of land subsidence. In addition, the establishment of a definitive institution to address the issue and to be the implementer of the roadmap is crucially needed. The establishment of such institutions is hoped to be accompanied with a robust legal framework and regulation. With an integrated and fully established institution, as well as robust policy and regulatory framework, it can be anticipated that the impacts of land subsidence will be significantly reduced in the coming years. The reduced risks of land subsidence in Indonesia in general, and Central Java in particular, will consequently lift a huge economic loss by the disasters, and by the cost to deal and recover from the impacts.

5.2 Recommendations

From the assessment and roadmap in addressing land subsidence in Central Java, the following are some key recommendations and practical next steps that can be taken by relevant stakeholders to better mitigate and adapt to land subsidence. The recommendations are related to some of the challenges in existing sectors relevant to land subsidence in Central Java, as well as the issues of governance to respond towards the issue. Some of the recommendations can be listed as follow:

The issue of land subsidence has proven to be challenging, as it presents complex technical and societal issues involving many stakeholders with wide-range of interests and issues from water provision, groundwater extraction, land use management, as well as water management and coastal protection (to reduce the increasing flood risk). This issue must be adequately mainstreamed between various sectors, actors, and programs. Thus, development of more integrated policy and institutional framework is needed to foster a more effective effort in addressing the issue. The following are recommendations regarding policy and institutional framework.

1. ***More integrated policy and institutional framework***

   The issue of land subsidence has proven to be challenging, as it presents complex technical and societal issues involving many stakeholders with wide-range of interests and issues from water provision, groundwater extraction, land use management, as well as water management and coastal protection (to reduce the increasing flood risk). This issue must be adequately mainstreamed between various sectors, actors, and programs. Thus, development of more integrated policy and institutional framework is needed to foster a more effective effort in addressing the issue. The following are recommendations regarding policy and institutional framework.

   a. *Establishment of a governance platform:* Existing structures related to address land subsidence in the local government could be integrated to manifest as a Working Group (Kelompok Kerja) / Council (Dewan) / Forum of Stakeholders - this newly established platform should exercise the coordination process between different structures in the local government in order to coordinate the effort to address land subsidence more effectively.

   b. *National regulation as a framework of action at the local level:* The development of the governance platform on land subsidence will be more effective if encouraged from the national level though a national regulation, which then can be followed up at the provincial / local level.

   c. *Development of Action Plan:* As this Roadmap document provides the general framework in addressing land subsidence in the longer term, an action plan to adapt and mitigate land subsidence is needed as a common reference for different stakeholders to coordinate efforts in the shorter terms.

   d. *More robust regulation enforcement:* The research has suggested that one of the key weaknesses in addressing land subsidence in CJP is the weak capacity to enforce regulation. Existing regulations must be optimally enforced to ensure the compliance of related stakeholders dealing with the subsidence issue, especially in the area of groundwater management, as well as land-use arrangements in the coastal area.

   e. *Penta Helix approach:* To complement the progress at the national level, a multi-stakeholder and multi-level participation should be promoted. Existing community initiatives in CJP (i.e. mangrove rehabilitation program, polder system, reforestation in upstream areas) and village regulation must be properly acknowledged and upscaled to be integrated with the government programs and to accommodate bottom-up approach of mitigation and adaptation to land subsidence through the village development. In addition, private sectors should be involved more collaboratively through their CSR mechanism and public-private partnership in order to support mitigation and adaptation to land subsidence (e.g. PDAM water, the coverage of pipe-water services, as well as overall water services delivery and management).

   f. *Transfer of knowledge:* Transfer of best practices between different cities-countries must be promoted for knowledge sharing on mitigation and adaptation measures related to land subsidence.

2. ***Accelerating the improvement of water provision and water conservation***

   As the rate of population growth is rising, the demand for water will subsequently rise as well. In both Semarang and Demak, however, poor provision and management of water resources is considered to be one of the important factors that contribute to the land subsidence issue. This results in various externalities leading to the occurrence of land subsidence. Therefore, an improvement in the management of water services is a prerequisite to address the underlying problems, which can be improved through:

   a. *Improvement of piped-water supply coverage: I*mprovement on PDAM piped-water supply coverage is highly necessary, particularly in critical areas with no access to the service is one way to reduce the use of groundwater.
   b. *Optimization of water reservoirs in improving water supply capacity:* Optimization of water reservoirs (such as Rawa Pening and Kedung Ombo in Demak) and various watersheds (Jragung watershed, Tuntang, Serang-Lusi) to to improve clean water services in the area which can also serve as flood control mechanism.
   c. *Water-neutral industry zone:* Reforming the water supply in industrial areas is critical in addressing land subsidence. Thus, promoting a decentralized water management system to capture, treat, and reuse water locally in industrial areas is one way to reduce groundwater extraction. This would require a regulatory framework and strong enforcement mechanism.
   d. *Optimization of water conservation measures:* As fresh clean water is a limited resource, water conservation is important. There are various opportunities for water conservation such as rainwater harvesting, recycling systems, and artificial recharge - these potential must be utilized optimally throughout the city through the government programs to promote behavioural change in the use of water.

3. ***Improved Spatial Planning and More Responsible Industrial Activities***

As previously mentioned, the north coast of Central Java Province, particularly Semarang and Demak are considered industrial cities due to heavy industrial activities in the region. Development of industrial zones is planned to be growing in the future, particularly in Demak. However, it has not been accompanied by a better management of spatial planning as well as water resources for the industrial activities. Most of the land for industrial zones in both cities is converted from mangrove areas for coastal protection--in which will weaken the natural measures to protect the land from coastal abrasion. In addition, the expansion of industrial zones will also increase the demand for excessive groundwater extraction, which serves as the main factor of land subsidence. Therefore, the transformation of spatial planning, and also permission for industrial activities must be ensured - which can be achieved through:

a. *Promoting and reinforcing the risk-based land use management:* Applying special protection in special zones, defined by hydrogeological criteria, is needed to provide better socio-economic and environmental returns. Areas with high risk of land subsidence should not be treated equally. There are different types of groundwater conservation and protection, which require the definition of land-surface zones at varying geographical scales. There should be stricter regulation regarding the type of development that is allowed, restriction on groundwater extraction, type of building suggested, etc. This should be enforced with the regulation and clear reinforcement and monitoring mechanism.

b. *Development of sets of standard and principle for industrial activities:* Standard and principles should be developed and enforced for industrial activities in the land-subsidence prone area in order to assist the mitigation and adaptation strategies to land subsidence. Some of the examples of the principles are:

   i. Safe-guard mechanism to mitigate the risks of land subsidence and the impacts to the community in the area.

   ii. Specific financing allocation to obtain permission for new industrial activity in land subsidence prone areas. This will ensure that their industrial externalities will lead to land subsidence (e.g. excessive and uncontrolled groundwater extraction) will be prevented, and if not prevented, the actor could be responsible for the adaptation measures, or can finance the government measures on mitigation and adaptation.

4. ***Reinforcement of groundwater extraction policy***

Groundwater policy is an essential instrument to reduce groundwater extraction. There are some examples of groundwater policy, such as tax procedure for private companies who use groundwater source, restriction policy for groundwater extraction, and groundwater use restriction by zoning. The groundwater policy needs to be assessed with policy reinforcement to ensure compliance with the procedures. Policy reinforcement can be implemented by monitoring the policy implementation and development incentives mechanism for the community.

5. ***Promoting a more soft and cost-effective adaptation measures***

As many adaptation measures are already in place in most cities in the north coast of Central Java Province, mostly in the form of hard infrastructure such as construction of embankments, elevating infrastructures, construction of polder systems, etc., a softer and more cost-effective approach is strongly recommended for the adaptation measures, particularly to reduce the risks of coastal, pluvial, and fluvial flooding due to the increasing subsidence rate. The following are some of the recommendations:

a. *Development of blue-green infrastructure:* Development of public blue-green infrastructure (e.g. public spaces, green open spaces, urban forests, bioretention basins to improve flood management by storing surface run-off while at the same time providing co-benefits in improving ecological connection, mitigating urban heat island, and provide open space for community. Specifically in the case of CJP, the toll-road can be retrofitted in order to add coastal protection elements (e.g. against coastal abrasion).

b. *Guideline for adaptive housing for the coastal communities:* Technological advancement is strongly needed by local government and local communities, for a more sustainable and cost-effective approach in building houses in the at-risk areas (e.g. the concept of affordable floating house should be further explored). A risk-based building guidelines that serve as a guide and permit for construction of new buildings in land subsidence prone areas, could be one instrument for implementation.

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ANNEX I
COMPILATION OF REGULATION

Annex 1 - Compilation of Regulations

Existing Policies related to Land Subsidence Issue in Central Java Province

Existing policies related to land subsidence in Central Java	Review	Relevance and Gaps
Law No. 7/2004 on Water Resources (Annulled) (Undang-undang No. 7/2004 tentang Sumberdaya Air)	• *Law No. 7/2004 oversees the management of water resources, water use rights, and water venture rights, as well as the authority of stakeholders in the management of water resources.* • *Annulled by the Constitutional Court in 2015 as it was argued that this law encourages privatization of water rights, that is against the Constitution.* • *Replaced with the re-enactment of Law No. 11/1974 on Irrigation, and later Law No. 19/2019 on Water Resources.*	*Land subsidence is considered as one of the water damage potentials along with flood, erosion, sedimentation, among others. The management of water damage potential shall be carried out by means of disaster mitigation.*
Draft Revision of Law No.24 / 2007 on Disaster Management (Draft Revisi UU No. 24 Tahun 2007 tentang Penanggulangan Bencana)	• *The Law No. 24 / 2007 classifies disasters into three categories: natural disasters, non-natural disasters and social.* • *While in the draft revision of regulation, there are four clusters of disasters based on the trigger: (1) geology and volcanology, (2) hydrometeorological disasters I (dry), (3) hydrometeorological disasters II (wet), and (3) non-natural disasters.* • *Non-natural disasters include four components: waste, land subsidence, epidemic, and technological failure, which include industrial disaster issues.*	*Land subsidence is included as one of the types of disaster in the regulation. This provides an opportunity to put bigger attention on this issue in the future.*
Governor Regulation of Central Java Province No. 47 of 2015 on Local Drinking Water Provision System Development Policy and Strategy of Central Java Province (Peraturan Gubernur Jawa Tengah Nomor 47 Tahun 2015 tentang Kebijakan dan Strategi Daerah Pengembangan Sistem Penyediaan Air Minum Provinsi Jawa Tengah)	• *The coverage of urban drinking water service in Central Java Province at the end of 2013 only reached 63.99%, consisting of Piping Network 42.76% and Non-Piping Network 21.23%. The coverage of rural drinking water service is 49.13%, consisting of Pipeline 42.76% and Non-Pipeline Network 10.99%. The MDG target to be achieved by the end of 2015 is 75%.* • *The drinking water service in Central Java Province is currently managed by PDAM of Central Java Province, Regional/City PDAM, and independently by the community. There are 35 Regional/City PDAMs and 1 PDAB in Central Java Province.* • *In Central Java Province, there are 573 IKKs: 427 have been built and 146 have not been built, with an average idle capacity of 3.000 L/s. Currently, the average leakage in the pipeline is 30-40% and it is expected to be 3.10% by the end of 2019 with a plan to reduce leakage by 1% per year.*	*The city government of Central Java has planned to develop reservoirs to increase the retention capacity to increase the volume of raw water.*

Existing policies related to land subsidence in Central Java	Review	Relevance and Gaps
Local Regulation of Central Java Province No. 3 / 2018 on Groundwater Management (Perda Provinsi Jawa Tengah Nomor 3 Tahun 2018 tentang Pengelolaan Air Tanah)	• *Drilling, excavation, or any other activities within a 200 m radius of the emergence of the spring is prohibited.* • *Groundwater management affairs are carried out by the head of the institution in charge of energy and natural resources* • *The holder of groundwater concession permit is required to, among others, provide at least 15% on the use of groundwater discharge limits set out in the permit for the fulfillment of basic daily needs of the local community; to operate monitoring wells for every five well or for an extraction discharge rate of 50 L/s or more from one or more wells in the area less than 10 hectares.* • *The provincial regulation mandates the development of a groundwater conservation zone map as well as a groundwater information system, serving as a basis to determine the groundwater protection and utilization area* • *The implementation of groundwater management is financed by the APBD of Central Java and/or other legal and not binding sources.*	*There is already a lead institution for monitoring groundwater extraction (the Department of Energy and Natural Resources). However, the capacity mechanism of monitoring needs to be increased.*
Law No. 17/2019 on Water Resources (Undang-undang No. 17/2019 tentang Sumberdaya Air)	• *Replaced the previous Law No. 11/1974 on Irrigation (and the annulled Law No. 7/2004 on Water Resources).* • *Reaffirmed the state control on water rigths. Prescribes clear hierarchy of water utilization: guaranteed fulfilment by the government (basic daily needs, public agricultural activities, drinking water supply system), non-commercial purposes, and commercial purposes (subject to license).* • *The law emphasizes that water utilization for specific (commercial purpose) can only be done if the above hierarchy is met.* • *Water resources management plans include the management of transnational river basins, inter-provincial river basins, and nationally strategic river basins, including groundwater basins in these river basins.* • *Currently there are no derivative regulations at the national and sub-national levels.*	• *Land subsidence is considered as one of the water damage potential along with flood, erosion, sedimentation, among others. The management of water damage potential shall be carried out by means of disaster mitigation.* • *Stipulates the authorization of groundwater basins as part of the river basins.* • *This will affect the institutional arrangement of ground water affairs at the sub-national level (once the derivative regulations are already in place).*

Annex 1 - Compilation of Regulations

Existing Policies related to Land Subsidence Issue in Central Java Province

Existing policies related to land subsidence in Central Java	Review	Relevance and Gaps
Govt. Regulation No. 5/2021 on Execution of Risk-Based Business Licensing (Peraturan Pemerintah No. 5/2021 tentang Penyelenggaraan Perizinan Berusaha Berbasis Risiko)	• *Derivative regulation of Job Creation Act (Law No. 11/2020) which specifically stipulates many affairs on business licensing across sectors.* • *Stipulates the norms and criteria for business in water resources as one of the sub-sector.*	• *Stipulates the strict duties of business in water resources to be responsible for negative impacts/risks associated with their business.* • *List hierarchies of licensing activities for business in water resources.* • *Encourage better utilization of water resources by the private entities.*

ANNEX II

CENTRAL JAVA PROVINCE LAND SUBSIDENCE ADAPTATION AND MITIGATION ROADMAP ESTABLISHMENT OF INSTITUTION

ANNEX 2.1 DESCRIPTION REGARDING INSTITUTIONAL FORMATION

The first step in implementing the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is by forming an institution, which remains unavailable as of current. Forming an institution is a crucial step since land subsidence adaptation and mitigation activities will be under the responsibility and authority of the established institution. Additionally, land subsidence disaster adaptation and mitigation activities in Indonesia, particularly in Central Java, remain overlooked because in reality an institution charged with the authority to create programs relating to land subsidence has yet to be formed. The need to form such an institution is, thus, most evident in this case. By considering the level of authority, Central Java Province's BAPPEDA (Regional Development Planning Agency) can serve as a coordinator of the institution in charge of the adaptation and mitigation of land subsidence and related disasters in the Central Java area.

Table ANNEX.2.1.1 Description regarding the first step of the roadmap in forming land subsidence adaptation and mitigation institution in Central Java Province

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2021	*Form an Institution*	*To be further reviewed*	*An institution that can take initiatives, which can be from BAPPEDA or the Governor.*	*Estimated budget of IDR 250 to IDR 500 million*	*Institutional formation is a crucial first step since activities of land subsidence adaptation and mitigation will be under the responsibility and authority of the established institution.* *Land subsidence disaster adaptation and mitigation activities in Indonesia, particularly in the Central Java area, remain overlooked because in reality an institution charged with the authority to create programs relating to land subsidence has yet to be formed. The need to form such an institution is, thus, most evident.*
2022	*Evaluate the established institution*	*A Decree on Institutional Formation along with other relevant legal basis*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	*There are several suggestions stating that land subsidence disaster will be a highly significant issue in the future, which will, consequently, be able to affect programs in the SDGs/Sustainable Development Goals.* *If the newly formed institution is not sufficient and capable of addressing issues of land subsidence in the future, then it will be possible to make amendments. So that the institution in charge of land subsidence disaster adaptation and mitigation in Central Java Province becomes stronger and more empowered.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2023	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2023**
2024	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2024**
2025	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2025**
2026	*Report performance of the established institution*	*To be determined later*	The established institution	*Estimated budget of IDR 250 to IDR 500 million*	**2026**
2027	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2027**
2028	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2028**
2029	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2029**
2030	*Report performance of the established institution*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2030**

ANNEX 2.2 DESCRIPTION REGARDING REGULATION DRAFTING

The second scenario of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is carried out by drafting regulations that facilitate in implementing actions. It can, currently, be concluded that some efforts to address land subsidence disaster risks are still hindered by regulatory issues. Without a regulation, there will be no program. Without a program, there will, automatically, be no budget. Matters relating to the description of Regulation Drafting is provided extensively in the table below;

Table L.2.2.1 Description regarding the drafting of regulation for Land Subsidence Adaptation and Mitigation in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2021	*Include tidal flood and land subsidence disaster in the revision of Law No. 24/2007 on Disaster Management* *Draft Technical Regulations relating to Land Subsidence Adaptation and Mitigation Action Plan in the Central Java area*	*To be explained*	*The established institution*	*Estimated budget of approximately IDR 500 million*	*It can, currently, be concluded that some efforts to address land subsidence disaster risks are still hindered by regulatory issues. It can be, firmly, stated that without any regulation, there will be no program.* *As a matter of fact, land subsidence disaster has not been included in the disaster category according to Law No. 24/2007 on Disaster Management and its derivative regulations.* *As of current, there is yet a disaster management program and budget available concerning land subsidence. This is due to the absence of regulation pertaining to land subsidence.*
2022	*Draft Technical Regulations relating to Land Subsidence Adaptation and Mitigation Action Plan in the Central Java area (CONTINUED).*	*To be explained*	*The established institution*	*Estimated budget of approximately IDR 500 million*	*To execute the mandate of the normative Law, a subordinate technical regulation must be prepared.* *The technical regulation must be prepared thoroughly; it should not be hindered by problems in its execution. For instance, there is, currently, no regulation that manages large scale hazard mapping. Or, actually, the thematic hazard map should not follow map scale as it may lead to aliasing.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2023	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2023**
2024	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2024**
2025	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2025**
2026	*Evaluate and renew regulation if necessary*	*To be determined later*	The established institution	*Estimated budget of IDR 250 to IDR 500 million*	**2026**
2027	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2027**
2028	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2028**
2029	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2029**
2030	*Evaluate and renew regulation if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2030**

ANNEX 2.3 DESCRIPTION REGARDING PROGRAM AND BUDGET CREATION

The third scenario of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is carried out by creating programs and budget, which is an absolute condition for implementing actions. It can, currently, be concluded that several efforts to implement measures addressing land subsidence disaster risks are still hindered by program and budget issues. This is affected by the issue of regulation. Without a regulation, there will be no program. Without a program, there will, automatically, be no budget. Matters relating to the description of Program and Budget Creation is provided extensively in the table below;

Table ANNEX 2.3.1 Description regarding Program and Budget Creation for Land Subsidence Adaptation and Mitigation in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2021	*Carry out efforts to include programs of land subsidence adaptation and mitigation in Central Java into the National Mid Term Development Plan (RPJMN) and the Regional Mid Term Development Plan (RPJMD)* *Prepare budget for programs of land subsidence adaptation and mitigation in the Central Java area*	*To be determined later*	*The established institution, in coordination with BAPPENAS and BAPPEDA*	*Estimated budget of approximately IDR 500 million*	*The land subsidence and mitigation program in Central Java Province is an urgent matter to include in the National Mid Term Development Plan (RPJMN) and the Regional Mid Term Development Plan (RPJMD). Once the program has been included in RPJMN and RPJMD, the next step is to create a budgeting scenario for the program.*
2022	*Prepare budget for programs of land subsidence adaptation and mitigation in the Central Java area (CONTINUED)*	*To be determined later*	*The established institution, in coordination with BAPPENAS and BAPPEDA*	*Estimated budget of approximately IDR 500 million*	*The land subsidence and mitigation program in Central Java Province is an urgent matter to include in the National Mid Term Development Plan (RPJMN) and the Regional Mid Term Development Plan (RPJMD). Once the program has been included in RPJMN and RPJMD, the next step is to create a budgeting scenario for the program.*
2023	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2023**
2024	*Evaluate and renew program and budget if necessary*		*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2024**

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2025	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2025**
2026	*Evaluate and renew program and budget if necessary*	*To be determined later*	The established institution	*Estimated budget of IDR 250 to IDR 500 million*	**2026**
2027	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2027**
2028	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2028**
2029	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2029**
2030	*Evaluate and renew program and budget if necessary*	*To be determined later*	*The established institution*	*Estimated budget of IDR 250 to IDR 500 million*	**2030**

ANNEX 2.4 DESCRIPTION REGARDING MONITORING ACTIVITIES

The fourth scenario of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to carry out a monitoring program. The successful implementation of land subsidence adaptation and mitigation efforts is reflected in the results of the early warning and monitoring programs. Matters relating to the description of the monitoring program implementation is provided extensively in the table below;

Table ANNEX 2.4.1 Description regarding the Implementation of Land Subsidence Adaptation and Mitigation Monitoring in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2021-2030	*Monitor land subsidence in the Semarang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both. The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data. The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer. Technological combination that is currently a reference in America is a GNSS Extensometer.*
2022 -2030	*Monitor land subsidence in the Pekalongan area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both. The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data. The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer. Technological combination that is currently a reference in America is a GNSS Extensometer.*
2025 -2030	*Monitor land subsidence in the Brebes area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both. The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data. The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer. Technological combination that is currently a reference in America is a GNSS Extensometer.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2026-2030	*Monitor land subsidence in the Batang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both.* *The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data.* *The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer.* *Technological combination that is currently a reference in America is a GNSS Extensometer.*
2027 -2030	*Monitor land subsidence in other areas in other Central Java areas that experience subsidence issue*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both.* *The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data.* *The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer.* *Technological combination that is currently a reference in America is a GNSS Extensometer.*

ANNEX 2.5 DESCRIPTION REGARDING EARLY WARNING SYSTEM DEVELOPMENT

The fifth part of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to carry out an early warning system program. The successful implementation of land subsidence adaptation and mitigation efforts is reflected in the results of the early warning system and monitoring programs. Matters relating to the description of the early warning system program implementation is provided extensively in the table below;

Table ANNEX 2.5.1 Description regarding the implementation of Land Subsidence Adaptation and Mitigation Early Warning in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2021-2030	*Implement land subsidence early warning in the Semarang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 10-20 billion per 5 years for one area (covering regencies/cities or Agglomeration)*	*Data and information from the monitoring results involving geodetic (GNSS CORS and campaign, then the utilization of InSAR data) and geophysical (GNSS Extensometer) technologies are required for analysis and early warning.* *An Early Warning System will be developed using instruments with Geo-Information Technology.* *Data and information will be gathered in real time by using telemetry and others.*
2022 -2030	*Monitor land subsidence in the Pekalongan area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Data and information from the monitoring results involving geodetic (GNSS CORS and campaign, then the utilization of InSAR data) and geophysical (GNSS Extensometer) technologies are required for analysis and early warning.* *An Early Warning System will be developed using instruments with Geo-Information Technology.* *Data and information will be gathered in real time by using telemetry and others.*
2023 -2030	*Implement land subsidence early warning in the Demak area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both.* *The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data.* *The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer.* *Technological combination that is currently a reference in America is a GNSS Extensometer.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2024-2030	*Implement land subsidence early warning in the Tegal area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 10-20 billion per 5 years for one area (covering regencies/cities or Agglomeration)*	*Data and information from the monitoring results involving geodetic (GNSS CORS and campaign, then the utilization of InSAR data) and geophysical (GNSS Extensometer) technologies are required for analysis and early warning.* *An Early Warning System will be developed using instruments with Geo-Information Technology.* *Data and information will be gathered in real time by using telemetry and others.*
2025 -2030	*Implement land subsidence early warning in the Brebes area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Data and information from the monitoring results involving geodetic (GNSS CORS and campaign, then the utilization of InSAR data) and geophysical (GNSS Extensometer) technologies are required for analysis and early warning.* *An Early Warning System will be developed using instruments with Geo-Information Technology.* *Data and information will be gathered in real time by using telemetry and others.*
2026 -2030	*Implement land subsidence early warning in the Batang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	*Monitoring activities must involve geophysical and geodetic technologies along with a combination of both.* *The geodetic technology that should be used, among them, are GNSS CORS and campaign, then the utilization of InSAR data.* *The geophysical method, among others, are conducted by constructing groundwater monitoring well and extensometer.* *Technological combination that is currently a reference in America is a GNSS Extensometer.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	ANNOTATIONS
2027-2030	*Implement land subsidence early warning in other areas of Central Java that experience subsidence issue*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 10-20 billion per 5 years for one area (covering regencies/cities or Agglomeration)*	*Data and information from the monitoring results involving geodetic (GNSS CORS and campaign, then the utilization of InSAR data) and geophysical (GNSS Extensometer) technologies are required for analysis and early warning.* *An Early Warning System will be developed using instruments with Geo-Information Technology.* *Data and information will be gathered in real time by using telemetry and others.*

ANNEX 2.6 DESCRIPTION REGARDING LAND SUBSIDENCE RISK ANALYSIS AND MAPPING

The sixth strategy of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to conduct land subsidence risk analysis and mapping. The risk level significantly influences effectiveness and efficiency in the implementation of land subsidence disaster adaptation and mitigation efforts. Matters relating to the description of land subsidence risk analysis and mapping is provided extensively in the table below;

Table ANNEX 2.6.1 Description regarding Land Subsidence Risk Analysis and Mapping in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2021	*Map out and analyze land subsidence risks in the Semarang area*	*To be determined later*	*The established institution in coordination with the National Agency for Disaster Management (BNPB) or the Regional Agency for Disaster Management (BPBD) and supported by data custodians.*	*Approximately IDR 1-2 billion depending on the existing data for 1 regency/city*	
2022	*Map out and analyze land subsidence risks in the Pekalongan area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	
2023	*Map out and analyze land subsidence risks in Demak and Tegal area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2024	*Map out and analyze land subsidence risks in Brebes and Batang area*	*To be determined later*	*The established institution in coordination with the National Agency for Disaster Management (BNPB) or the Regional Agency for Disaster Management (BPBD) and supported by data custodians.*	*Approximately IDR 1-2 billion depending on the existing data for 1 regency/city*	
2025	*Map out and analyze land subsidence risks in other areas of Central Java experiencing land subsidence*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	
2026	*Update land subsidence risk analysis and mapping in the Semarang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2027	*Update land subsidence risk analysis and mapping in the Pekalongan area*	*To be determined later*	*The established institution in coordination with the National Agency for Disaster Management (BNPB) or the Regional Agency for Disaster Management (BPBD) and supported by data custodians.*	*Approximately IDR 1-2 billion depending on the existing data for 1 regency/city*	
2028	*Update land subsidence risk analysis and mapping in Demak and Tegal area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	
2029	*Update land subsidence risk analysis and mapping in Brebes and Batang area*	*To be determined later*	*The established institution in collaboration with the Geospatial Information Agency (BIG), Geological Agency of the Ministry of Energy and Mineral Resources, and other relevant stakeholders*	*Approximately IDR 40-50 billion per 5 years for onearea (covering regencies / cities or Agglomeration)*	

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2030	*Update land subsidence risk analysis and mapping in other areas of Central Java experiencing land subsidence*	*To be determined later*	*The established institution in coordination with the National Agency for Disaster Management (BNPB) or the Regional Agency for Disaster Management (BPBD) and supported by data custodians.*	*Approximately IDR 1-2 billion depending on the existing data for 1 regency/city*	

ANNEX 2.7 DESCRIPTION REGARDING THE IMPLEMENTATION OF ADAPTATION (SHORT TERM MEASURES)

The seventh strategy of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to implement adaptation programs or short term measures such as constructing embankments, BwN, and others. These measures, although temporary, are efforts that must, immediately, be carried out in order to reduce land subsidence disaster that has occurred. Matters relating to the description of adaptation or short term measure implementation is provided extensively in the table below;

Table ANNEX 2.7.1 Description regarding the Implementation of Land Subsidence Disaster Adaptation or Short Term Measures in the Central Java Area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2021-2030	*Implement land subsidence disaster adaptation or short term measures in the Semarang area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*
2022-2030	*Implement land subsidence disaster adaptation or short term measures in the Pekalongan area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2023-2030	*Implement land subsidence disaster adaptation or short term measures in the Demakarea, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*
2024-2030	*Implement land subsidence disaster adaptation or short term measures in the Tegal area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2025-2030	*Implement land subsidence disaster adaptation or short term measures in the Brebes area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*
2026-2030	*Implement land subsidence disaster adaptation or short term measures in the Batang area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2027-2030	*Implement land subsidence disaster adaptation or short term measures in the Central Java area, i.e. constructing embankment, improving coastal infrastructure, and others*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated to be approximately IDR 1 to 100 billion per area depending on the complexity of the adaptation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*

ANNEX 2.8 DESCRIPTION REGARDING THE IMPLEMENTATION OF MITIGATION (LONG TERM MEASURES) : WATER AND LAND MANAGEMENT

The eight part of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to implement mitigation programs (long term measures). These efforts are long term solutions to optimally reduce land subsidence disaster that has occurred. Matters relating to the description of the mitigation or long term measure implementation is provided extensively in the table below;

Table ANNEX 2.8.1 Description regarding the implementation of Land Subsidence Disaster Mitigation (Long Term Measures) in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2021-2030	*Implement land subsidence disaster mitigation or long term measures in the Semarang area, in the form of water and land management system*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR), the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN), and a number of spatial and infrastructure related institutions, along with expert supervision from the established Land Subsidence Mitigation Institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*
2022-2030	*Implement land subsidence disaster mitigation or long term measures in the Pekalongan area, in the form of water and land management systems.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing adaptation or short term measures for land subsidence disasters is by constructing coastal embankment or sea wall, improving coastal infrastructure (elevate roads, bridges, elevate buildings and others).* *In cases where the rate of land subsidence is not too substantial, BwN (Building with Nature) measures may be applied such as sediment capturing and mangrove.*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2023-2030	*Implement land subsidence disaster mitigation or long term measures in the Demak area, in the form of water and land management system.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*
2024-2030	*Implement land subsidence disaster mitigation or long term measures in the Tegal area, in the form of water and land management system.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2025-2030	*Implement land subsidence disaster mitigation or long term measures in the Brebes area, in the form of water and land management system.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*
2026-2030	*Implement land subsidence disaster mitigation or long term measures in the Batang area, in the form of water and land management system.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2027-2030	*Implement land subsidence disaster mitigation or long term measures in other areas of Central Java experiencing land subsidence, in the form of water and land management systems.*	*To be elaborated and updated later*	*Collaboration between the Ministry of Public Works and Housing (PUPR) and the Ministry of Environment and Forestry (KLHK), and a number of infrastructure and environment related Institutions, along with expert supervision from the established land subsidence adaptation and mitigation institution*	*Estimated at approximately IDR 1 to 200 trillion per area depending on the complexity of the mitigation design and area*	*A common means of implementing mitigation or long term measures for land subsidence disasters is by implementing a Water and Land Management System.* *Concerning water management, it can be conducted by substituting groundwater with surface water, rain water harvesting, water recycling, desalination, artificial recharge, etc.* *Concerning land management, it can be conducted by synchronizing spatial layout with water availability and needs*

ANNEX 2.9 DESCRIPTION REGARDING EDUCATION AND CAPACITY BUILDING

The ninth part of the Land Subsidence Adaptation and Mitigation Roadmap in the Central Java area is to conduct education and capacity building activities. One of the key elements in implementing land subsidence adaptation and mitigation lies in the hand of the impacted communities. Matters relating to the description of the land subsidence adaptation and mitigation education and capacity building is provided extensively in the table below;

Table ANNEX 2.9.1 Description regarding education and capacity building of land subsidence adaptation and mitigation in the Central Java area

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2021	*Conduct education and capacity building activities and form regional work unit in the Semarang area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	
2022	*Conduct education and capacity building activities and form regional work unit in the Pekalongan area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	
2023	*Conduct education and capacity building activities and form regional work unit in the Demak area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	
2024	*Conduct education and capacity building activities and form regional work unit in the Tegal area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	
2025	*Conduct education and capacity building activities and form regional work unit in the Brebes area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	

YEAR	FORM OF ACTIVITIES	LEGAL BASIS	INSTITUTION	BUDGET	NOTES
2026	*Conduct education and capacity building activities and form regional work unit in the Batang area*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	
2027-2030	*Conduct education and capacity building activities and form regional work unit in other areas of Central Java experiencing land subsidence*	*To be determined later*	*The established institution supported by Scholars and Non Government Organizations*	*Estimated at approximately IDR 500 million for each area*	