

Spatial Planning Support System for an Integrated Approach to Disaster Risk Reduction

By

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DECLARATION

This is to certify that the thesis has not been submitted for a higher degree to any other university or institution.

Due acknowledgement has been made in the text to all other material used,

The text does not exceed 100,000 words.

Parts of this work were published in books, journals and refereed conference proceedings as listed in Appendix.

Heri Sutanta
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ABSTRACT

Natural disasters are increasingly threatening human lives, infrastructure, and economic and social activities. Although most of the losses and casualties result from rapid onset disasters, the effects of slow onset disasters cannot be neglected. Little attention is paid to slow onset disasters, as their effects are not immediately evident. Nonetheless, their economic impacts are high and might hinder development and sustainability in many highly developed and densely populated cities. With the global climate change, particular attention should be paid to coastal cities. Global sea level rise, combined with locally borne hazards, have threatened many lowland areas in coastal cities.

Coastal cities are economically and socio-politically important, with more than half of the worlds' largest cities located in the area. Environmentally, the areas are sensitive to sea- and land-based activities, and are vulnerable to many types of natural, human-made and human-enhanced hazards. In light of this situation, protecting coastal cities from current and future natural hazards is an urgent matter. Specifically, it is important and less expensive to reduce the potential risks of disasters before they materialise.

Disaster risk reduction is an activity that involves multiple disciplines, perspectives and actors. Therefore, it requires an integrated approach that brings together all elements. It also requires cooperation between government agencies at different levels of hierarchy and jurisdiction.

Time is an important element in natural disaster risk reduction, where there are short- and long-term activities. Without discounting the benefits of short-term activities, long-term benefits will be higher, although not immediately evident. Long-term efforts rely on the reduction of exposure of elements at risk to multiple types of hazards, as well as measures to increase the coping capacity of the community and government to withstand disaster impacts. Long-term efforts should be served well by managing long-term relationships between people and infrastructure on one side, and natural hazards on the other. Spatial planning, with its function to regulate the long-term utilisation of land, is potentially very useful in minimising the exposure of people, socio-economic activities and infrastructures to natural hazards. It is important to both rapid and slow onset disasters, but is particularly relevant for slow occurrence natural hazards or predictable hazards such as sea level rise and land subsidence.

This thesis asserts that the development of spatial planning would be better if facilitated by a planning support system (PSS), which functions to help planners and decision makers envision the future by simulating the developmental likelihood using a set of parameters and scenarios. The process will result in a prediction of where and when a particular development will occur. At the same time, the potential progression of natural hazards is also modelled. This information is essential for evaluating whether the initial spatial plan has met disaster-resiliency measures. Any possible collisions between the predicted progression of natural hazards and planned development would be avoided in advance.

The model has been developed based on the acceptable risk concept. All land use designations have different levels of risk, vulnerability and coping capacities, which should be taken into account when developing a spatial plan. Determining the acceptable risk level should be a result of public consultation; however, the government, which has better knowledge and resources, should lead the process. Considering the physical and psychological distance between people and the government, the process is best conducted at the local level. Local governments need guidance and directives from the relevant central government agencies, as they have limited resources, funding and capacity.

This study presents the methods and requirements to predict the potential effects of future natural disasters. The research differentiates between slow and rapid onset disasters, and focuses on slow onset disasters. The findings revealed that neglecting the possibility of disaster progression would result in a high economic cost in the future. The economic cost will likely be unaffordable for less affluent people, who are forced to live in marginal lands that are highly vulnerable to a number of disasters. To overcome limitations in the available space, cooperation with neighbouring jurisdictions is required to transfer activities from disaster-prone to disaster-free areas.

A PSS is essential for delivering the method, and particularly for obtaining the information on where and when the projected development will be realised. Spatial data infrastructure (SDI) is required to facilitate data discovery and exchange among local and national government agencies working on the topic. However, the use of a PSS has been limited in local government agencies. In the event that a PSS is to be introduced, it needs to be low cost, have high compatibility with existing GIS software and have a shallow learning curve.

Many recent statistics from national and international agencies reveal an increasing number of natural disasters, along with greater numbers of people affected and higher economic losses. Advanced preparations will benefit both the government and the people, leading to sustainable development. This research fills the gap in linking risk mapping and disaster risk reduction.

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DEDICATIONS

To my wife Lilik Herawati

To my children, Fahmi, Affan, Naila and Kayla

To my father and mother

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LIST OF ACRONYMS

AAL	Average Annual Losses
BAU	Business-As-Usual
BKPRD	Badan Koordinasi Penataan Ruang Daerah
BKPRN	Badan Koordinasi Penataan Ruang Nasional
BNPB	Badan Nasional Penanggulangan Bencana
BPN	Badan Pertanahan Nasional
BPBD	Badan Penanggulangan Bencana Daerah
CBA	Cost benefit analysis
CD	Compact Disc
DAD	Decide, Announce and Defend
DESA	Department of Social Affairs
DGTL	Direktorat Geologi Tata Lingkungan
DRR	Disaster risk reduction
DRSP	Disaster-resilient spatial plan
DSP	Detailed Spatial Plan
DTDP	Different Time Different Place
DTM	Digital Terrain Model
DTSP	Different Time Same Place
DVMBG	Direktorat Vulkanologi dan Mitigasi Bencana Geologi
EMA	Emergency Management Australia
FDMA	Fire and Disaster Mitigation Agency
FEMA	Federal Emergency Management Agency
GDP	Gross Domestic Product
GIS	Geographic Information System
GUI	Graphical User Interface
HFA	Hyogo Framework for Action
ICT	Information and Communications Technology
IDSN	Infrastruktur Data Spasial Nasional
IPCC	Inter-governmental Panel for Climate Change
JICA	the Japan International Cooperation Agency
LGR	Local Government Regulations
NGO	Non-governmental Organisations
NIMBY	Not In My Back Yard
PBB	Pajak Bumi dan Bangunan
PC	Personal Computer
PML	Probability of maximum losses
PSS	Planning support system
RDPA	Regional Development Planning Agency
SDI	Spatial data infrastructure

SLR	Sea level rise
STDP	Same Time Different Place
STSP	Same Time Same Place
SWP	Satuan Wilayah Pengembangan
UN	United Nations
UNISDR	United Nations International Strategy for Disaster Reduction
VR	Virtual Reality

Chapter 1. INTRODUCTION

1.1. Background and Motivation

Natural disasters are increasingly threatening human lives, infrastructure, and economic and social activities. Statistics from the Emergency Events Database (EM DAT; available from <http://www.emdat.be>) show that there were more than 500,000 casualties in the past 15 years from different types of natural disasters, including earthquakes, tsunamis, floods, droughts, wind storms and landslides. Recent events include an earthquake in Haiti (January 2010), flooding in Pakistan (July 2010), a landslide in China (August 2010), a volcanic eruption in Indonesia (October–November 2010), extreme flooding in Queensland (December 2010–January 2011) and a tsunami in Japan (March 2011). In addition, there are slowly occurring hazards—the effects of which are not immediately evident—including the rise in the global sea level rise (SLR) as a result of climate change (Raper, Wigley et al. 1996; Bindoff, J. Willebrand et al. 2007) and a more localised disaster resulting from land subsidence (Sutanta and Hobma 2002; Rodolfo and Siringan 2006). Although they may result in few casualties, the economic damage is higher, since they strike many highly developed and densely populated coastal cities.

The high number of casualties and enormous economic losses has raised awareness among community, government and international organisations regarding the importance of a more systematic and institutionalised way of dealing with disasters in an effort to reduce their effect on people and the economy. Efforts to reduce disaster risk involve many disciplines and can be viewed from many perspectives, such as data, actors, modelling strategy and management perspective. Therefore, an integrated approach to disaster risk reduction is needed, which brings together all available resources and perspectives. It requires cooperation between government agencies at different levels of hierarchy and jurisdiction. A new agency should be established to coordinate and govern disaster risk reduction activities.

Time is an important element in natural disaster prevention. Disaster risk reduction can be classified as involving short- and long-term efforts. A short-term effort may involve, for example, evacuating people from the flank of a volcano to protect them from the danger of eruption. Long-term efforts rely on reducing the exposure of elements at risk to multiple types of hazards, as well as measures to increase the capacity of the community and government to withstand disaster effects. This includes, for example, the relocation of residential areas to safer locations and building dykes along the coast. The benefit to the community of long-term efforts may be greater, but short-term activities are always required.

Spatial planning, with its function to regulate the long-term utilisation of land, is potentially very useful in minimising the exposure of people, socio-economic activities and infrastructures to natural hazards. It is important to both the rapid and slow onset of disaster, but is particularly relevant for slowly occurring natural hazards or predictable hazards such as the rising sea level and land subsidence. These hazards are predictable, at least partially, in terms of their progression and the location of the likely occurrence. In addition to land use management, sudden disasters, such as earthquakes or typhoons, requires hard engineering or structural measures, such as building better and stronger infrastructures. Spatial planning for disaster risk reduction is important because:

1. There is a need to reduce the vulnerability of development by minimising exposures to natural hazards.
2. It provides ample time to study different options and choose the best strategy to provide the greatest benefit to the community with the least cost.
3. Reversing already-developed areas is expensive, time consuming and faces hard social resistance, which in many cases is almost impossible.
4. Natural hazards are dynamic; their behaviour, frequency, magnitude and spatial footprints are changing through time, which need to be addressed in the long term.
5. The progression and consequences of slowly moving natural hazards are observable but less likely to get appropriate attention because their adverse impacts are not directly obvious in the short term.

A spatial plan is formulated through the cooperation of multiple agencies and therefore needs a platform to facilitate data sharing and data integration. One crucial component in spatial planning is the availability of accurate, up-to-date and complete spatial data, which often have to be sourced from many government agencies. The establishment of spatial enablement and spatial data infrastructure (SDI) is a necessary means to facilitate spatial data-sharing activities. While SDI has already been well developed and utilised in many developed countries (Masser 1999; Rajabifard, Feeney et al. 2002), it is still at the early stage of development and nation-wide implementation in many developing countries (Boos and Mueller 2009). Among sub-national governments, there is a lack of technical expertise, funding, spatial data, supervision from a national agency and a supportive policy. This situation will impede spatial plan development. In addition to the involvement of many government agencies, participation from the public and collaboration with stakeholders are important for achieving better spatial plans (Boaden, Goldsmith et al. 1980; Creighton 2005; McCall and Dunn 2012).

1.2. Research Problem

In facing increasing events related to natural hazards, disaster risk reduction is an indispensable element in ensuring the safety of life, as well as sustaining socio-economic activities and urban environment infrastructures. It is a complex situation, requires multidisciplinary involvement, multi-stakeholders' participation, and a need to access and share multiple types of spatial and non-spatial data. Long-term efforts in disaster risk reduction activities need to be implemented by integrating different elements in spatial planning, which is not sufficiently addressed in current practices. Therefore, an integrated approach is needed in disaster risk reduction by using spatial planning facilitated by an enabling platform for data sharing and integration.

Absence of an integrated approach and dedicated systems for supporting spatial planning and lack of a spatial enabling platform for data sharing, discovery and integration is impeding in disaster risk reduction.

In this thesis, a study has been conducted on developing an integrated approach for disaster risk reduction using spatial planning in the framework of a spatial-enabled platform. This research has adopted a case study approach, focusing on a coastal urban environment that is currently threatened by the impacts of natural disasters. An acceptable risk indicator was used to evaluate the initial land use designation. A prototype of a planning support system (PSS) and a spatial platform was tested in a real-world situation, involving participants from local government agencies, the community and other stakeholders.

1.3. Research Aim, Questions and Objectives

In response to the research problem described above, the aim of this research is to:

Design and develop an integrated approach to disaster risk reduction using acceptable risk measures and spatial planning support systems.

The main deliverable of this research is a new approach for disaster risk reduction that makes use of the PSS and spatial-enabling platform. SDI will be used as an enabling platform for spatial data sharing required in the formulation of spatial plans using spatial PSSs. An integrated approach to disaster risk reduction is the application subject of this research.

To achieve the aim, the following objectives have been defined:

1. Identify the issues and challenges of current practices in disaster risk reduction.
2. Design and develop a model for an integrated approach to disaster risk reduction.
3. Design and develop a method for incorporating a spatial PSS for an integrated approach to disaster risk reduction using acceptable risk concept.
4. Investigate the role of spatial enablement and SDI in the integrated approach to disaster risk reduction using spatial planning.
5. Test the applicability of the integrated approach in a case study approach using a prototype of a spatial PSS.

These objectives were developed to answer the following research questions:

1. How can disaster risk reduction be conducted considering the number of parties, disciplines and policies involved?
2. What are the roles of SDI in spatial planning that is facilitated by a PSS?
3. How can a PSS be used for disaster risk reduction?
4. What are the roles of SDI in disaster risk reduction in the framework of an integrated approach?
5. Can the concept of an integrated approach be implemented in the case study area, and can the result be generalised?

1.4. Research Approach

This thesis uses a mixed approach, drawing on both qualitative and quantitative methods. The qualitative approach was used to investigate issues and changes in the current practices in spatial planning and disaster risk reduction worldwide, as well as in the study area. It was used to answer ‘who’, ‘what’, ‘why’ and ‘how’ questions. The ‘who’ question was developed to ascertain the stakeholders and participants in disaster risk reduction and spatial planning. The ‘what’ question related to the types of disasters affecting a particular locality and a survey of the list of actions to reduce the disaster risk. The ‘why’ question examined the reasons for developing alternative solutions for designating land use and incorporating hazards. Finally, the ‘how’ question sought understanding of the current practice of disaster risk reduction and its connection to spatial planning.

The quantitative and exploratory approach was used to develop the PSS and analyse the results. It was designed to calculate the extent and magnitude of disasters in the future, the impact on infrastructures and communities, and possible economic losses due to the negligence of natural hazards. The result is a cost benefit analysis (CBA) of natural hazards incorporated in spatial planning.

The research consists of four steps (see Figure 1-1) and concludes with a case study that demonstrates how the developed method was applied. Stage 1 comprises research formulation, whereby a literature review was conducted to find the existing methods that are available in scientific literature, agency reports and publications and

to use them as the basis for developing a new, integrated approach. Further, the research method was developed to achieve the research aim and objectives.

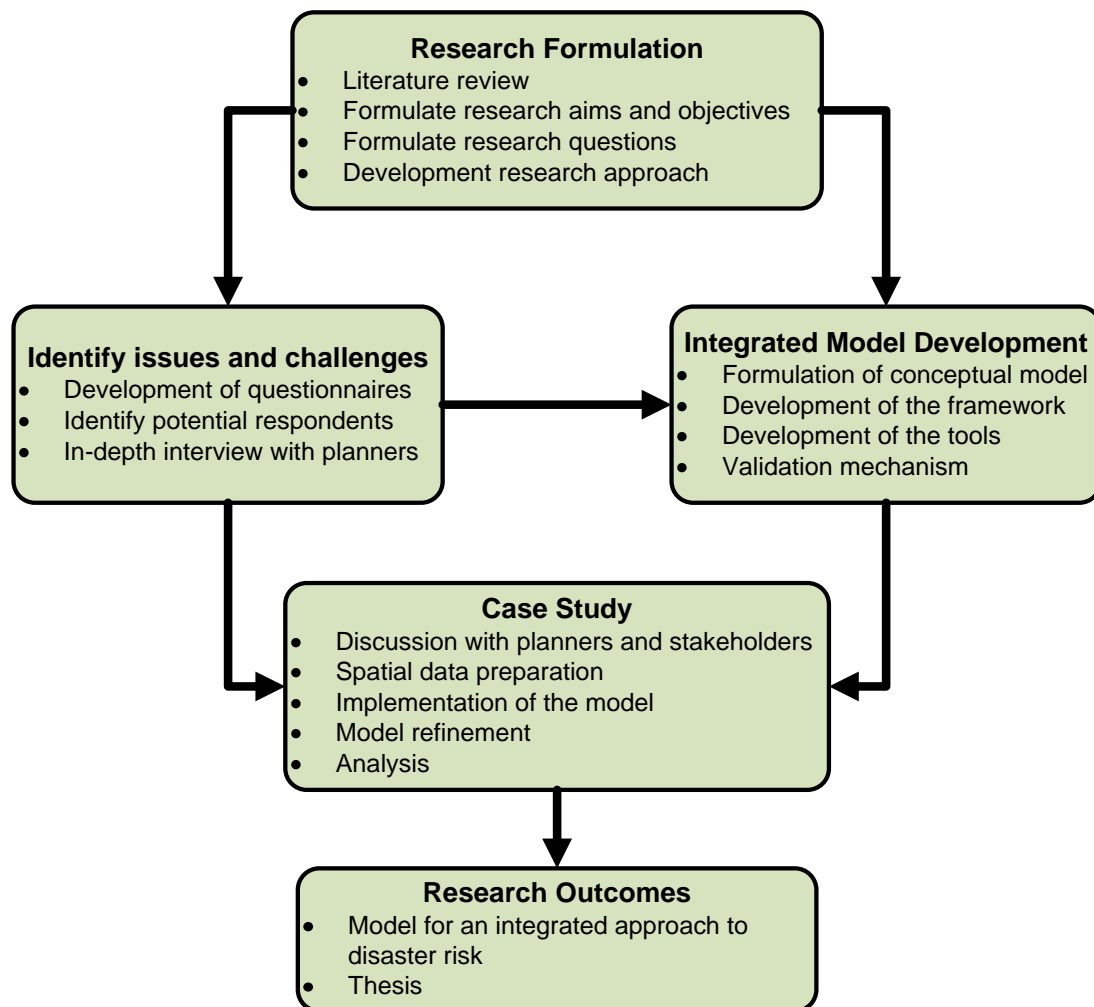


Figure 1-1 Research stages.

Stage 2 covers the identification of issues and challenges in the current practices of disaster risk reduction and spatial planning at the global level and in the case study area. At the global level, the issues and challenges were gathered and analysis from literature. To support assessment at the local level, two types of questionnaires were developed: one for the local development planning agencies at the district level in Indonesia and one for the planners and stakeholders in the case study area. For the first questionnaire, respondents were sought from the participants of a workshop on SDI and disaster management that was held in July 2009. The participants came from various planning agencies in Indonesia. The questionnaire was also distributed to

other planning agencies by mail. In-depth interviews were conducted with stakeholders from the case study area of Semarang, in the Central Java Province in Indonesia, including planners, government officials, consultants and real estate developers. The second questionnaire was distributed to planners, non-government organisations (NGOs), consultants and academics in the case study area.

Stage 3 involves the development of the integrated approach model. In this stage, the conceptual model of integrated approach was formulated. In addition, it covers the development of acceptable risk measures, how they can be implemented in spatial planning and what circumstances should be considered. Finally, the strategy for model validation and evaluation was elaborated.

Stage 4 implements the model in the case study. It involves spatial data preparation, processing and running the model, refinement and analysis of the results. Discussions with planners and stakeholders were conducted before the system was developed, during the development process and after the finalisation. The aim of the discussions was to gather input from stakeholders, inform participants of the results, obtain feedback and fine-tune the model.

Stage 5 analyses and summarises the results. The integrated approach to disaster risk reduction is presented. The stage also includes the writing of the thesis.

1.5. Scope of the Study

This study focuses on developing an integrated approach to disaster risk reduction by employing an acceptable risk method in a PSS environment. It attempts to combine and enhance the processes of disaster risk reduction and spatial planning, which are often conducted by different agencies without close collaboration. The approach is implemented using a PSS to facilitate a scientifically sound and more objective assessment of the environmental situation. This will ensure that there are few short-sighted views regarding land use management. Considering that many hazard-prone urban areas are already developed and populated, the acceptable risk method is proposed. It is infeasible to completely abandon areas facing certain types of disasters because of several difficulties, including the limitation of available land.

The research was implemented using a case study approach. The city of Semarang, in Central Java, Indonesia, was chosen as the case study area. Six types of natural hazards threaten the city, including coastal abrasion, floods, land subsidence, landslides, tidal inundation and typhoons. The research focuses on the effects and containment of land subsidence and rising sea levels. Both can be considered the most costly disaster, although they are slowly progressing and create no direct casualties; thus, the effects are not immediately obvious. The spatial and non-spatial data used in the research were obtained from the Regional Development Planning Agency (RDPA) of Semarang. The data were also used by the RDPA for the development of a new spatial plan that was enacted in June 2011. However, the research and the city's spatial planning were not connected. The development of an acceptable risk method in spatial planning was mostly directed towards finding the optimal plan for the ongoing and continuously progressing land subsidence, which affects a large part of the city's lowland area.

1.6. Organization of This Thesis

The results of this study are presented in eight chapters. The outline of the thesis, along with its relation to the research objective, is presented in Figure 1-2. The following descriptions outline the content of the chapters.

Chapter 2 identifies issues and challenges in the current practices of disaster risk reduction, especially in relation to spatial planning. It includes a description of natural hazards, the importance of elements in risk mapping and methods for disaster risk reduction. The chapter specifically examines hazards that affect coastal urban environments. It argues the necessity of using acceptable risk measures to overcome difficulties in disaster risk reduction using spatial planning. Considering the utilisation of hazard-prone areas and the limited space available for relocation, living with disaster situations cannot be avoided. Therefore, an acceptable risk measure was developed to assist planners with land use management. The chapter concludes with a model for an integrated approach to disaster risk reduction.

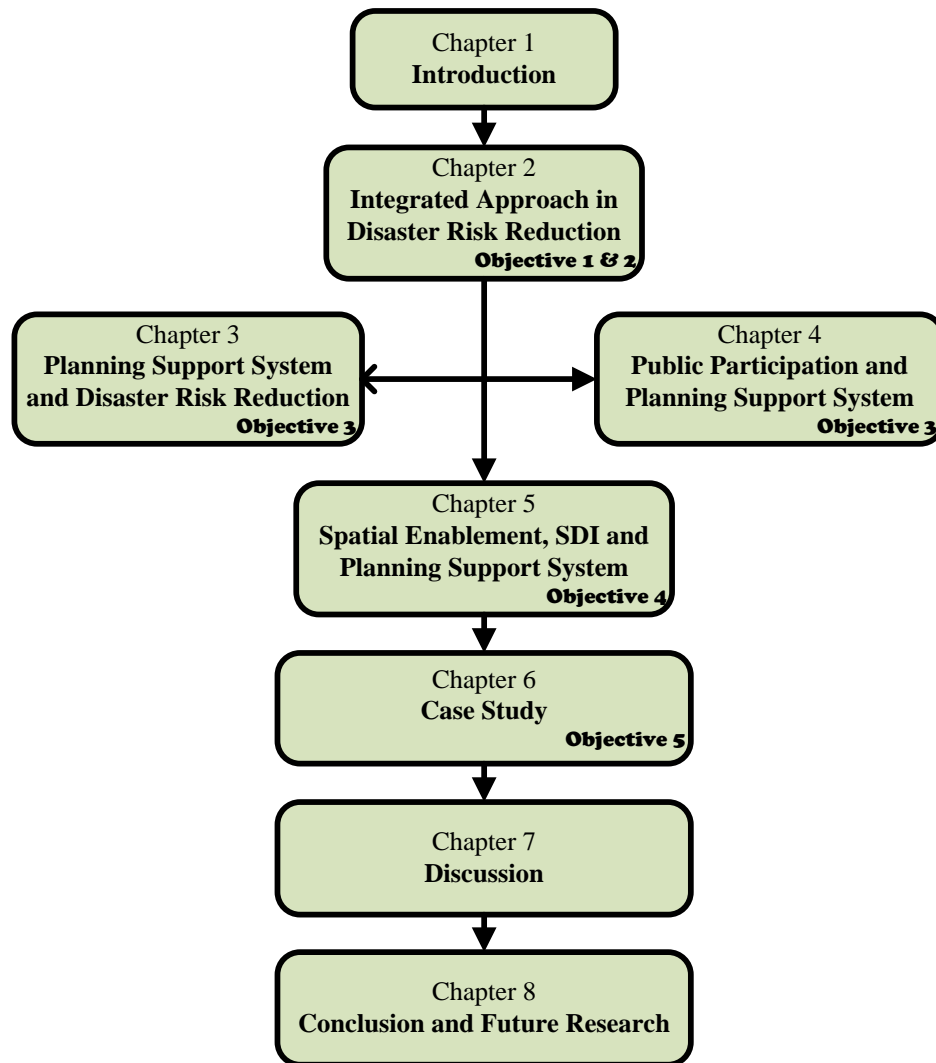


Figure 1-2 Thesis structure and its relation to the research objectives.

Chapter 3 investigates the development of PSSs for disaster risk reduction and critically reviews spatial planning and its importance in disaster risk reduction. It then considers how a PSS can be customised for disaster risk reduction, as well as its system architecture, technical requirements, and challenges and opportunities for implementation.

Chapter 4 discusses the way that stakeholders can participate in spatial plan development related to disaster risk reduction. It covers the general concept of public participation and how PSSs can be adapted and used to aid public participation. It then describes the components and strategies necessary for public participation and collaboration using PSSs. The architecture and mechanism for collaboration is presented.

Chapter 5 examines how spatial enablement and SDI can facilitate better spatial planning and, in turn, a better disaster risk reduction strategy. It comprises a discussion of spatial enablement, elements and requirements for spatial enablement, and how SDI can contribute. Specifically, this chapter discusses the development of SDI for spatial planning and the conceptual model of SDI for spatial planning and disaster risk reduction.

Chapter 6 presents the results of the case study. It begins with a description of the physical situation, the natural hazards affecting the case study area and governance related to spatial planning. The preparation and processing of spatial data is described, and the concepts of PSS development and parameterisation are expanded.

Chapter 7 summarises and discusses the research findings. It is followed with the response to the research aim, objectives and questions. The chapter concludes with a discussion on the contextualisation of the research.

Chapter 8 concludes the research and is followed by recommendations of potential topics for further research. A summary of the chapters and their deliverables is presented in Table 1.1.

Table 1.1 The chapters and summary of their content

Chapter	Deliverables
Chapter 1 Introduction	
Chapter 2 Integrated Approach in Disaster Risk Reduction	<ul style="list-style-type: none"> List of issues and challenges in disaster risk reduction regarding spatial planning List of hazards in the coastal urban environments Review of the existing disaster risk reduction methods Conceptual model of an integrated disaster risk reduction
Chapter 3 Developing a Planning Support System Application	<ul style="list-style-type: none"> Review of spatial planning Review of PSS Roles of spatial planning in disaster risk reduction Requirements for the inclusion of disaster risk reduction in spatial planning Conceptual model of PSS application for disaster risk reduction Method to build a PSS application
Chapter 4 Public Participation and Planning Support Systems	<ul style="list-style-type: none"> Issues and challenges in public participation Roles of public participation in spatial planning Roles of public participation in disaster risk reduction PSS functions in public participation Implementation of public participation in Indonesian context
Chapter 5 Spatial Data Infrastructure Platform for Spatial Planning and Disaster Risk Reduction	<ul style="list-style-type: none"> Issues and challenges in SDI development Drivers for SDI development at the local government level SDI conceptual model for spatial planning and disaster risk reduction
Chapter 6 Case Study	<ul style="list-style-type: none"> Assessment of the case study area Issues and challenges in spatial planning Issues and challenges in disaster risk reduction Issues and challenges in public participation Issues and challenges in SDI development Analysis of the PSS implementation for disaster risk reduction
Chapter 7 Discussion	
Chapter 8 Conclusion and Recommendation	

Chapter 2. INTEGRATED APPROACH TO DISASTER RISK REDUCTION

2.1. Introduction

This chapter provides a foundation to develop a strategy for disaster risk reduction based on past and current practices. It elaborates on the development of an integrated approach in disaster risk reduction. The importance of this approach is related to necessities in response to the various natural disasters faced by societies, and the involvement of different organisations and disciplines in the disaster mitigation process. Thus, this chapter begins with a description and analysis of natural disasters and the elements at risk. These sections will form an understanding of several key factors underpinning the study of natural disasters, how they interact with each other, the types of impacts and the features to be affected. It is followed by an elaboration of the disaster risk reduction concepts, how they evolve into current practices and the methods that are currently employed. An acceptable risk measure is proposed as one of the key indicators in disaster risk reduction. The measure is chosen considering the current state of land utilisation in many urban environments and the limitation of options for disaster mitigation faced by planners and decision makers. Finally, the conceptual model of integrated approach in the disaster risk reduction is presented using acceptable risk.

2.2. Natural Disaster

2.2.1. Key terminologies

A discussion about natural disaster requires a clear definition of many terminologies. Hazards are a potentially damaging phenomenon that can cause damage to property and other public infrastructure and disruption to economic and social activities, as well as injury or loss of life and environmental degradation (Federal Emergency Management Agency [FEMA], 1997; United Nations International Strategy for Disaster Reduction [UN/ISDR], 2009). When the source of a hazard derives from nature, it is called a natural hazard. A natural hazard is the product of a geological,

geophysical or hydro-meteorological activity in the form of an earthquake, landslide, volcanic eruption, flooding or storm (Benson and Clay 2004). When it strikes an uninhabited area and has no impact on human life, it is still a natural phenomenon. A natural hazard can be transformed into a natural disaster if it directly affects human activities and infrastructure. A natural disaster is a result of the exposure of elements at risk to hazards and a community's incapability to tackle the situation (Misonali and McEntire 2008; UN/ISDR 2009). While the capability of communities and governments to confront natural disasters is increasing, the exposure of people and infrastructure to hazards is also increasing, which in turn results in an increase of the disaster risk. The degree of disaster risk faced in a particular location is a function of hazard, vulnerability and resilience, as presented in the following formula:

$$\text{Disaster Risk} = \text{Hazard} \times \text{Vulnerability} - \text{Resilience}$$

In this formula, vulnerability is a condition of the potential to suffer damage or loss due to hazards. Resilience is the condition whereby a system or community faced with disaster can withstand its impacts using its own resources to restore its pre-disaster conditions and functions. However, it is not easy to quantify resilience; therefore, other methods need to be used to calculate risk in the economical or structural terminology. The modification of the previous formula is as follows:

- a. $\text{Disaster Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Amount}$
- b. $\text{Risk} = \text{probability} \times \text{consequences}$
- c. $\text{Risk} = \text{hazard} \times (\text{vulnerability} / \text{capacity})$
- d. $\text{Risk} = f(\text{hazard}, \text{vulnerability}, \text{exposure})$

For a, consider a house worth \$100,000 that is located in an area subject to flood, with a recurrence period of 20 years. In this case, the hazard is the probability of occurrence in a given time. In one year, the hazard will be 0.05; therefore, the risk for one year can be calculated as follows:

$$\begin{aligned} \text{Risk} &= 0.05 \times 1 \times \$100,000 \\ &= \$5,000 \end{aligned}$$

The above example is a simple illustration, as it only involves one element at risk and one hazard type. The calculation would become more complicated in the real world, and it would consider:

- number of elements at risk that are involved
- that the hazard will not threaten entire sections of the element at risks
- number of hazards incorporated
- predictability of hazards
- progression of hazards
- variation in the recurrence period
- variation in the coverage of a different hazard's recurrence period
- different level of threat from individual hazards (low, medium, high).

With the increasing interaction and complexities between human activities and natural phenomena, it is generally accepted that natural hazards sometimes evolve into unnatural disasters (UN 2010). The originally pure natural phenomenon can be altered by human activities and become a human-enhanced disaster, with further and larger impacts. Land use and land use changes modify the natural path of hazards, creating human-made or human-influenced hazards. Therefore, it is important to carefully manage land use and land use changes to reduce the impact and alteration of natural disasters. This requires the incorporation of natural disasters into development planning.

Considering the time of occurrence, natural disasters can be classified as either rapid or slow onset. Rapid onset disasters occur suddenly, in a very short time, without any prior warnings to people in the area. Slow onset disasters provide early warnings so that people can prepare for the catastrophic events and are able to see how they develop. The impact is develop slowly, from a low risk within limited areas to a higher risk that affects wider areas.

Based on their recurrence, natural disasters can be categorised as sporadic or continuous. Earthquakes, landslides and volcanic eruptions are examples of sporadic natural hazards. They may strike once or several times in a certain period, but there will be a time when there is no disaster and people can return to normality. These types of disasters have a recurrence period of several years to hundreds of years, although their impact can be felt days, weeks, months or even years after they strike.

In the category of continuous disaster, the process never stops for a long period. The disaster continuously progresses with no break until it reaches its end. Continuous disasters include rising global sea level and land subsidence, which have in effect developed into local relative sea level rise.

The calculation of risk from a continuous disaster is different from the risk resulting from a sporadic disaster. In the case of relative sea level rise, as time passes, the risk continues to increase. The number of residential buildings to be affected by tidal inundation in 20 years, in an area subject to a rise of 10 cm per year in the relative sea level, will increase substantially.

Natural disasters have many severe impacts on society and infrastructure. The affected features can be classified as follows:

- Human: disasters can cause loss of life, injury, disease and psychological impact from traumatic experiences.
- Economic; disasters can disrupt economic activities, causing loss of land, property, income and economic opportunity, destruction of economic infrastructure and financial losses due to the re-allocation of funds for response and reconstruction efforts (Benson and Clay 1998).
- Physical: includes destruction of road networks, bridges, railways and utility networks.
- Environmental: includes loss of wetlands, changes in land cover, biodiversity loss and destruction of ecological areas.

These impacts can directly or indirectly strike people and infrastructure. One type of natural disaster can trigger a sequence of disasters, where the primary disaster (e.g. volcanic eruption) can create a secondary disaster (e.g. destruction of agricultural fields) and perhaps a tertiary disaster (e.g. starvation). Land subsidence can develop into a relative sea level rise and then increase the frequency and magnitude of floods.

Disaster risk reduction requires consideration of the progression and predictability of the hazards. Progression is a result of the increasing magnitude of the hazard sources and/or the developmental activities that occupy disaster-prone areas. Predictability relates to the possibility of early projection regarding when and where a particular disaster will occur. The advancement of scientific method and technology has made

sophisticated measurement methods and early warning systems available for some natural disasters, including floods, volcanic eruptions, tsunamis, hurricanes, land subsidence and landslides. Some disasters are predicted weeks in advance, while others can be predicted in days or hours. Only earthquakes are still impossible to predict.

Due to different environmental settings, one type of disaster may have different characteristics that affect its predictability. For example, floods in lowland flat areas are more predictable than flash floods in areas near mountainous regions. Floods are one of the major threats in coastal zones and currently play an important role in economic and socio-political activities. The coastal urban environment is also environmentally sensitive to many external influences and physically vulnerable to many types of natural, human-made and human-enhanced hazards.

2.2.2. Natural disaster in the coastal zone

Coastal urban environments are currently highly utilised, densely populated and are sought after for new developments. The areas are economically and socio-politically important, but they are environmentally sensitive and physically vulnerable to many types of natural, human-made and human-enhanced hazards. It is estimated that around 38 per cent of the world's population live in areas less than 100 km from a shoreline (Cohen, Small et al. 1997; Kay and Alder 2005), with more than 50 per cent of the Asian population living in this area (Mimura 2008). Fourteen out of 25 of the world's largest cities are located in coastal environments, including Tokyo, Mumbai, New York, Manila, Los Angeles, Shanghai, Osaka, Karachi, Guangzhou, Jakarta, Buenos Aires, Istanbul, Rio de Janeiro and Lagos (Brinkhoff 2009).

A coastal zone is a transition area between the land and the sea, and it possesses characteristics of both elements. It is influenced by physical processes and human activities (Fletcher and Smith 2007) from both land and sea, with different functions and scales of effect (Le Tissier, Hills et al. 2004). The interaction between physical processes and human activities in the coastal zone determines the vulnerability of the coastal environment to natural hazards. Many coastal cities are located in a delta region or alluvial plain and have low elevation. Coastal urban cities usually consist

of an inner urban area surrounded by suburban areas (Gurran, Blakely et al. 2007) along the coastline or in the hinterland area.

Many natural hazards, especially water related hazards that threaten coastal cities, are directly related to the low elevation of the area. This includes flooding, tsunamis and deterioration of groundwater. Sea level rise caused by global warming increase the vulnerability of many coastal cities (Titus and Narayanan 1996). The eustatic, or absolute sea level rise, is relatively small compared to the rate of rapidly subsiding coast (Raper, Wigley et al. 1996). Figure 2-1 illustrates the relative position between land and sea levels in different conditions.

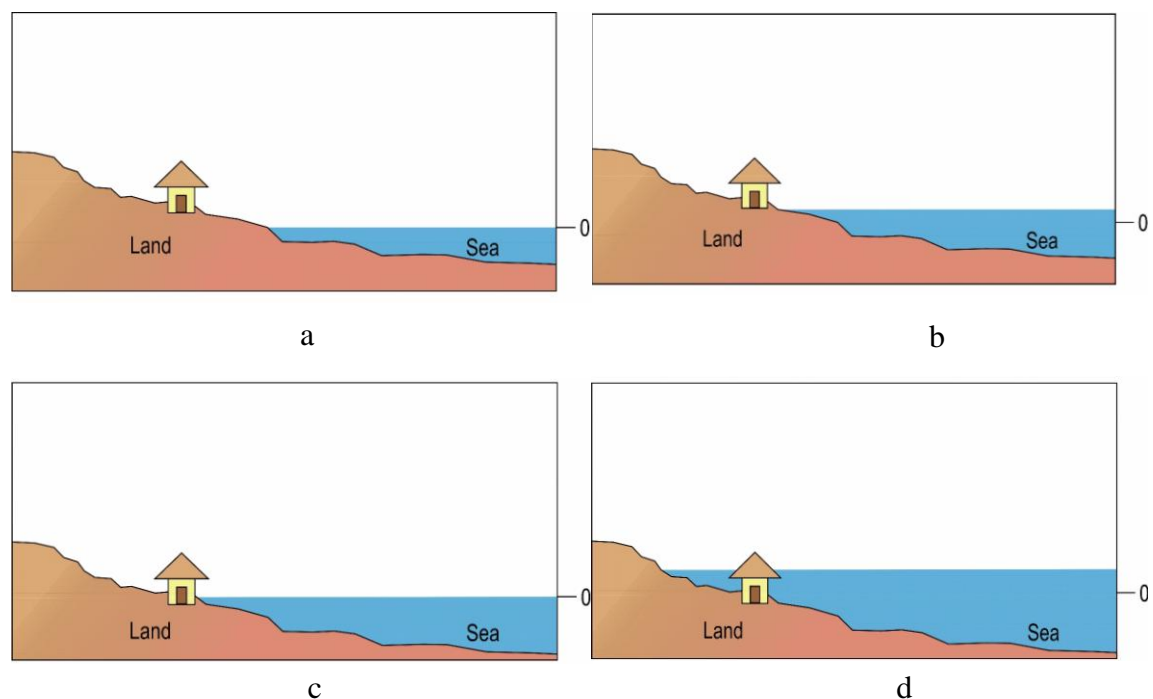


Figure 2-1 Relative position between land level and sea level.

Figure 2-1.a illustrates the normal conditions between the land and sea levels. A variation of the sea level occurs daily with the tidal cycle. Figure 2-1.b shows the extent of seawater inundation if the sea level rises. The land area will be taken by seawater. A similar situation and effect occurs in the event of a land subsidence situation, as shown in Figure 2-1.c. The combined effect of the sea level rise and land subsidence is illustrated in Figure 2-1.d. The impact is enhanced, although the share of land subsidence is higher than the sea level rise.

Land subsidence is commonly occurring in coastal cities around the world, such as Venice, Shanghai, Bangkok, Jakarta and Semarang (Hoogeveen and Van Leeuwen 1995; Sestini 1996; Teatini, Ferronato et al. 2005; Phien-wej, Giao et al. 2006; Zhang, Xue et al. 2008; Abidin, Andreas et al. 2010; Kaneko and Toyota 2011). To a degree, it is a natural phenomenon caused by the consolidation of the clay layer in the coastal zone (Sestini 1996; BGR 1998; Kaneko and Toyota 2011). These coastal cities have several things in common, including the young alluvial sediment underlying the city, rapid population and industrial growth, buildings and infrastructure load, and extensive groundwater withdrawal (Teatini, Ferronato et al. 2005; Rodolfo and Siringan 2006; Zhang, Xue et al. 2008; Kaneko and Toyota 2011). Thus, the previously classified natural disaster becomes a human-accelerated disaster (UN 2010).

The clay layer that supports coastal cities is very sensitive to the amount of water above it. In normal situations, the clay layer is compacted due to its own weight and the weight of the sediment above it. The compaction of the clay layer may be accelerated by extensive groundwater extraction, the building load and the reduction of water infiltration in recharge areas of the water basin. This process is followed by lowering the land elevation relative to a certain datum, which is called land subsidence (Sutanta, Rustamaji et al. 2005; Phien-wej, Giao et al. 2006). The direct and indirect impacts of land subsidence and relative sea level rises include (Titus 1991; Milliman and Haq 1996; Titus and Narayanan 1996):

1. Direct impact:

- a. cracking and bending of structures and pipes
- b. detachment of septic tanks
- c. water flows back during high tide
- d. coastal erosion
- e. deterioration of groundwater and salt water intrusion
- f. increase in the length, depth and frequency of floods and tidal inundation.

2. Indirect impact:

- a. slowing down economic activities
- b. land loss
- c. decrease in land value
- d. reduction in health quality due to problems in the sanitation network and drainage
- e. reducing the government's capacity for development, since they have to allocate a budget to overcome the direct impact

Regarding the current utilisation and state of development of the coastal urban environment, the consequences of a relative sea level rise will be severe in terms of the economic cost, population affected and damaged infrastructure. The rapid development in coastal urban environments add more involvement from a range of stakeholders and interest groups, leading to more complex requirements in the government's decision-making process to guarantee physical and socio-economical sustainability (Milligan and O'Riordan 2007). More interest from stakeholders means more competing uses of space, which needs to be addressed appropriately.

In response to higher demand for space, land use conversion is usually high to accommodate the need for housing, industrial and commercial uses. It creates multiple effects, such as the disappearance of protected areas and conflict in the use of available space. Some people will be forced to live or work in marginal land areas, which are usually located along the riverbank, close to swampy areas or on the slopes of steeper hills. These areas are more vulnerable to disaster compared to prime locations. Regulated and unregulated developments occur in areas susceptible to future disasters. Unregulated settlements are common in fast-developing coastal cities. The community and infrastructures, which constitute elements at risk, need to be identified, classified and mapped to reducing disaster risks.

2.3. Assessment of Impacts on Elements at Risk

2.3.1. Mapping and projecting elements at risk

Element at risk includes all human-made infrastructure and natural features, which consist of physical and non-physical infrastructures that face risks from natural disasters (Montoya 2002). Human-made physical infrastructures include houses, road networks, utilities networks, bridges, drainage networks and railways. Human-made non-physical elements consist of economic, cultural and political environments. Natural features that may be affected by natural disasters include beaches, river systems, swamps, vegetation and all fauna in these environments.

Understanding what constitutes elements at risk is essential in determining the most appropriate method for risk assessment and disaster risk reduction. In response to a particular disaster, the elements at risk possess different levels of vulnerability and coping capacity. Compared to road networks, residential houses have a higher vulnerability to floods but less coping capacity because of their individualistic usage and funding capacity. Elements at risk inherently have a different significance to the community, which will determine the response of governments and communities to defend them. Table 2.1 shows an example of the classification of vulnerability and the coping capacity of elements at risk for different types of hazards.

Table 2.1 was developed using the land use commonly found in many urban and rural settings. The time of the hazard's occurrence will modify the vulnerability and coping capacity of the elements at risk. Over time, the spatial footprint and magnitude of natural hazards may also be changed. In this regard, it is essential to map the elements at risk in the present situation and project their possible future extension.

The elements-at-risk map depicts the location and identification of the elements in society and infrastructures that are at risk if confronted with certain types of natural and human-made hazards at any given time and magnitude. It requires large-scale maps of infrastructures and utilities, as well as small- to medium-scale hazard maps. The basic map for this purpose would be a parcel map, planning permit and/or property information. Unfortunately, not all of these maps are available in all countries or jurisdictions. There are gaps in the availability of complete and reliable

spatial data between developed and developing countries, and between sub-national governments.

The absence of the operational use of SDI as an enabling platform may also impede the flow of data between agencies responsible for property maps and disaster mitigation. This situation will also affect data discovery and access. Irrespective of this circumstance, the spatial data are required to be as detailed, complete and current as possible.

Table 2.1 Samples of vulnerability and coping capacity of different elements at risk.

Hazards	Elements at risk	Vulnerability	Coping capacity
Floods	Residential building	Low–high	Low
	Government building	Low–medium	High
	Commercial building	Low–high	Medium–high
	Industrial building	Low–medium	High
	Road	Low	High
	Railway	Low–medium	High
	Utilities	Low–medium	High
	Drainage network	Low–high	High
Landslides	Residential building	Low–high	Low–medium
	Government building	Low	High
	Commercial building	Low	Medium
	Industrial building	Low	High
	Road	Low–medium	High
	Railway	Low	High
	Utilities	Low	High
	Drainage network	Low	High
Land subsidence	Residential building	Low–high	Low
	Government building	Low–high	High
	Commercial building	Low–high	Medium–high
	Industrial building	Low–high	High
	Road	Medium–high	High
	Railway	Medium–high	High
	Utilities	Medium–high	High
	Drainage network	Medium–high	High
Volcanic eruption	Residential building	Low–high	Low
	Government building	Low–medium	High
	Commercial building	Low–medium	Medium–high
	Industrial building	Low	High
	Road	Low	High
	Railway	Low	High
	Utilities	Low	High
	Drainage network	Low–high	High

In line with the hierarchical structure of government—that is, central or federal, provincial or state, district or cities—elements-at-risk mapping needs to be conducted

at different scales, from a small scale at the national level to medium at the provincial level and large at the district level.

Regarding the integration of this information into disaster risk reduction in the framework of spatial planning, the number and location of elements at risk in the future needs to be projected. Projecting future development requires detailed information or comprehensive plans to be available in every local government. These spatial plans usually consist of information regarding where planned developments will be allocated, the capacity of each allocated area and the approximate time when each development project should be started and finished. Although the realisation of these plans depends on several external factors, such as economic and political situations, it is a formal guidance on development and will serve as initial data for projecting the extension elements at risk.

At any stage in the development of a detailed spatial plan, the natural hazards that may affect the future use of land are considered. At different levels, the government requires reliable data and resources. However, these requirements are not always met in many developing countries. For example, local governments in Indonesia do not always have the resources and data to conduct the appropriate mapping of natural hazards; therefore, the detailed spatial plan still exhibits deficiencies. In effect, a disaster-prone area may still be incorporated into the detailed spatial plan. An area that is currently disaster free, but is projected to become disaster prone in the future, may still be designated as an area suitable for development. Other factors that contribute to this unfortunate situation are the current limited availability of suitable locations, and jurisdiction constraint, which limits some planning aspects to consider only one administrative unit.

The limitation of vacant and suitable land in the current situation leads to the occupation of marginal land and even environmentally sensitive areas for industrial, commercial and residential use. Many local governments have been forced to utilise marginal lands, although several precautions were developed to limit potential loss due to natural hazards. Thus, many elements at risk may not be appropriately mapped and projected.

2.3.2. Methods for risk assessment

Different models have been proposed by researchers to assess disaster risks. These models take into account different variables and serve different purposes. Three methods of risk assessment will be reviewed, including methods developed by the Munich Reinsurance Company (Munich Re), Hazards Research Lab, Department of Geography at the University of South Carolina and the Institute of Spatial Planning at the University of Dortmund (IRPUD).

The Munich Re model aimed to discover the overall risk index of 50 megacities around the world. It consists of three major indices: hazards exposure, vulnerability and exposed value. The hazards exposure component consists of average annual losses (AAL) and probability of maximum losses (PML). The vulnerability components consist of six elements: standard of preparedness, standard of safeguards, residential construction vulnerability, commercial/industrial vulnerability, building density and quality of construction. The exposed values components focus on the area's economic values and consist of average value for households (residential), gross domestic product for commercial/industrial buildings and value in an overall context. The three main components receive the same weight of 33.3 per cent. The model appears to end with an overall risk index of the existing environment, but without a prediction of the future situation. This can be understood, since the model was developed from the viewpoint of an insurance company.

The Total Place Vulnerability Index ranks counties according to their level of vulnerability to hazards. The description of this model follows the 'State of South Carolina Hazards Assessment 2005' (SCEMD 2005) and Greiving, Fleischhauer et al. (2006). To detect the total place vulnerability, the model received inputs from the scores of total probability of hazards' occurrences and total social vulnerability. These two inputs have the same weight of 50 per cent. The scores for total hazards' probability of occurrences were based on the historical data of all hazards' affected counties in the region, without considering their extent and magnitude. The total social vulnerability scores were obtained from the following variables: age, gender, population, race, income and number of mobile homes per county. All sub-elements in the two inputs have similar weights, regardless of their degree of importance.

Although mathematically simple, some extreme values in one sub-element can distort the final place vulnerability index.

The Integrated Risk Assessment of Multi-Hazards index was developed by the IRPUD (Greiving, Fleischhauer et al. 2006). The objective of the model was to develop an integrated risk map based on integrated hazards and vulnerability maps. Inputs for the integrated hazards map were all relevant hazards in a particular geographical location. The weight for each hazard class—for example, typhoon, landslide, flood—were derived using the Delphi process, based on the opinion of scientists and stakeholders in the region. Therefore, there will be different weights for each hazard class. The vulnerability map consists of hazard exposure and coping capacity. Hazard exposure is the product of GDP per capita and human damage potential based on population density. GDP per capita is an aggregation of infrastructures, residential buildings and production capacity. Coping capacity represents the financial capacity of the nation or region to cope with the disaster.

The Integrated Risk Assessment of Multi-Hazards index is thought to be the most common method of risk assessment currently employed worldwide (van Westen, Montoya et al. 2002). Its strength is that it can reveal the information of the total hazard for any given location. However, the three methods reviewed concentrate on the present situation and do not examine future possibilities in terms of the extension of vulnerable elements. Nevertheless, the result of the risk assessment process will be beneficial for developing the most appropriate strategy in disaster risk reduction.

In summary, the risk assessment methods that best serve as the basis for long-term disaster risk reduction should:

- use the highest-detailed base map available
- incorporate all relevant hazards
- evaluate the current hazards as well as the prediction for the future.

2.4. Disaster Risk Reduction

2.4.1. The increasing impacts of natural disaster

Statistics from several sources, such as the United Nation Development Program UNDP (2004), (Scheuren, de Waroux et al. 2008), EM DAT (2011) and the

UN/ISDR (2012) show that there was significant increase in disaster casualties and economic losses in the past 20 years. The increasing number of casualties in many natural disasters triggered a question of why this situation occurred. Is it merely related to the increasing number of natural hazards, or is it a combination of increased natural hazards and increased exposure of humans and infrastructures? On the hazard side, climate change was thought to be one of the factors in the increasing frequency and magnitude of hydrological and meteorological disasters (Resurreccion, Sajor et al. 2008), and sea level rise ((Titus and Narayanan 1996; Meehl, Stocker et al. 2007)Titus, 1996; the Intergovernmental Panel for Climate Change [IPCC], 2009). Other researchers argue that this situation can be attributed to the increasing exposure of people to hazards due to rapid urbanisation, physical infrastructure development, uncontrolled land use and land use change, as well as limited available space in disaster-free areas (Sanderson 2000; Pelling, Özerdem et al. 2002).

Statistics also indicate that the number of economic losses is increasing significantly. Between 1975 and 2010, economic losses increased from less than US\$5 billion to more than US\$120 billion annually (EM-DAT 2011). The increase is related to the increase in disaster frequency, the state of economic value in different years and the country where the disaster occurred. In the immediate past, a disaster might strike an area with a small population; however, that area might now be densely inhabited. This will certainly increase the economic values at stake. Losses to a disaster of similar magnitude in developing and developed countries may result in completely different economic losses due to the different stages of development and economic valuation.

High economic losses will force the government, and private funding to be re-allocated for emergency response, recovery and reconstruction efforts, instead of the continuation of economic and infrastructure development. Disasters also affect the poverty alleviation program, in part because poor people are more vulnerable compared to the wealthy. The financial effects of disasters may severely affect a country's annual budget (UNDP 2004).

To minimise casualties and economic losses, and to ensure sustainable development, a number of policies and efforts should be sought and immediately implemented to reduce the disaster risks. This can be done using short- and long-term measures. Short-term measures usually involve structural activities, such as building protection walls and heightening dykes and levees. Long-term measures incorporate readjustment to the relation between hazard sources and elements at risk. This includes better land management, the relocation of affected or predicted-to-be-affected elements at risk and modification of the underlying hazard sources. Each of these approaches has its own advantages and disadvantages, as presented in Table 2.2.

Table 2.2 Long-term measures to reduce disaster risks.

Activities	Structural	Non-structural
Classification	<p>Extensive</p> <ul style="list-style-type: none"> ▪ Land reclamation ▪ Increase of groundwater infiltration ▪ Delay runoff ▪ Decrease groundwater extraction ▪ Relocation <p>Intensive</p> <ul style="list-style-type: none"> ▪ Polder ▪ Pumping house ▪ Drainage networks ▪ Levees, dikes ▪ Dams ▪ Flood gates ▪ Diversions and channel improvement ▪ House raising 	<p>Regulation</p> <ul style="list-style-type: none"> ▪ Zoning ▪ Building regulation ▪ Groundwater extraction <p>Defence</p> <ul style="list-style-type: none"> ▪ Projection ▪ Warning ▪ Relocation
Advantages	<p>Immediate results</p> <p>Delay runoff and increase infiltration</p> <p>Groundwater control</p>	<p>No significant environmental impact</p> <p>Lower economic cost</p> <p>Reduce building load</p>
Disadvantages	<p>High possibility of environmental impact</p> <p>High cost for construction and maintenance</p> <p>Increased building load</p>	<p>Pressures for other location</p> <p>Rise of property values</p> <p>Depend on the land availability</p> <p>Benefit are not immediately visible</p>

Sources: (Petry 2002); (BTRE 2002)

However, these efforts were not always possible due to complex circumstances surrounding the relation between natural hazards, people, infrastructures, and economic and social activities. For existing built-up areas, the solutions are more difficult to find, as they will directly affect a large number of people and infrastructures already in the location. In many developing countries, building

massive protection infrastructures is impeded by insufficient funding. Relocating a large number of people and infrastructures that are severely threatened by natural hazards is almost impossible because of the funding required, social resistance, political difficulties and the emotional attachment of the residents to the land. The difficulties are smaller for newly planned developments for vacant land. There are several available options for reducing disaster risk that are easier to achieve. However, the most difficult limitation is searching for available and suitable land. In this situation, authorities and people are often left with only one option; that is, to live with disaster risk. The implication to the spatial plan is that some land use designation already assumed they would be affected by natural disasters to some degree.

What degree of risk can people accept or live with? Can acceptable risk measures be implemented for all land use designation, or only partially? More importantly, how can the concept of acceptable risk be integrated into disaster risk reduction efforts? To answer these questions, the components and methods of disaster risk reduction need to be thoroughly investigated.

2.4.2. Methods for disaster risk reduction

With reference to the severity of the impact of natural disasters, comprehensive efforts are urgently required to reduce disaster risk. UN/ISDR (2009) defines disaster risk reduction as

‘the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events’

The reduction of the exposure of elements at risk to natural hazards can be achieved by, for example, better planning of land use. In some cases, such as landslides, land use planning can be used to reduce its sources. It can also be employed to increase the coping capacity of the land use designations, thus reducing its susceptibility. This effort should be comprehensively conducted in a systematic way, and it requires the involvement of many government institutions, NGOs and communities. It should

also have a multidisciplinary nature, as shown in Figure 2-2. Organisational management and participation methods between these parties needs to be carried out systematically—not as an *ad hoc* activity—to sustain its effectiveness.

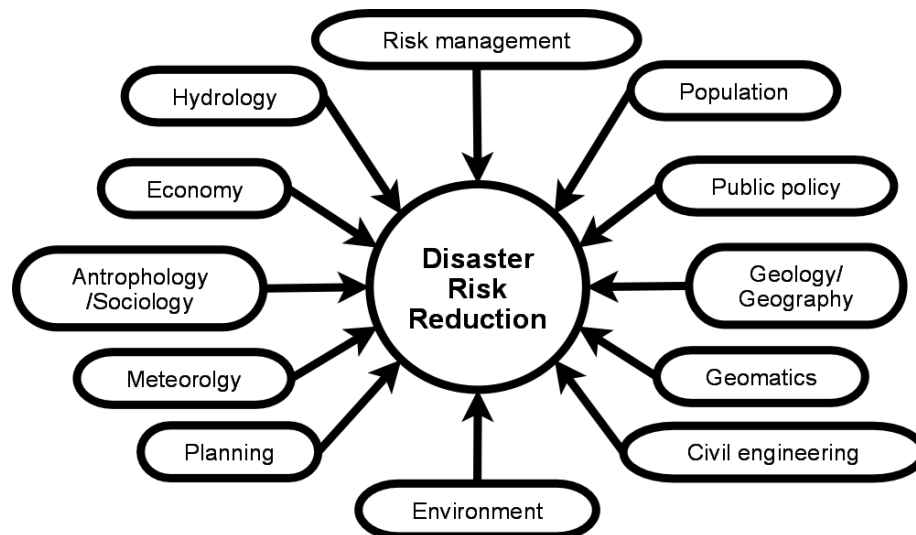


Figure 2-2 Multidisciplinary elements of disaster risk reduction.

Essentially, disaster reduction policies should have a two-fold aim:

- enable societies to be resilient to natural hazards
- ensure that development efforts do not increase vulnerability.

As disasters occur in a certain geographic location, spatial information is vital in disaster risk reduction. The locations at risk of certain types of disasters are at least partially predictable. Therefore, as a representation of spatial data, a map is an indispensable requirement for successful efforts in disaster mitigation (NRC, 2007). The functions of spatial data in disaster risk reduction are, for example, the creation of thematic maps of populations and infrastructures potentially affected by natural hazards, and underlying hazards in certain areas. Elements at risk can be identified individually, but current practices show that a multi-hazard approach is more frequently implemented. This has made elements-at-risk mapping become more complex, since different characteristics of multiple hazards need to be taken into account.

One of the key elements in disaster risk reduction is conducting effective land use management. This initiative is one of the efforts listed in the Hyogo Framework for

Action 2005–2015 (HFA, 2005), a key endorsement from the UN/ISDR. It has also been advocated to integrate disaster risk reduction into land use planning (Burby et al., 1999; Sengezer & Koc, 2005). The HFA requested that risk assessment be incorporated into urban and rural land use planning, especially in mountainous and coastal flood plain areas. Before the middle of the 1990s, a lack of attention was paid to spatial planning and its functions in disaster mitigation (Sanderson, 2000). Fortunately, in more recent research, it was found that land use planning for risk prevention has been implemented in some places, including France and Italy (Menoni, 2004). Table 2.3 provides examples of the types of measures of mitigating disaster risk specifically related to land use and spatial planning that have been used, implemented or researched in the past 40 years.

Table 2.3 Land use planning in disaster risk reduction.

Period	Method and disaster types	Researcher/organisation/country
1970–1980	Hazard zone and land use control—hurricane (1977)	Baker (1977)
1980–1990	Vulnerability-based land use planning—multi-hazards (1988)	Centre for Prevention of National Disaster in Central America—CEPRENAC (Montoya, 2002)
1990–2000	Local planning to address natural hazards—multi-hazards 1998	American Planning Association (Burby et al., 1999)
2000–2008	Community participation and collaborative efforts, information dissemination, multidisciplinary approach—multi-hazards Decision support framework for hazard mitigation—land subsidence and sea level rise (2005) Incorporation of hazard risk information in regional planning and land use planning—multi-hazards (2005) Land use policy—land subsidence, sea level rise and flooding (2007)	UNISDR Stockholm and Gdansk (Schmidt-Thome et al., 2005) European Union (Greiving et al., 2005)

There is a close relationship between disasters, spatial planning, mitigation and adaptation, as presented in Figure 2-3. Mitigation refers to lessening adverse impact of hazards by implementing various strategies and actions (UNISDR, 2009). Not all natural disasters can be completely avoided; some can only be reduced. Mitigation may result in different adaptation strategies. In general, there are three possible adaptation options: retreat, accommodation and protection (IPCC 1992). The adaptation strategy that is suitable for a given locality or community depends on the type of disaster and the capability of the community to withstand its effects.

Mitigation and adaptation strategies are important elements in formulating a spatial plan. They contribute to the consideration of land use designations and aim to reduce and modify natural hazards.

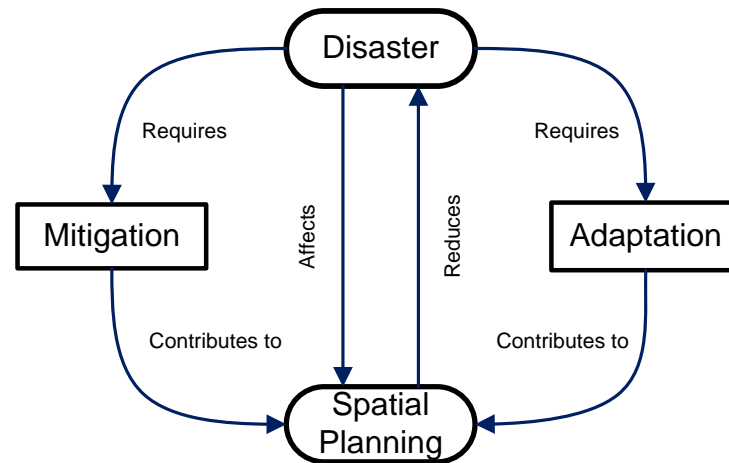


Figure 2-3 Inter-relationship between spatial planning and disaster mitigation (modified from Fleischhauer, 2005).

2.5. Acceptable Risk in Disaster Risk Reduction

With limited options available on how to best allocate land in the framework of reducing disaster risks, planners and decision makers need to accept that an unfavourable outcome needs to be made. Land use designations are affected by this situation. Some people or infrastructures may voluntarily or involuntarily be located in a disaster risk area. It is important for the government to know the degree of risk faced by a particular land use allocation. This information can be obtained from an integrated risk map, which presents information on all types of hazards that threaten a particular location. Previously, individual hazards were treated individually—sometimes by different government agencies that were also executing hazard prevention activities. This traditional method was suitable when disaster mitigation mostly relied on structural measures. Spatial planning requires that all natural hazards be approached integrally before being fed into GIS or PSS modelling and used in the spatial plan development.

Basically, there are two predominant methods used in developing an integrated risk map. The first method requires individual risk maps to be assessed, scored and weighed. Using a weighted overlay technique, all individual maps are then integrated

as a unified risk map. This method has been used, for example, by Greiving et al. (2006). The second method considers that every element at risk has a different capacity to cope with different types of natural hazards. The coping capacity of all land parcels or planning zones needs to be evaluated against all relevant hazards in the area. The terminology of 'acceptable risk' is used to denote the severity level at which a particular land use designation can withstand a certain type of hazard. For example, an area susceptible to floods with a 10-year recurrence period can still be designated for agriculture use, but not commercial or residential use. An earthquake is disastrous to residential areas but poses no risk to agriculture fields. Conversely, floods will have negative consequences on both residential and agriculture use. Therefore, a criterion needs to be developed for the acceptable level of risk for each land use in relation to the different types of hazards. This process requires the assessment of the coping capacity of each land use designation, especially regarding who will utilise the land. However, this first requires the definition of risk and acceptable risk.

Risk can be defined as the probability of the loss of lives, injury, damaged property or infrastructure and disruption of economic activities as a result of hazards that strike a particular place at a given time and of a given duration (Crichton, 1999; Downing et al., 2001). It can also be defined as the probability of occurrence of certain hazards (Downing et al., 2001; Brooks, 2003). Risk involves hazards, vulnerability and exposure (Crichton, 1999).

Defining acceptable risk involves professional judgment, historical precedents and formal analysis (Fischhoff et al., 1984). It is a decision problem that includes ascertaining crucial facts and values, as well as predicting human responses to hazards (Fischhoff et al., 1981). These steps are common in spatial planning and are particularly relevant for assigning the most suitable designated land uses for a particular area. In this approach, the possibility of actions being conducted by different parties to minimise potential risks (e.g. by hard engineering methods) should also be recognised. The realisation of this approach requires the description of acceptable risk measures.

Acceptable risk criteria are affected by different perceptions of risk thought by different individuals, communities (Vrijling et al., 1998) and governments. Each individual has a different perception of what constitutes risk depending on their experience, knowledge and the information they received. It may differ from the risk perceived by the wider community, particularly for residents who are living or have activities in the areas that are potentially affected. Conversely, governments can be expected to act as an expert, providing information and advice to individuals and the community. In addition, governments have some political and economic risks from disaster. The way the government disseminates hazard information to the public will influence the perception of risk among community members. These three actors have choices of voluntary and involuntary actions and have different degrees of acceptance. For example, an individual or a community may or may not opt to live in, travel to, buy property from, run a business in, or invest in natural disaster-prone areas. To avoid budget risk, governments may or may not approve development proposals or impose certain conditions.

Based on the above description, the definition of acceptable risk from the UN/ISDR (2009) is followed here: ‘the level of potential losses that a society or community considers acceptable given existing social, economic, political, cultural, technical and environmental conditions’. In an address regarding water quality standards, Hunter and Fewtrell (2001) proposed that, to make risk acceptable, it should fall into the following conditions:

- below the predicted probability of occurrence
- below the level of tolerable threshold
- cost of preventing and reducing risk, including ‘cost of suffering’, would exceed the cost saved
- cost of reducing risk would be better spent on other development projects
- agreement between the public and politicians.

The key components here are cost, potential losses and acceptance from potentially affected parties. Potential losses consist of two main elements: safety of people and economic loss. Acceptance from potentially affected parties depends on their

perception of risk, coping capacity and voluntary or involuntary situation. Less fortunate people may involuntarily accept the disaster risk because they have no other choices. Peculiarities in the real-world phenomenon are unavoidable. After the recent eruption of Mt Merapi in Indonesia, which killed 312 people, several villages were defined as inhabitable by the government because they were located in the level 3 danger zone. However, some villagers insisted on living in these danger zones. This case might not be an isolated one, especially if it deals with slow onset disasters that have little threat to people's safety or lives. Nonetheless, it provides a clear example of the difficulty between the government and community in agreeing on the acceptable risk level. There are evident differences in the perceptions of risk between parties.

Risky outcomes are inherent in defining acceptable risk (Bell et al., 2005). It involves uncertainty and inaccuracy in spatial data, hazard information and future projections. A safety margin in the modelling of likely impacts will help stakeholders and decision makers to establish the most appropriate course of action. It also requires technical assessment of the situation, historical data and precedents as the basis for projecting possible future events and devising solutions. As it involves the economics and safety of life measures, there will be trade-offs between the anticipated costs and the expected benefits of different types of responses (Fussell 2007). Relocation or change in land use designation will certainly have impact on the cost of development, transport and public infrastructures. Regarding the potential economic loss, a CBA can be used to facilitate the determination of the acceptability level.

The projected risk is likely to change over time with different types of conditions. Bell, Glade et al. (2005) identified several factors that may alter the risk assessment in the future, including change to the risk itself (e.g. changing a fire risk because of vegetation growth) or change to the estimated risk through alteration to the assumed process, the process model employed, the risk model used, the reference units and the resolution of the underlying spatial data. In modelling complex natural phenomena, all required elements may not be completely captured, and the interaction between them may be incompletely recorded and assessed. The projection results will be affected by this situation.

The occurrence/recurrence of natural disasters will also affect their associated risks. Sporadic and continuous disasters have different types of risks, as do their acceptability levels. For continuously progressing disasters, the acceptability level will decrease through time as the hazard is increasing. Therefore, the period for assessment should consider when the hazard would stop to develop further. However, in some cases, the time frame for hazard projection is matched with the validity of the spatial plan for a particular jurisdiction. In this respect, the sustainability of the development cannot be ascertained. A lack of reliable data and an accurate prediction developed by local governments may impede the long-term assessment of the susceptibility of land use designation. The length of the disaster occurrence may not be fully understood and modelled.

Once the level of acceptable risk has been established, the government will decide what action to take. Three general options are available: retreat, accommodation and protection (IPCC 1992). Retreat is usually taken if the safety of the people is in danger, or if the threat is greater than the coping capacity of the community and the government. Retreat is suitable for planned developments that can be relocated, provided there is available land. Accommodation relates to the situation where people consider the hazards manageable and to possess limited risks to their safety. Heightening the ground level of a house is part of the accommodation strategy. For an area that has high importance and cannot be moved to another location, building protection infrastructure is the only viable solution. For an area that has a mixture of developed land and land that is suitable for development, a combination of these actions is usually taken. For an area that is already occupied by existing buildings and infrastructures, the accommodation and protection strategy is more suitable.

2.6. Conceptual Model of the Integrated Approaches

2.6.1. Requirements for integration

Disaster risk reduction requires input from many disciplines, sectors and agencies. Some researchers argue that there is a need for an integrated disaster management (Chen, Blong et al. 2003; Gopalakrishnan and Okoda 2007) or holistic approach (McEntire, Fuller et al. 2002). However, there is a diverse definition of what can be

considered an integrated approach. Chen, Blong et al. (2003) used a definition that relates to the capability of the Geographic Information System (GIS), data integration, risk assessment and supporting decision making. Although somewhat technical, this definition is useful in developing a conceptual framework. To implement an integrated approach, Gopalakrishnan and Okoda (2007) proposed a new institution as a vehicle. Building a new institution that has a specific mandate to conduct disaster mitigation has been implemented in many countries, including FEMA in the United States, Emergency Management Australia (EMA) in Australia, the Fire and Disaster Mitigation Agency (FDMA) in Japan and Badan Nasional Penanggulangan Bencana (BNPB), or National Agency for Disaster Mitigation, in Indonesia. These agencies not only deal with disaster mitigation, but they also work on aspects of risk reduction. They are required to cooperate and collaborate with existing agencies, such as geological or meteorological agencies, that were established to deal with specific types of hazards. This collaboration mainly relates to information sourcing and sharing. They do not have the authority to direct land use planning, which is conducted by the governments.

Taking this into consideration, the integrated approach proposed in this thesis does not develop a new institution; rather, it focuses on the viewpoint of risk reduction. It needs to involve a long-term vision, relevant disciplines, stakeholders and agencies. Several key stakeholders involved in DRR (Figure 2-4) have their own perspectives and expertise. Their focuses are diverse, from housing provision to ensuring the safety of lives, saving public infrastructures, the continuation of economic activities and environmental sustainability. All focuses and interests should be placed together in one integrated approach that aims to satisfy different needs.

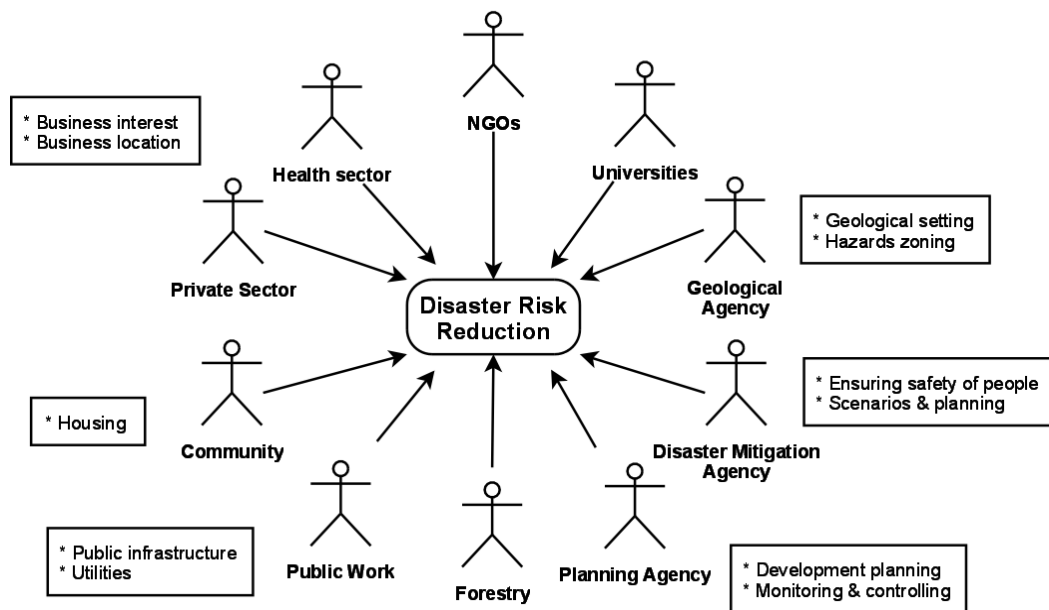


Figure 2-4 Stakeholders' interest in disaster risk reduction.

The integrated approach to disaster risk reduction makes use of existing knowledge, datasets, expertise, perspectives and existing institutional settings. Regarding the long-term objective, the integrated approach is best facilitated by spatial planning, which is concerned with the management of land use; therefore, it is important in managing and modifying the relationship between land, people and natural hazards. As many interactions between natural components and human activities are relevant to spatial planning, a tool is required to facilitate assessing, analysing, modelling and envisioning the future. PSS is important in supporting spatial plan development; thus, it is fundamental in the integrated approach to disaster risk reduction.

PSS is essential in enhancing the capabilities of actors involved in spatial planning and disaster risk reduction. It can facilitate an objective modelling of the land use allocation based on clearly defined parameters and aims within a data- and model-driven process. Even though people create the parameters, aims and models, and subjectivities may be carried forwards in alternative solutions, the results are less subjective than they are without these factors. In fact, the choice of policy is a result of dialogue between stakeholders. The objectivity of the results is an important element, as spatial planning involves political processes with conflicting interests.

To achieve a high degree of participation and objectivity, transparent collaboration is required among stakeholders, for example, using web-based systems. The use of web-based systems will enable Same Time Different Place (STDP) and Different Time Different Place (DTDP) collaborations. It is also a medium for disseminating the spatial plan and inviting stakeholders to participate in the collaboration process. However, in many jurisdictions, the local Internet infrastructures or Information Technology (IT) situation does not permit the use of web-based collaborations. In this situation, deliberation can be conducted via in-office meetings facilitated by a PSS running different scenarios.

The integration of disaster risk reduction into spatial planning involves several aspects: policy, organisational, data and platform (see Figure 2-5). Policy provides direction on how the integration can be conducted, who should be involved, how they operate and the specifications and standards of data. Policy manifests in the form of laws, government regulations, ministerial decrees and sub-national regulations. Laws and regulations will clearly define the responsibilities of all participating agencies, institutional arrangements and how the operational procedures will be executed. Regulation is required at the national level to ensure that standards are realised and maintained at the local levels, and to provide the umbrella for which local policy will be derived.

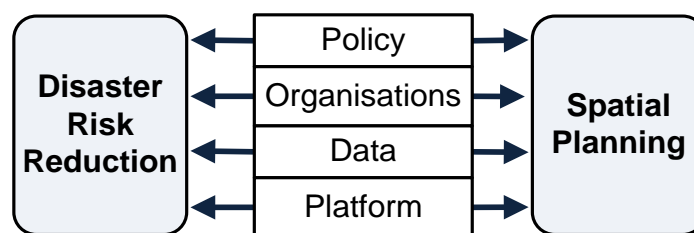


Figure 2-5 Elements in the integration of disaster risk reduction into spatial planning.

Regarding the organisational aspects, it appears that organisations with tasks on disaster risk reduction and spatial planning are working in isolation. Local planning agencies are responsible for spatial planning and the local disaster mitigation agency is responsible for disaster mitigation. This situation can be attributed to the lack of clear regulations and guidance from the higher level of government. It appears that

there is no direct relation between national or local disaster management agencies and their counterparts on spatial planning.

Data for disaster risk reduction are received from agencies in different formats. A standardised data format is preferable to enable seamless data exchange and sharing, especially for spatial data. Spatial data that originate from different agencies might have different formats, projection systems, visualisations, semantics and scales. The similarity, or interoperability, of data formats and projection systems is a basic requirement. Different visualisation coding may be used by different organisations to depict similar features, which should be resolved. The classification of categorical data among participating organisations—for example, slope steepness—should be made alike. Natural hazards such as landslides and flooding are usually represented in medium- and small-scale maps. Conversely, detailed spatial planning requires large-scale representation for zoning purposes. Matching scale maps that are largely different can lead to discrepancies and inaccuracies. Interoperable spatial data need to be established through standardisation to avoid poor modelling outcomes and misleading decisions. In essence, the following thematic maps are required for integrating disaster information into spatial planning:

- past events of disaster
- hazards map
- current and projected element-at-risks map.

Incorporating disaster risk reduction strategies into spatial planning involves active participation from various government agencies and public engagement. A platform is required to incorporate the hazard data into the spatial plan development and facilitate collaboration and public participation. A PSS is proposed as the tool to facilitate spatial plan development, with disaster data as one of the main components. SDI is required to facilitate data exchange and sharing among the government agencies involved. Careful design is essential for the improvement and development of the three interrelated components in SDI: people, technology and policy.

2.6.2. Model for integrating disaster risk reduction into spatial planning

The previous risk assessment methods reviewed in Section 2.3.2 provide a foundation on how to assess multi-hazard risks in urban and rural areas. However, those models are deficient; that is, they stop after the risk indexes or maps have been produced. They do not move forwards into projecting the extension of elements at risk into the future and integrating within spatial planning. In this section, a model is presented that takes risk maps into spatial planning (see Figure 2.6).

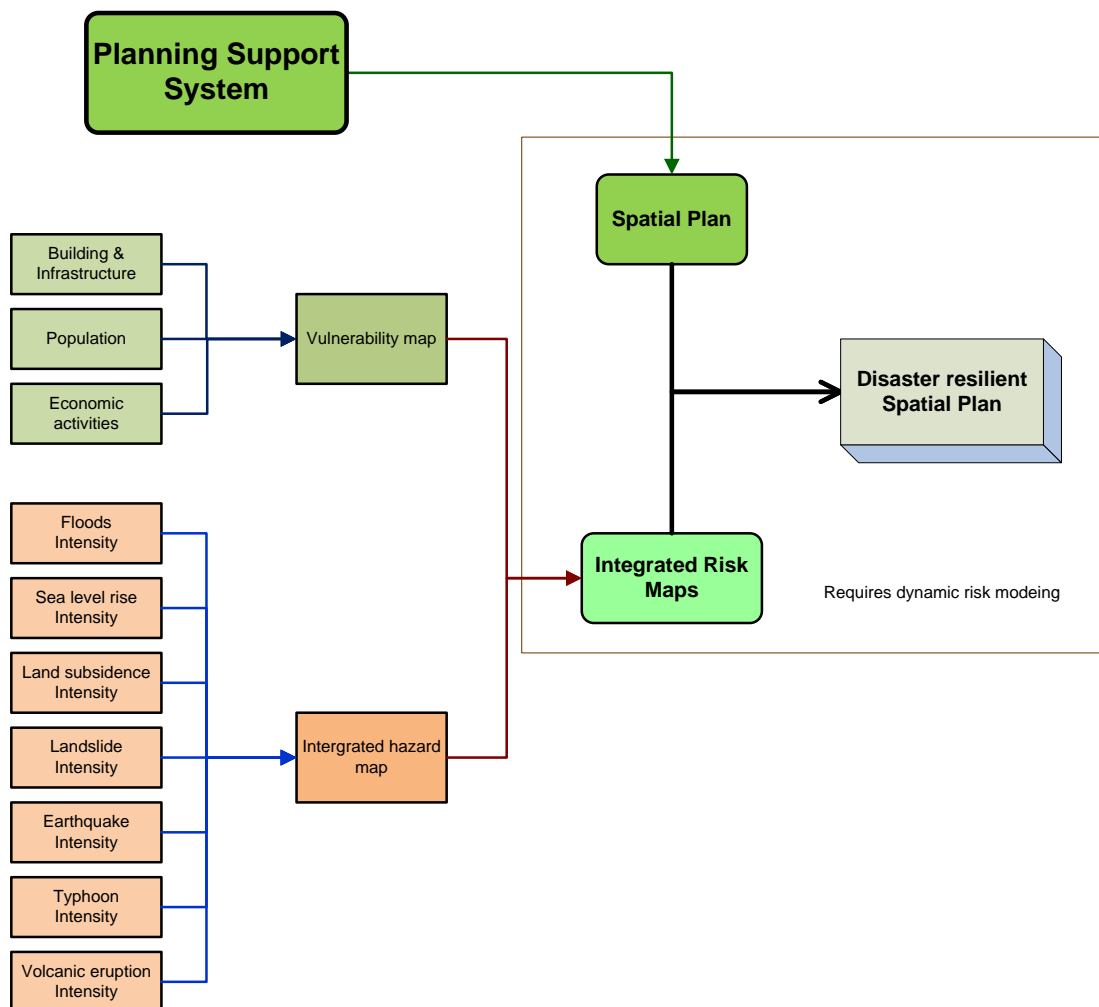


Figure 2-6 A model for the integration of disaster risk reduction into spatial planning.

This model makes use of part of the Integrated Risk Assessment Model developed by IRPUD; that is, the aspect of developing an integrated hazards map. The essential components of this model, which improves on other methods, focus on the following aspects:

- explicit incorporation of natural hazards into the spatial planning
- projection and prediction of natural hazards' progression
- assessment and mapping of the current elements at risk
- projection of the elements at risk in the future
- use of acceptable risk measures to evaluate land use designation.

An integrated hazard map is the cumulative product of an individual hazard. In this model, the natural hazards considered are those that are commonly found at many coastal urban cities located in a deltaic area or an alluvial plain. An individual hazard map is developed using historical data and predicting future progression. The latter is essential in the context of dynamic disasters. They contain information on the frequency, magnitude and extent of the disaster. The vulnerability map is created using three inputs: building and infrastructures, population, and economic activities. Although hazards may affect social activities, they are difficult to quantify or model. It is assumed that the social fabric of a society is the manifestation of its resiliency towards disaster. Therefore, if the disaster risk can be reduced or removed, there will be limited effects on social activities.

Building is an aggregation of residential, commercial, industrial and public buildings. Ideally, the value of all buildings can be sourced from a property valuation map. Thus, the calculation of risk will be more realistic. If these data are not available or complete, estimation is required. Infrastructures consist of road and rail networks, bridges, utilities, and energy and telecommunication facilities. The number and distribution of the population can be calculated from census data. All of these factors need to be mapped and assessed for the current situation and projected into the future, and large-scale maps are required for this purpose. The integrated hazard map and the vulnerability map are then combined to develop an integrated risk map.

The integrated risk map is used to evaluate the fitness of the initial spatial plan to ascertain whether they comply with the acceptable risk requirements. The spatial plan preferably, although not necessarily, uses a PSS for its development. The conventional method of developing a spatial plan is still sufficient, as long as the results are in a digital database. In this respect, a measure on the acceptable risk

indicators should be developed to accommodate any land use assignments that can accept a certain degree of risk. For example, an agriculture field can be located on a flood plain, as its danger to human life is minimal. All land use designations passed in this process will result in a disaster-resilient spatial plan, otherwise the spatial planning should be repeated until it satisfies the requirements. The testing procedure is essential in relation to the possibility of future disasters, as shown in Figure 2.7.

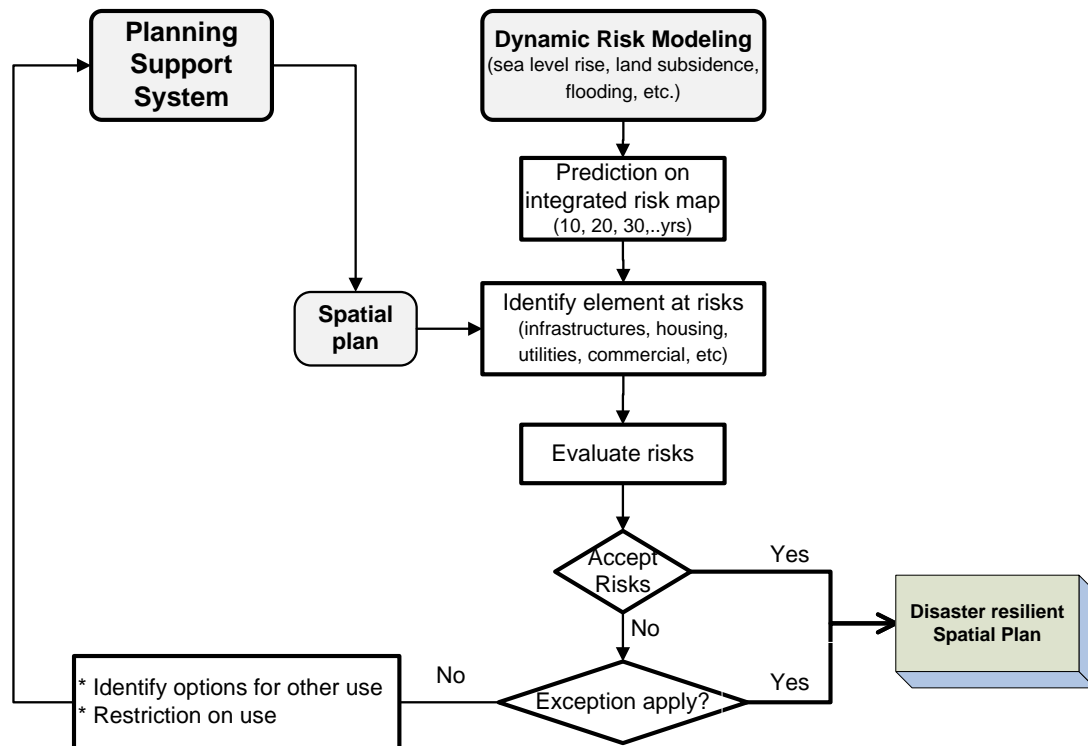


Figure 2-7 Dynamic risks modeling in spatial planning.

The process begins with the dynamic risk modelling of some natural hazards, for example, sea level rise, land subsidence and flooding. Sea level rise and land subsidence in a lowland coastal city can amplify the current flood and increase its frequency, magnitude and extent. Locations that are not currently subject to floods may be inundated 10–20 years from now. Therefore, an anticipation strategy should be developed at the earliest possible time, as almost all development activities are irreversible. Relocating highly populated residential areas or industrial complexes will be costly and delicate, and it will culminate with high financial losses.

The next step is to evaluate the degree of risk of the designated land use plan. If no risks are found, or if the risks are within the acceptable threshold, the designation

plan for the area can be made final. If the risk is not acceptable, a second test will be conducted to ascertain whether a condition of exception is applicable. An example of an applicable exception is the location of the seaport in the flood-prone area. There is little possibility of moving the seaport to another location, but the flood hazard should be overcome by hard engineering measures. If the disaster risk cannot be accepted and no exception applies, then the next step is to identify options for other uses or to impose restrictions on use. This will go back to spatial plan formulation. A PSS will speed up the process with a technically unbiased result.

2.7. Summary

The occurrence, casualties and economic cost associated with natural disasters are increasing. There is growing awareness that reducing the disaster risk before disasters occur will be of more benefit to society and the government. Reducing disaster risk is best approached from the perspective of reducing the exposure of elements at risk to the source of the disaster. In this context, the integrated approach to disaster risk reduction is relevant. It aims to reduce disaster risk by incorporating all stakeholders, disciplines and perspective, and to be conducted with long-term vision in the framework of spatial planning.

Spatial planning is essential in managing relations between elements at risk and natural hazards. Each parcel or zone in the spatial plan may possess several risks from different sources of hazards. All natural hazards that may strike each zone need to be identified, assessed and mapped. Their level of threat at the current situation and possible progression in the future are fundamental. The process of spatial plan development will be significantly enhanced if it is supported by a PSS. The possible limitation is that PSS may not be found everywhere.

In many local governments, land use planning is often impeded by the availability of vacant and suitable land. When the behaviour of natural hazards changes, the amount of available land decreases. Disaster-free areas are becoming smaller and land use needs to be allocated in areas with known hazards. Given that different land use has different coping capacities for different hazards and hazard levels, the acceptable risk indicator was proposed. It attempts to accommodate the limitation faced by planners

and decision makers on the available land, the high demand from community and industry, and the requirement to minimise disaster risks. It may not be an ideal solution that provides satisfactory results for all stakeholders, but it is a compromise.

The implementation of acceptable risk measures using a PSS requires the evaluation of all initial land use designations. If a particular designated land use meets the acceptability level set for it, then it can be considered the final designation. On the contrary, if there is no exception, alternative solutions are sought. The evaluation procedure is especially relevant for dynamic disasters that may develop into larger disasters covering wider areas. With the use of a PSS in the spatial planning and the incorporation of disaster risk information into the process, it is expected that the final product will be a disaster-resilient spatial plan. The use of an integrated approach to disaster risk reduction is expected to minimise the long-term losses to people and the community.

Chapter 3. DEVELOPING PLANNING SUPPORT SYSTEMS APPLICATION

3.1. Introduction

One of the key components of an integrated approach to disaster risk reduction through spatial planning is the use of a PSS. This chapter discusses spatial planning and its development, the use of a PSS in spatial planning and the method used to build a PSS for disaster risk reduction. A PSS facilitates a vision of the future using a set of assumptions, runs different planning scenarios and evaluates the consequences of following (or not following) certain actions. Further, the special position of spatial planning and a PSS in disaster risk reduction is discussed. The development of a conceptual model is presented for the use of a PSS for disaster risk reduction.

3.2. Spatial Planning

Spatial planning is the process of allocating, forming, sizing and harmonising space or land for multifunction uses (Albrechts 2006). This activity is the responsibility of planning agencies at different levels of government and jurisdictions. It requires input from many disciplines, such as planners, economists, sociologists, public administrators, transport analysts and geo-information specialists (Berke and Godschalk 2006). The objective of spatial planning is to develop a plan that ensures the sustainability of land resources to fulfil the needs of citizens and future generations in term of economic activity, liveability, environmental protection and socio-cultural life. Many factors affect the process and outcomes, including existing land use, population growth, economic development, environmental carrying capacity, infrastructures, transportation policies, socio-cultural aspects and natural hazards. Natural hazards are essential to ensure that current and future development will not be set back by future natural disasters. Further, political groups and the business community also try to influence spatial plan development to gain the highest benefit.

There are several ways to classify a spatial plan (Berke and Godschalk 2006; Greiving, Fleischhauer et al. 2006; Hudalah and Woltjer 2007). The first is the area covered by the plan. There are national or federal, provincial or state, and district or city-level spatial plans. National or federal level plans cover the entire country. They are represented in small-scale maps that depict general and macro-level plans. Provincial or state level plans are represented by larger-scale mapping with better-detailed coverage compared to the national plan. District or city-level plans cover smaller areas and are represented in a larger-scale map. At the district or city level, there are comprehensive and detailed plans. Comprehensive plans comprise all designated land use plans, and detailed plans focus on sub-district, or several sub-district, plans (Hudalah and Woltjer 2007).

A successful spatial plan should meet a set of requirements. (Berke and Godschalk 2006) suggest four core values to be achieved: environmental protection, equity, economic development and liveability. Environmental protection values relate to the issues of land resource utilisation and the production of waste, with environmental sustainability as the main element. Equity values aim to maintain the harmony of the social situation and promote the equitable distribution of resources, services and opportunities. A spatial plan needs to consider the benefits of better management of land, since land and location are important factors in production and investment. Land value and land market are significant elements that affect, and are affected by, land use allocation. These general principles need to be attained to develop a successful spatial plan; however, the unique characteristics of each location are equally important.

Spatial planning begins with a description of these core values that are relevant to the region. This will guide the formulation of the spatial plan (see Figure 3-1). Advances in computers and geographic information systems (GISs), as well as more complex data requirements and the involvement of more stakeholders, have led to an increased need for effective PSSs (Geertman and Stilwell 2004; Batty 2007). However, there are impediments to its widespread use (Vonk and Geertman 2005). The function of a PSS is to gather, manage and analyse spatially relevant information (Berke and Godschalk 2006), thus facilitating spatial plan development. A PSS can

provide information on the outcomes of policy while facilitating discussion and decision making about the vision, structure and pattern of space utilisation.

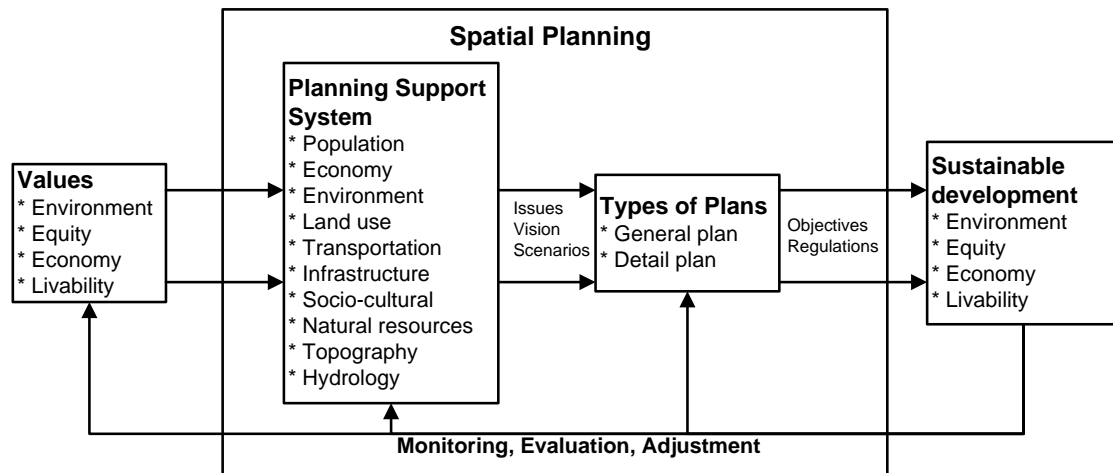


Figure 3-1 Development of spatial plan (modified from Berke & Godschalk, 2006).

Although a PSS is increasingly being used by planning agencies, many planning activities require human planners and thus cannot be completely replaced by a PSS (Lowry and Balling 2009).

3.3. Roles of Spatial Planning in Disaster Risk Reduction

Spatial planners are responsible for decisions regarding the long-term utilisation of land and the interaction between people and space. Although planners are not directly responsible for disaster risk reduction, the planning process plays a fundamental role in disaster risk reduction. The main functions of spatial planning in disaster risk reduction are to reduce the exposure of the elements at risk to the disaster sources and to modify the pathway of the disaster event.

The first function can be achieved by appropriately managing the relationship between present and future land utilisation and potential disaster sources. This requires the projection of future development (an inherent function of spatial planning) and the progression of disasters. By avoiding a collision between these two frequently opposing transitions, the exposure of the elements at risk can be eliminated or reduced, both in the present and in the future.

The second function relates to the modification of disaster pathways by applying proper land use management. These functions can be achieved only in the medium to

long term, which means that spatial planning is not a suitable short-term remedy for disaster mitigation, except for prohibiting certain land use types.

Spatial planning plays a role in reducing the exposure of elements at risk to disaster (Greiving, Fleischhauer et al. 2006). It has the power to direct land use allocation in ways that are beneficial to risk reduction, and to reject proposals that increase the vulnerability of people and infrastructures. These roles mainly lie in the long-term arrangements of interactions between space utilisation and disasters. (Fleischhauer, Greiving et al. 2005) identified four potential roles of spatial planning in disaster risk reduction:

- Prohibit future development in certain areas: in high-risk areas, especially with a history of disaster occurrences, development should be prohibited. Areas required for public use during emergency response and retention should be kept free.
- Classify different land use zoning for different levels of disaster-prone areas: each disaster has its own acceptable risk in different land use classes. Agriculture fields, but not residential areas, may be located in five-year return floodplains. Steep slopes that are highly susceptible to landslides should not be in residential or commercial use, but may still be suitable for plantation.
- Regulate land use or zoning plans with legally binding status: in an area vulnerable to earthquakes, regulations on building codes and building density are essential to reduce the impact of building collapse.
- Hazard modification: spatial planning can play a role in promoting soft engineering methods to reduce the risk of flooding. For example, a retarding basin that is required to contain floodwater should be kept free from development in order to maintain its function.

The need to incorporate disaster risk reduction into spatial planning has been advocated by many researchers (Menoni and Pergalani 1996; Menoni 2004; Campbell 2006; Greiving, Fleischhauer et al. 2006; Neuvel 2009; Berke 2010). In addition, several recent international initiatives have taken the message to a wider audience. They include the Hyogo Framework for Action (HFA) and the Incheon Declaration (HFA 2005; Incheon 2010). Specifically, the Incheon Declaration stated

the importance of local government activities in disaster risk reduction. The endorsements in the HFA and Incheon Declaration are relevant to the hierarchical nature of spatial planning, as disaster risk reduction is best conducted at the local government level (district or city). The local government is initially required to respond to the disaster, in the hope of averting a catastrophe. During the prevention stage, it is responsible for preparing a comprehensive policy on disaster mitigation. Figure 3-2 shows the relationship between the local disaster, planning and action.

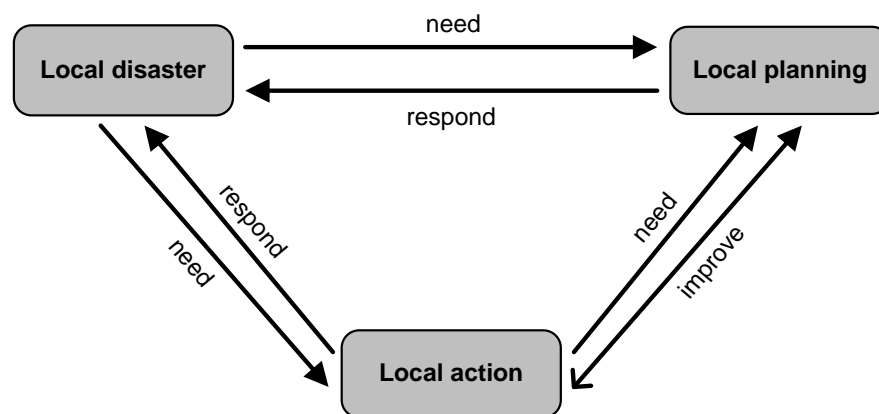


Figure 3-2 The importance of local planning in disaster risk reduction.

As disaster occurrences originate in a small geographic area, the local government has the responsibility and authority to prepare plans to overcome the consequences. Any disaster incidents will require local planning and actions. In this respect, the local government is indispensable in developing a mitigation strategy that clearly incorporates disaster risk information, preferably into its spatial plan. The advantage of local government involvement is its knowledge and understanding of local contexts (Kartez and Lindell 1987).

With this in mind, predicting how disasters will occur in the future is an important element in developing a disaster-resilient spatial plan. Prediction is more likely to be accurate for slow onset disasters with gradual progression, such as land subsidence and sea level rise. Disasters of these types produce noticeable signs for their progression in the long term, although in the short term, they may not be visible. In addition, their impacts may not be immediately felt by residents. For rapid onset disasters, combination between hard and soft engineering methods is more suitable to protect people and infrastructures.

In all natural disasters, planners and scientists are confronted with uncertainty, for example, in geographical coverage of the disasters, their magnitude and frequency. The uncertainty factor makes risk assessment difficult and requires several safety measures to be taken into account. To accommodate a problem that is larger than predicted, a safety margin should be employed. However, the safety margin should not be higher than the level necessary to reduce the associated cost required, and it should not remove the development potential.

Essentially, reducing disaster risk by utilising spatial planning requires an integrated approach (El-Masri and Tipple 2002). It requires input from a broad range of disciplines, involving many stakeholders and facilitated by a spatial-enabling platform. The realisation of an integrated approach concept requires projection of the population growth as well as progression of infrastructures and natural disasters. The first two have been commonly conducted by planning agencies; however, the latter has only recently received increasing attention. Local governments may have deficiencies in this aspect, thus requiring assistance and supervision from higher levels of government.

With growing pressure from population growth and the limited availability of disaster-free land, developments affected by natural disasters are unavoidable. Residents must adjust to living with disasters. However, there is a certain level at which the impacts of disasters are beyond the capacity of the residents to withstand them. Setting up an acceptable level, whereby the potential loss and cost of protection are tolerable (Schmidt-Thoméa 2006; UN/ISDR 2009), is part of the formulation of a spatial plan.

The common language used to estimate the acceptable level is economic valuation. It requires detailed information on natural disasters, buildings, land uses and infrastructures. Not all of the required data are available or fully utilised due to limited resources at the RDPA.

3.4. Planning Support System

3.4.1. Evolution of planning support system

The advent of new computer technology and improvements in GIS software has enabled the emergence of PSSs since the late 1980s (Malczewski 2006; Batty 2007). The term ‘planning support system’ was first coined by (Harris 1989), when he discussed the use of GISs among planners. Following (Geertman and Stilwell 2004), a PSS is defined in this thesis as a dedicated framework to support planning tasks. It consists of elements for information gathering, data modelling and visualisation. A PSS is specifically directed for planning related to spatial aspects. Although PSS functionality is provided largely by geo-information technology, it is different from GIS in the sense that GIS serves general purpose tasks while PSS focuses on planning tasks (Vonk, Geertman et al. 2007).

PSS users are planners, geo-information specialists, government officials and politicians, citizens and other stakeholders. They use PSS at the various stages of plan development, with planners and geo-information specialists at the forefront. They design, develop and use PSS at the early stage of plan development, including presentation in the deliberation process.

PSSs have been widely used in assisting spatial plan formulation; however, it seems that there are geographical biases. Most users originate from the United States, Europe and Australia (Vonk and Geertman 2005). As a subset of geo-information technology tools for supporting planning, the implementation of a PSS must be preceded by the mature use of a GIS. That is, if there are no operational and extensive uses of GIS in a planning agency, there is little chance of having a PSS implemented. The operational use of a PSS requires extensive GIS data and experience in GIS modelling. These requirements are not always found at the local planning agency in developing countries.

To date, various PSSs have been developed with diverse approaches and scopes. Most PSSs are designed for general purpose use, such as WhatIf?, CommunityViz, INDEX, SLEUTH and UrbanSim, and only small numbers are built for specific tasks (Klosterman 1999; Waddel and Ulfarsson 2004; Allen 2008; Clarke 2008; Waddell, Liu et al. 2008; Walker and Daniels 2011). Many more PSSs are available from

research institutions and the commercial sector. A comprehensive list of the PSSs available in the market and at research institutes is provided in (Geertman and Stilwell 2004; Klosterman 2005). Table 3.1 provides a list of the PSS software that is currently used in many cities and countries.

Table 3.1 Review of PSS software

	Approach	Modelling	Application scope	Visualisation
CommunityViz	ArcGIS extension	Rule-based model	Local level	2D, 3D, Google Earth
CUF	Independent—open source	State-change model	Regional	2D
INDEX	ArcGIS extension	Rule-based model		2D, 3D
METROPILUS		Large-scale urban model	Regional	2D, 3D
SLEUTH	Independent—open source	Cellular automata	Regional	2D, 3D
TRANUS	Independent—open source	Large-scale urban model	Local-regional	2D
UrbanSim	Independent—open source	Large-scale urban model	Regional	2D
WhatIf?	ArcGIS extension	Rule-based model	Local-regional	2D

Different techniques are applied by a PSS, including a large-scale urban model, rule-based model, state-change model and cellular automata (Klosterman 2005). The selection of the most suitable model for a particular planning agency depends on several factors, such as the objectives of the modelling, the capacity of the planning agency and the data availability.

3.4.2. Elements of PSS

A PSS consists of elements for information gathering, storage and retrieval, system modelling and analysis, communication and visualisation (Vonk, Geertman et al. 2007). In some instances, the GIS can be regarded as a PSS itself. There may be a loose connection between the two or no connection at all. In the loosely coupled connection, output from the spreadsheet is fed into the GIS software to be used in the spatial analysis. There are cases where the GIS and the spreadsheet are used independently, without any connection at all. The results from each processing area are treated individually.

As presented in Figure 3.4, information gathering is located at the beginning of the system, and the result is entered into a database. Two types of data are required in a PSS: spatial and non-spatial. Non-spatial data are part of government regulations and are required to define parameters such as density regulation, setback rules, conservation zones and growth projection. These data are stored and maintained in a database to be used in the modelling and analysis stages.

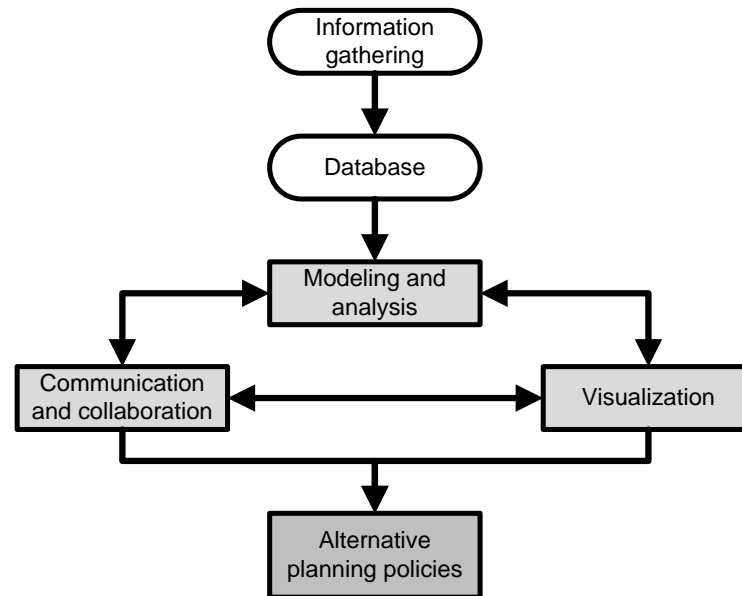


Figure 3-3 Elements of spatial planning support systems.

Many planning laws require that scenarios used in spatial planning and policy development are communicated to stakeholders in various ways, such as the Internet, as part of the consultation process (MacEachren and Brewer 2004). Two-way communications exist between modelling and analysis, communication and collaboration, and visualisation. Web technology is the most efficient medium for communicating detailed information regarding government programs and regulations in developed countries, and it is increasingly popular in developing countries. It can facilitate highly effective socialisation through different forms of presentations, encourage engagement and participation from the public and facilitate collaboration in spatial planning. Batty (2007) highlights that the planning process has been largely influenced by visualisation and Internet map usage. Two- or three-dimensional visualisation is an effective means for communicating planning concepts to

constituencies. The use of the Internet to disseminate city planning options will enable stakeholders to provide feedback, regardless of the place and time.

3.4.3. Development model for a planning support system

Several methods for developing an IT-related project have been suggested, including waterfall, incremental or iterative, and rapid prototyping. In the waterfall model, each step needs to be completed before moving to the next step. This model is suitable for projects with time and budget constraints, and limited changes are allowed. The incremental model consists of several project components that match the waterfall phases. Proof of concept can be conducted at an early stage; thus, errors can be fixed earlier. This model suits software development projects. In the rapid prototyping model, a rough prototype is built according to the draft of the system concept.

Regarding the development of a PSS in developing countries, the iterative model is the most suitable method. In this model, each increment is a waterfall model, thus allowing the tight monitoring of activities. Conversely, it allows for some changes, as the planning agency is in the learning period.

As shown in Figure 3-4, the development of a PSS follows three steps: intelligence, design and decision/choice (Sharifi and Rodriguez 2002). The intelligence phase gathers the information required to develop the system while the objectives of the system are formulated.

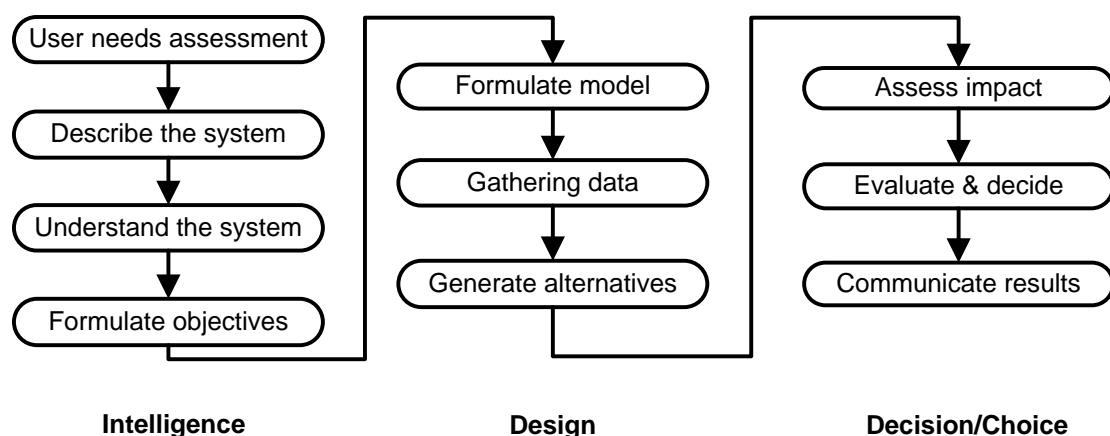


Figure 3-4 Process of decision making in spatial planning, modified from Sharifi and Rodriguez (2002).

3.4.4. User need assessment

The implementation of a new system in an organisation requires appraisal of the organisation's current situation, its needs and projections of future development. The need assessment aims to identify the user's requirements, considering their local situation, need, scalability and implementation program. Users' needs will also be different according to the differences in challenges between developed and developing countries. Given the limitations in developing countries, the intended PSS should be:

- low cost
- fast to learn
- compatible with existing systems and data
- easy to incorporate into support deliberation processes.

Several factors influence the definition of a low-cost system, including software purchasing costs, hardware costs, maintenance costs and additional software required to run the PSS software. Up-front costs to purchase the PSS software and hardware are relatively affordable for many local governments in developing countries. There are different PSS systems on the market with different price ranges, from no cost to tens of thousands of dollars. UrbanSim, TRANUS and SLEUTH are currently free, while there is a cost for INDEX, Metropilus and Wadbos, as they bundle the software with site-specific customisations. Other considerations include the use of supporting software for the installation. CommunityViz and What?If require the installation of ArcGIS to run the software, while UrbanSim and SLEUTH do not require additional proprietary software. If a planning agency chooses PSS software that requires a supporting GIS, there is a potentially high cost for purchasing and maintaining the core GIS software. The cost can be reduced if the planning agency has the software in advance, and in many cases, a planning agency wishing to adopt a PSS is already using a GIS in spatial planning. A free PSS system such as UrbanSim, TRANUS or SLEUTH can be trialled to gain initial experience. As these systems are based on an open source initiative, a planning agency may be faced with limited documentation and support.

Current PSS software can be run on virtually any ordinary computers. For relatively simple simulation and modelling, the processing time will not be significantly affected. The better the computer specification, the faster the process.

Open source PSSs use sophisticated advanced modelling techniques that can accommodate multiple inputs and models, and they can run complex simulations. These facilities suit high level and detailed planning of a city or regional area. However, planning agencies in developing countries lack capable and dedicated staff to study and implement the software. Further, there is a limitation on the data to run the sophisticated models. While present-state data may be available, historical data are difficult to obtain, as good data production and archiving only began in the past 20 years or so. In effect, agencies may prefer to use software that is easier to learn, possibly with less modelling capacity but without compromising its outcomes.

It is difficult to assess the training requirements of different systems in advance. It depends on the skills of the staff members, complexities of the program and required customisation. Of the PSS software reviewed, CommunityViz, WhatIf, INDEX and Metropilus were the easiest to learn, as they were add-ons to ArcGIS, which is used in many countries. Their Graphical User Interface (GUI) is also familiar to most GIS users. UrbanSim and SLEUTH were more difficult to learn. These open source software have limited documentation and support, and a limited GUI.

Consideration of the existing available data is significant to find the most suitable PSS. If the existing data format is not interoperable with the PSS, extensive data conversion will be required. When there is an existing GIS, an add-on is likely to be preferred. Converting existing data into the new system is time consuming and prone errors. A favourable PSS makes use of existing data, with only small adjustments required.

3.5.6. Stages of planning support system implementation

The stages of PSS implementation are similar to other types of IT projects (see Figure 3-5). It begins with the growing importance of the PSS, first with the acknowledgement by a few individuals in the organisation, until it is fully adopted by the organisation. In the support role, a PSS is usable at the operational level but possesses no strategic influence to the organisation. At the intermediary level, the

importance of the PSS moves up and becomes more than a support tool. If the implementation is successful, then its function becomes strategic. At the strategic level, a PSS is indispensable for running the organisation. If the PSS fails to meet the organisation's expectations, it can be scaled back to become a support tool, otherwise its presence will be vital for the organisation (Bestebreurtje 1997).



Figure 3-5 Stages in the PSS implementation.

The steps for adopting a new system in an organisation consist of adoption, diffusion, management, integration and maturity phases. Initially, a number of individuals within the organisation are exposed to the new technology and are interested to apply them. The initiative, at first is not coordinated and or properly planned. As the benefits become evident, the number of users increases and the system gains wider acceptance. From a system with limited planning, the next phase has better planning and funding, as it is being integrated into the organisation. The business process is re-engineered to maximise the benefits of the new system and ensure the smooth transition from the old mechanism to the new model. At the end, the new system matures and is fully integrated into the organisation to fulfil its duties.

The process to implement a PSS in an organisation follows a similar path. However, as a PSS intensively uses a GIS and GIS data, its implementation should be preceded by the maturity of GIS use. As with other types of IT implementation, some challenges lay ahead.

3.4.5. Challenges in the implementation of a planning support system

Despite advances in the PSS and its associated technology in recent years, a survey conducted by (Vonk and Geertman 2005) found that there are some impediments to the spread of its usage, along with a geographical bias of users. The diffusion of a PSS to planners is relatively slow. Further, they stated that a strong focus on the systems side and little attention to the user side is one cause of the bottleneck ((Vonk and Geertman 2005). Therefore, it is crucial that research on PSSs conducts consultations with planners to obtain information regarding their needs (Petit 2005).

Most current users are from North America and Australia. In many developing countries, PSSs are still in the early stages of adoption. In developed countries, PSSs are widely available and frequently used, although the use is perhaps still at the strategic level (Batty 2007; Vonk, Geertman et al. 2007). IT readiness in developing countries is one of the factors in the slow adoption of PSSs into daily practice.

Although not specifically directed towards assessing Geo-IT readiness or spatial enablement readiness, the United Nations (UN) Surveys on the e-government readiness index (DESA 2008; Economist 2009) and The Economist's surveys on e-readiness (Economist 2009; McCall and Dunn 2012) can be used as a guide. There is an indication that IT situations highly correlate with PSS adoption. Countries with a high ranking in both readiness indexes have widely implemented a PSS (e.g. the US, Australia and the Netherlands). Thus, local governments in countries with low e-government readiness or an e-readiness index will have more challenges to overcome, such as:

- funding: start-up funding for preparing new IT infrastructures and inducting a PSS from scratch will be high. Funding for an investment that does not directly affect people's daily life is usually limited. Many urgent programs other than PSSs directly improve people's welfare and are easily visible to taxpayers. Investing in GIS or a PSS will have few direct effects compared to building new roads or other public facilities.
- human resources: as discussed in Section 3.2.3.2., local planning agencies in developing countries lack skilled staff members to design, run and maintain such a system. In Indonesia, not all local planning agencies have staff members with official backgrounds in geomatics-related disciplines (geography, geodesy and surveying). This results in a relatively low use of GISs, as those disciplines produce staff that are qualified in operating GISs.
- supportive policy: there are no laws or central government regulations that explicitly or implicitly order the use of digital processing methods in spatial planning. Specifically, there are no requirements to conduct certain types of spatial analysis to fulfil spatial planning needs. A GIS was mostly used to generate maps that, while important, were separated from the non-spatial data

analysis. Non-spatial data were treated independently from spatial data. Although the management of spatial information was conducted using a better method than five years ago, managing information spatially is in its very beginning.

- organisational setting: appropriate intra-organisational arrangement and inter-organisational cooperation was absent, partly because there were no directives from the central government and no policies supporting reorganisation to respond to the current challenges and future requirements.

Regarding the political and cultural contexts, in Indonesia, a top-down approach is more feasible than a bottom-up approach. This was started by the enactment of a new law on Geospatial Information: Law 4/2011. This law provides a legal umbrella, direction and mandate to the national, provincial and local governments to advance the use of spatial information for governance. It covers the production, management and utilisation of spatial data. Technical specifications and institutional settings regarding spatial data, data discovery, access and sharing have been defined clearly in this law. This will be covered further in Section 5.4.3.

3.5. Building a PSS for Disaster Risk Reduction

3.5.1. Conceptual model

The four roles of spatial planning in disaster reduction that were discussed in Section 3.3.2 provide a foundation for the development of a conceptual model of a PSS function for disaster risk reduction. These four roles need to be translated into schematic operational roles.

The fundamental idea of using a PSS for disaster risk reduction lies in the capability of a PSS to facilitate a prediction of future growth, specifically on the simulation of where, when and how certain types of buildings and infrastructures will be built. By integrating this information with the prediction of disaster progression in the period of a spatial plan, planners and decision makers will be equipped with better information on future disaster risks in their original plan. Figure 3-6 illustrates the conceptual model of this integration.

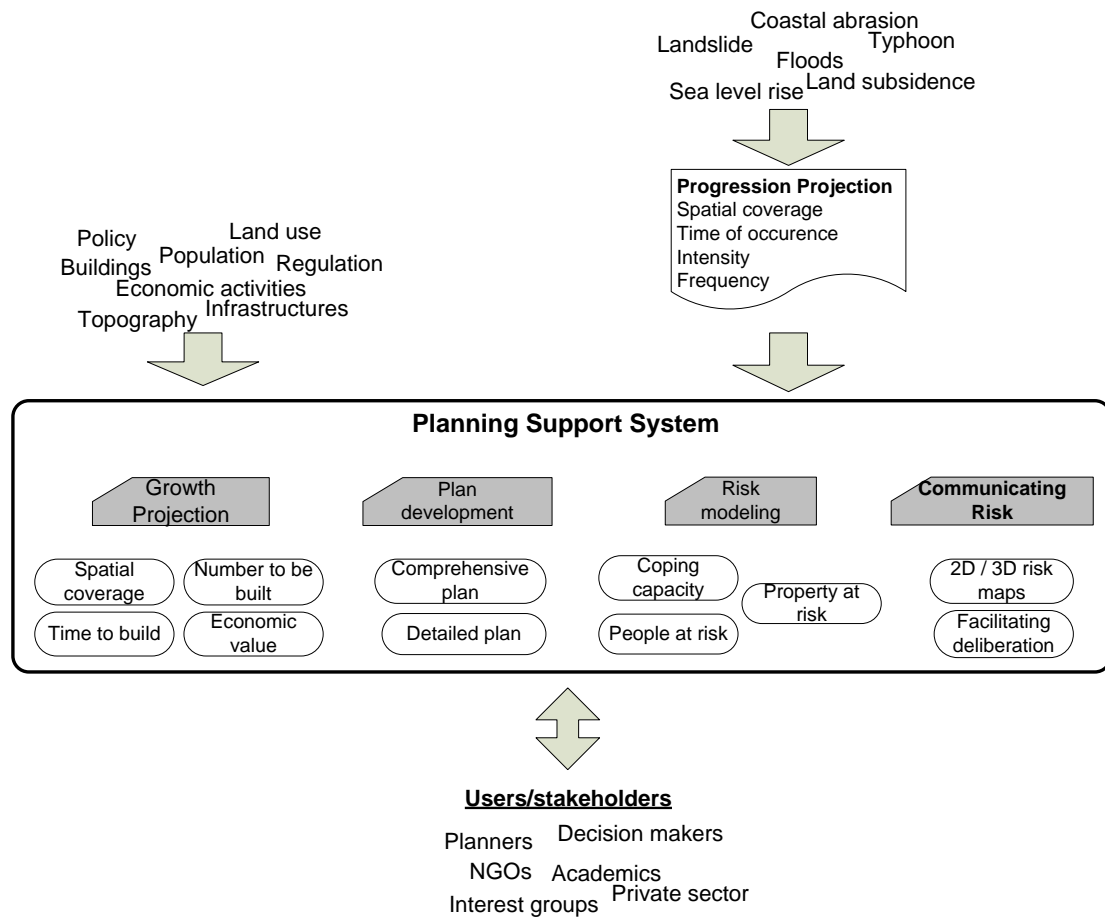


Figure 3-6 The conceptual model of the use of PSS in disaster risk reduction.

As with any plan development mechanism, the existing condition of buildings, infrastructures, population and topography will be used as the starting point for the formulation of a spatial plan. They are essential factors in the growth projection in order to calculate the carrying capacity of the environment and to estimate when and where a certain development will occur. The projected growth will then be evaluated regarding possible future risks. Communicating risks to all involved parties is essential to obtain a common understanding and gather additional input.

The main stakeholders will also be provided with similar information held by planners. In this instance, comparable information held by different parties is expected to benefit the spatial planning and increase the quality of the outcomes.

3.5.2. Technical framework

A. Hardware Trends

Three decades ago, the price of hardware with moderate computing power exceeded the capacity of many government agencies, especially in developing countries. Currently, the cost for acquiring a high-performance personal computer (PC) has dropped dramatically, allowing local planning agencies to own sufficient numbers.

The hardware component of a PSS should serve as high-performance computing and a good display unit. Typically, local planning agencies do not have high numbers of staff; therefore, only few workstations are required for the installation of PSSs. It should be noted that the peak use of the system would not be year-round. After the spatial plan has been defined, the system will be used in a moderate capacity, such as for implementation monitoring and facilitating permit issuance.

A good display unit is essential, especially in the process of public deliberation. A good projection system is sufficient to facilitate an effective public meeting. Advanced visualisation techniques can be implemented at a later stage.

B. Software trends

Before the availability of PSSs, some planning agencies used spreadsheets and early versions of GIS software. With a PSS, the two different processes were merged, allowing full spatial analysis to be conducted integrally. Some systems, such as the early version of CommunityViz, provided a policy analysis module to assist planners with decision making. Without the policy analysis in place, PSSs have already improved the decision-making process in spatial plan development.

The use of the Internet for spatial planning has increased since the mid 2000s for two reasons in particular: the introduction of web mapping and Web 2.0 (Kingston 2005; Bugs, Granell et al. 2010). Web mapping technology enabled planning agencies to publish planning maps online to reach a wider audience. This was accelerated by the introduction of Google Earth and Google Maps, followed by Bing Maps and OpenStreetMap. The public became spatially literate and increasingly familiar with maps and satellite images. Further, the widespread use of smartphones and tablets increased the usage of maps. Users were spatially enabled anytime and anywhere. In

the context of spatial planning, this opens new opportunities such as to evaluate the spatial plan or making queries. Essentially, the public does not need to go physically to the planning office to obtain, for example, a planning overlay in their property.

Web 2.0 offers possibilities for interactive communication among users. For example, users can actively query planning-related information with planning agencies. However, the use of the Internet was still limited for publishing purposes. Online digital charrettes are difficult to conduct due to the limitation of available bandwidth and processing power, as spatial planning is a computation-intensive activity. A change in one parameter in the modelling may require several minutes or hours of computation time, which is not acceptable. If charrettes can be conducted, the DTDP collaboration can be effectively run. In countries with limited Internet infrastructure, STSP collaboration is the most effective method.

C. Spatial data requirements

Spatial data are fundamentally required in spatial planning. With the development of GIS software over the years, numerous data formats are available on the market. On the commercial side, the leading package in the market includes ArcGIS, MapInfo, Geomedia, MapGuide, Smallworld and Bentley. Recent years are marked by the growing popularity of open source GIS software such as PostGIS, GRASS, QuantumGIS, ILWIS and uDig. The vast number of GIS software available and used in the market may create obstacles in meeting the requirements of a particular project.

As a result of spatial data being sourced by planning agencies and other participating agencies, it is necessary to obtain a unified spatial data format. All software keep their native formats, but providing a facility to export them to popular formats currently serves as the de facto standard (e.g. shapefiles). Otherwise, third-party transformation software may be used to obtain a unified spatial data format. This aspect is also applied to other technical specifications, for example, datum and map projection systems, so that the spatial data are interoperable.

Regarding the scale aspect, the data need to be at a similar level of scale and pursuant to the specifications set by laws or government regulations. The planning agency often has to work with scale differences that are too broad. For example, they have

infrastructure maps at a scale of 1:5,000, which need to be combined with the natural hazard maps at a scale of 1:100,000. Careful inspection and use must be conducted to ensure the accuracy of the outputs of the modelling.

The semantic aspect of the data also needs to be examined, as different agencies usually employ different terminologies to denote similar features or classes. The use of the same terminology to depict two different features should also be avoided.

Having all spatial data in a unified system, format and data model is a fundamental requirement in operating the GIS and PSS. It is preferred that all spatial data use a similar data model as the PSS. This similarity will ensure interoperability, reducing the extra work for conversion and transformation, and increasing the reliability.

3.6. Spatial planning in Indonesia

3.6.1. Practices of spatial planning

The history of modern spatial planning in Indonesia can be traced back to the time of Dutch occupation (Pratiwo 2005), when the Dutch colonial government enacted permit and zoning regulations through the Nuisance Ordinance 1926 (Hudalah and Woltjer 2007). Many cities, including Jakarta (formerly known as Batavia), Bandung, Surabaya, Semarang and Malang, were planned by Dutch planners. For example, Semarang was designed by Thomas Kartsen (Coté 2004) as a residential and business city. After independence on 17 August 1945, the influence of Dutch planners slowly began to disappear. The diminishment of the Dutch planning style notably occurred when relations between the two countries deteriorated in the late 1960s. The void was then filled by American-educated American planners (van Roosmalen 2003).

Due to the uncertain political situation, national development was not planned well until the early 1970s. Cities were developed organically, with limited government intervention. The introduction of the first Five-Year Development Plan in 1969 ensured that orderly physical infrastructure development began to take shape. The terminology of the Developmental Area Unit (Satuan Wilayah Pengembangan [SWP]) was introduced to denote specific areas for planning. Specific national laws

for spatial planning did not yet exist; at that time, it was based on several ministerial regulations.

It was not until 1992 that the Indonesian government enacted the first law on spatial planning (Law 24/1992). It consisted of eight sections with 32 articles. The changes to the political landscape in 1999—that is, the introduction of decentralisation and democratisation—make this law irrelevant (Hudalah and Woltjer 2007). Law 24/1992 was replaced by a new law on spatial planning: Law 26/2007. This law is more comprehensive (13 sections and 80 articles) in the topics it covers and in its detailed information content. One new aspect of the law is that it contains a sanction for activities that breach a spatial plan. The sanction and punishment are applicable to individuals and business entities that violate a spatial plan, and also to government officers who issue planning permits that violate the law. In developing a spatial plan, other important laws should be referred to, including:

- Law 5/1960 on Basic Agrarian
- Law 5/1984 on Industry
- Law 4/1992 on Housing
- Law 23/1997 on Environment
- Law 32/2004 on Regional Autonomy
- Law 38/2004 on Road
- Law 24/2007 on Disaster Mitigation
- Law 27/2007 on Management of Coastal Zones and Small Islands.

In addition, there are presidential decrees and ministerial regulations that provide policies and technical guidelines on how to conduct spatial planning, data that are required, types of zones, types of limitations pertaining to environmental sustainability, agency-specific responsibilities and engaging the public to participate in the spatial planning. The new law explicitly orders the incorporation of disaster risk reduction activities into every spatial plan at all levels of government. This requirement is strengthened by two other laws: the law on Disaster Mitigation and the Law on the Management of Coastal Zones and Small Islands.

According to the law on spatial planning and its derivative regulations, the hierarchical structure of spatial planning in Indonesia starts at the highest level, with

the national spatial plan, followed by the provincial and district, or city, level spatial plans (see Figure 3-7). District and city are at the same administrative level; the difference between them is that the city area is mostly urban or dominated by urban characteristics, while district refers to an area that is dominated by rural characteristics. The highest detail of spatial planning is made at this level. The development of a spatial plan at the city level must conform to the spatial plan at the provincial level, while the spatial plan at the provincial level must adhere to the national spatial plan. The Provincial Development Planning Agency supervises and harmonises the spatial plans of the districts and cities in its jurisdictions. At the national level, the National Coordinating Agency for Spatial Planning (Badan Koordinasi Penataan Ruang Nasional [BKPRN]) coordinates the development of the national spatial plan. The agency also supervises and evaluates the spatial plan developed by 34 provinces and almost 500 districts and cities. The spatial planning law ordered the revision of spatial plans at all levels to be completed by 2010. Due to several new requirements and a high number of spatial plans to be evaluated at BKTRN, many districts' and cities' spatial plans were enacted in 2011.

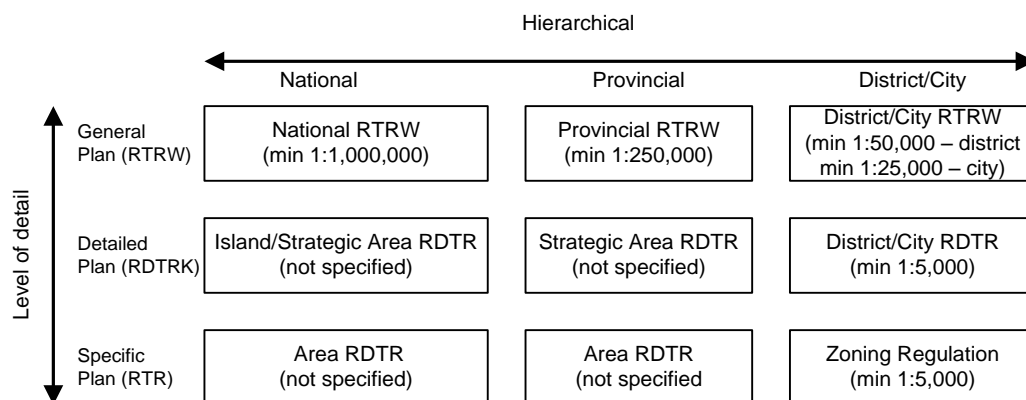


Figure 3-7 Classification of spatial plan in Indonesia
(Hudalah and Woltjer 2007; GOI 2010).

As mandated by Law 32/1999 on regional autonomy, many national government activities are delegated to district or city governments, including spatial planning. The development of spatial plans at the city level is coordinated by the Regional Coordinating Board for Spatial Planning (Badan Koordinasi Penataan Ruang Daerah [BKPRD]) with the RDPA as the lead agency. Other local government agencies are

involved, such as Public Work, Statistics, Agriculture and Forestry, Geological, and Land Administration. Additionally, the spatial plan formulation requires data, assistance and cooperation with local offices of national government agencies' located in the region.

Although local autonomy has been implemented in the spirit of Indonesian governance, provincial and national governments are involved in local spatial planning (see Figure 3.9). The technical component of the city spatial plan requires approval from the provincial BKPRD before going through the next steps. After approval is received, the draft spatial plan is sent to the local legislative body to draft local government regulations (LGR). The draft of the LGR is then sent to the provincial government and the National Coordinating Board for Spatial Planning (BKPRN) to obtain approval. Once approved, the LGR can legally be enacted.

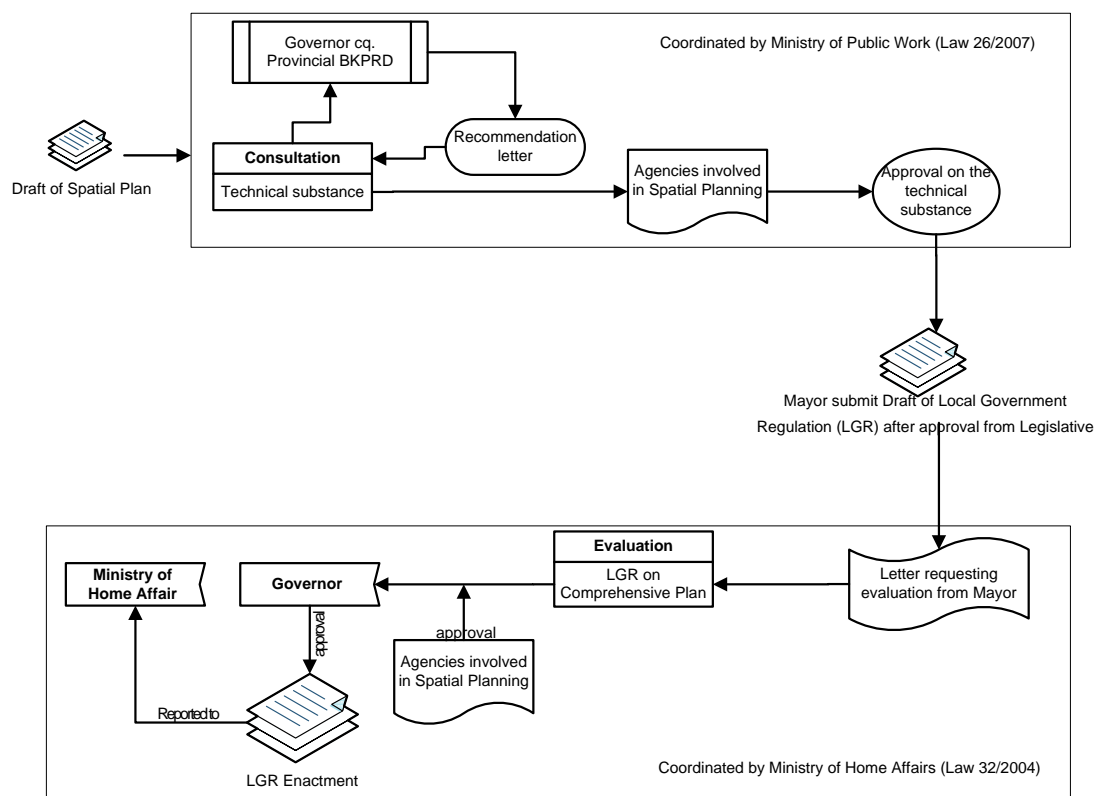


Figure 3-8 Procedure to develop a district/city level spatial plan.

Most technical activities that support spatial planning are carried out by a consulting company that works under close supervision and collaboration with the RDPA. They develop maps, conduct field surveys and draft documents. During the development, several public hearings, seminars, workshops and parliamentary meetings are

conducted. The participation from stakeholders is highly important. The following parties are represented in the spatial plan development:

- mayor of the district/city
- local parliament
- local government agencies
- real estate developers' organisation
- business chambers
- NGOs
- academics
- representative from residents.

3.6.2. Issues related to spatial data

Spatial and non-spatial data required for spatial planning are sourced from many government agencies. While non-spatial data are easily sourced and more available, there are several issues related to the acquisition of spatial data for spatial planning. The following issues were identified in discussions with planners and in the survey conducted in 2009 (see Section 1.4.):

- spatial data are not available
- spatial data are not accessible
- format and specification are not suitable
- spatial data are not up to date
- software to process spatial data is not available
- lack of staff members capable of operating GIS software.

The required spatial data may be not available in many local governments, especially those in remote areas. Many local government agencies do not have a digital spatial database repository due to staffs' limitations and infrastructure. They rely on their archive of printed maps and on private consultants for digital databases. Although the situation is improving, many local governments still experience this problem.

Data accessibility issues arise when spatial data are produced by different organisations that do not always cooperate. Some government agencies that produce and maintain large amounts of spatial data are vertical institutions, which mean that they report to their national superior rather than their counterpart at the local level. The relation to their local counterparts is through coordination activities without

supervisory or directive roles. These two vertical institutions are the National Land Agency (Badan Pertanahan Nasional (BPN)) and the Directorate of Tax. The BPN is responsible for mapping land parcels and registering land titles, and the Directorate General of Tax includes the former Directorate of Land and Property Tax, which was merged into the Directorate of Tax in 2006. The Directorate of Tax is responsible for mapping and managing the property database and land valuation. The land and property database is more comprehensive, although less accurate, than the BPN's parcel maps. These agencies have relatively complete land parcel maps, but they do not have the freedom to share their data with the RDPA. The absence of central government regulations on spatial data sharing contributes to this situation. In effect, the RDPA needs to rely on its own data, or data produced by its local counterpart. The recent reorganisation of the Property Tax section implies that land and property tax is currently the responsibility of the local government. However, in many districts and cities, the spatial data have not been handed over to the local government. Further, it was found that only few RDPAs utilised the parcel map as a base for developing their detailed spatial plans. In effect, many RDPAs use inaccurate, incomplete and obsolete spatial data.

Another problem found is that the spatial data used did not always meet the technical specifications for spatial planning. With limited time and resources for proper spatial data, many local governments were forced to rely on any available data for spatial planning. Therefore, the spatial data they used often had an inappropriate scale (too small), incompatible projection systems and diverse classification schemes. These problems were exacerbated by infrequent updates. Due to funding restrictions, most spatial data used in spatial planning were not up to date. The acquisition or update of new spatial data is not usually included in funding for spatial plan revisions. Recent changes in actual land use and new developmental activities were infrequently recorded and represented in the maps. As a result, analysis of the existing situation is commonly not based on the real world, which will affect the final outcome.

Further, in many places, spatial data were underutilised because of limited GIS software availability and low GIS capabilities among staff members in local governments. GIS software has actually been widely used by RDPAs and private consultants since the early 2000s for facilitating spatial plan development. However,

the survey conducted in 2009 reveals the surprising fact that a small number of RDPAs still did not recognise the need for using a GIS for spatial planning. Rather, they may rely on consulting companies for their GIS needs. Of the 34 respondents, 70 per cent stated that they did not have a GIS section or a similar type of organisational arrangement to handle spatial data processing. This situation is related to the limited funding, managers' visions and a lack of skilled staff members who can manage GIS operations. Regarding spatial planning, it was found that 26 per cent of respondents did not use a GIS for spatial plan development. A PSS has not been widely used by the Indonesian local government. Even the terminology of a PSS is still new for many respondents. Therefore, the main functions of a GIS are to create maps and conduct relatively simple spatial analysis, such as buffering and overlay. The employment of advanced spatial modelling and predictions is limited.

Estimations of the non-spatial data parameters, such as population growth, drinking water requirements and wastewater production, were conducted separately from the spatial analysis. For example, there are no clear links between the analysis of additional schools that are required and the location to accommodate the new schools. However, with this limited practice, spatial plans have already met all regulatory requirements. Considering the characteristics of the spatial data used and the estimation mechanisms, the spatial accuracy of the modelling will be poor.

These issues will directly affect the introduction of a PSS into the practice of spatial planning in Indonesia. As PSS uses extensive GIS capacity, the absence of GISs and GIS databases will significantly reduce the familiarity of the PSS. The implementation of the PSS will be slowed down, while spatial planning will not immediately obtain the benefit of using the PSS.

3.6.3. Issues related to disaster risk reduction

Several devastating disasters in 2004 and 2006 prompted the national government to recognise the importance of incorporating disaster risk reduction strategies as a formal requirement in a spatial plan. In effect, all district-level spatial plans now have disaster risk reduction components. The BPBD is now involved in spatial planning, although it is not the main actor. Figure 3-9 illustrates the hierarchical

structure of the organisations responsible for spatial planning and disaster mitigation at all levels of government in Indonesia.

In general, the RDPA does not conduct natural hazard mapping by itself; rather, it obtains hazard maps from other government agencies—mostly from the relevant national agencies. Prior to the establishment of the BNPB, natural hazard mapping was conducted by the Agency for Geology (formerly the Direktorat Geologi Tata Lingkungan [DGTL]) and the Centre for Vulcanology and Mitigation of Geological Disasters (Direktorat Vulkanologi dan Mitigasi Bencana Geologi [DVMBG]). Four issues related to the availability and uses of disaster risk information were identified in the 2009 survey:

- availability of hazard data and maps
- modelling of hazard progression and impact effects
- period for hazard projection
- educational backgrounds of the staff members.

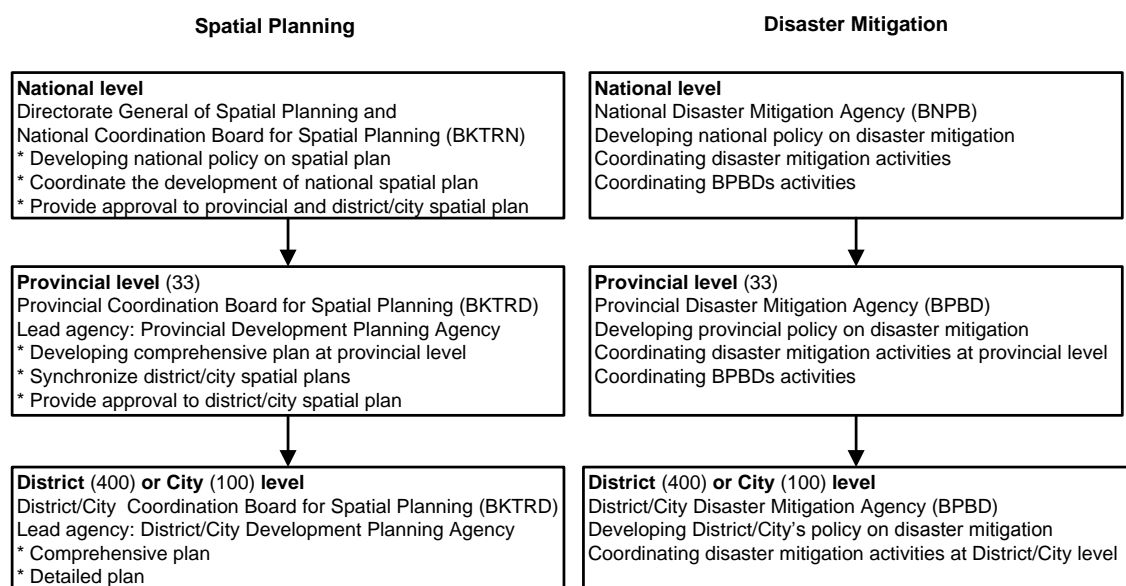


Figure 3-9 Organizations responsible of spatial planning and disaster mitigation at different level of government in Indonesia.

The issue of the availability of data and maps is related to the fact that intensive natural hazard mapping has only recently started, notably after the Indian Ocean tsunami in December 2004 and the earthquake in Yogyakarta in May 2006. The necessary skills have only recently been acquired by a number of local government officials. The formal requirement to incorporate disaster mitigation into spatial

planning has only been stated in the three laws enacted in 2007 (Law on Disaster Mitigation, Law on Spatial Planning and Law on Management of Coastal Zones and Small Islands). Many natural hazard maps sourced from external sources are only available in a small to medium scale, which affects the accuracy of merging them into large-scale planning maps.

The second issue is related to modelling the progression of hazards and possible impacts in the future. Natural hazards are occasionally perceived as static events, without any possibilities for progression or reduction. The possible collision between planned development and the extension of natural hazards has received little attention. Areas that are currently hazard free can become disaster-prone areas in the future. Limited activities are devoted to predicting the likely progression of hazards and linking them to development plans.

The third issue is the period for hazard projection. The implementation period for a spatial plan is 20 years, with a periodic review every five years. Longer-term forecasts have not been encouraged in law or government regulations, which causes RDPAs to consider only parameters that are relevant in this period. However, many sporadic natural disasters have a recurrence period of more than 20 years, and continuously progressing disasters may extend well beyond the period of the spatial plan. Planners may simply ignore such long-term events due to insufficient information, no scientific justification or no regulation that requires it to be incorporated. This situation may jeopardise the spatial plan beyond its implementation horizon.

Few RDPA staff members have an earth science background, which is identified as geology, geophysics, geography or geodesy in the 2009 questionnaire. A lack of such qualified staff members may impede the incorporation of disaster risk information into spatial planning.

Generally, disasters are incorporated into spatial planning only when they have been clearly visible and have significantly affected people and infrastructures. The situation arises partially because there are no guidelines regarding the types of disasters that need to be incorporated, the technical and non-technical requirements of the incorporation, and how to incorporate them. To address these deficiencies, the

first task is to identify the roles of spatial planning and what they can offer to disaster risk reduction.

3.6.4. Use of planning support system for disaster risk reduction

Basically, implementing a PSS for disaster risk reduction in Indonesia is similar to the process in developed countries. However, since PSSs are a relatively new technology for supporting the planning process, an introduction phase is needed. Findings from the 2009 survey reveal that only 9 per cent of respondents are believed to have experience in PSSs. Further, during a workshop on 13 February 2012 in Semarang, only three participants had heard of PSS terminology. Therefore, more time and effort is needed to implement a PSS as a tool to support spatial planning and facilitate disaster risk reduction. However, while the required steps to implement a PSS are similar to other countries, there are some differences in practicalities (Vonk and Geertman 2005), including:

- weight of each work package
- technical needs in data and software
- period to be considered
- impact models to be considered.

More effort is required in data gathering, preparation and smoothing. Data are scattered in many government agencies, with little use of e-government systems and spatial data infrastructures. A mechanism for technical cooperation was not established with the central government agencies that own the fundamental data; thus, the required data could not be obtained in a timely manner.

Many local planning agencies do not have a dedicated GIS unit. Based on the survey in 2009, it was found that only 30% of the RDPAs have GIS unit. Further, the sustainability of a GIS unit in many agencies depends on the availability of competent staff members. Among the staff with technical background (architecture/planning, geo-information and earth sciences), the portion of geo-information specialists, who are considered to have capability in developing GIS unit, only 14%. They. If the staff members who are mastering the GIS operation are promoted or moved to other agencies, the GIS unit may not be sustainable.

Projections on future developments are not long enough to cover all affecting factors. The period for the simulation is commonly made similar to the duration of the spatial plan, which is 20 years. Every five years, the comprehensive and detailed spatial plan will be reviewed by the local government. However, a long-term projection of up to, for example, 50 years, has never been conducted. The existing period for modelling future developments is not suitable in relation to the progression of natural hazards in the area.

Current practices show that scenario development and simulation is not always available or written explicitly in the associated documents. Therefore, many stakeholders find it difficult to criticise the draft of the spatial plan. For many planning agencies, scenarios and effect models could be developed intuitively based on their knowledge and experience.

3.7. Summary

This chapter presents a description of spatial planning in general and spatial planning in Indonesia, as well as the roles of spatial planning in disaster risk reduction, the use of a PSS for disaster risk reduction and the development of a PSS. The challenges and opportunities for doing so are also discussed. A description is given regarding the hierarchical structure of spatial planning. It is argued that local-level spatial plans are the most suitable for disaster risk reduction for several reasons, including the familiarity of planners with local disasters and the responsibility of local governments in the event of a disaster.

There are some commonalities and differences in developing a PSS in developed and developing countries. The similarities relate to the steps required for adoption and implementation, while the differences are the weight of each step and the maturity of the GIS unit. The maturity of the implementation of a GIS is necessary in the implementation of a PSS, since a PSS intensively uses GIS data and a GIS-type operation.

The development of a PSS needs to consider the technical framework, which consists of three aspects: hardware, software and spatial data. With computer hardware becoming cheaper and more powerful, this aspect is not a problem. The use of a

Virtual Reality (VR) system may provide advantages, but it may not be significantly required. The decision regarding the PSS software to adopt should consider existing GIS software, the format of available spatial data and the capability of staff members. Additional work for data conversion is unnecessary and should be avoided.

Chapter 4. PUBLIC PARTICIPATION USING PLANNING SUPPORT SYSTEMS

4.1. Introduction

This chapter discusses the conceptual model and methods of public participation in spatial planning and disaster risk reduction facilitated by PSSs. It begins with a general discussion of public participation and its benefits and challenges, as well as methods for implementation. This is followed by a discussion of the functions and requirements of a PSS in public participation. It then argues the importance of implementing public participation in the local government context. The chapter concludes with a model for incorporating a PSS for facilitating public participation in spatial planning and disaster risk reduction.

4.2. Public Participation in Spatial Planning

4.2.1. Public participation

Public participation is not a new topic in the public policy-making arena, including spatial planning. Since the 1960s, researchers have argued the importance of public participation and showed the methods and procedures where communities and the public can actively participate in governmental policy-making (Levine 1960; Burke 1968; Arnstein 1969; Boaden, Goldsmith et al. 1980). In the US, the legal requirement to incorporate public participation started in 1954 in the urban renewal program (Brody, Godschalk et al. 2003). The emergence of public participation cannot be separated from the issue of democratisation and the increased demand for greater transparency and accountability of public decision making. The public is increasingly curious about how their future is determined by the government. The spatial planning has shifted from the technocratic approach of the land use planners to involving a social science approach with wider participation (Rakodi 2001). In (Arnstein 1969) model of public participation, the top ladders are reserved for activities that are classified as having a high degree of public participation. They include partnership, delegation of power and citizen control. The lowest ladders—

manipulation and therapy—occur when there is no involvement from the public in the decision-making process.

Several definitions of public participation have emerged, as well as similar terminologies. Some researchers previously used the term ‘citizen participation’; however, the use of ‘public participation’ is now more widespread. Public participation is the process of providing the public with an opportunity to express their concerns, needs and values, and to incorporate them into the government’s decision-making process (Glass 1979; Creighton 2005). However, it should be noted that the planning agency has a mandate to perform the development and will be responsible for the output.

Many government projects directly affect people; thus, public involvement in the decision-making process is essential. Public participation is one step further than the previous method of Decide, Announce and Defend (DAD). In DAD, the government decides the best solution to a particular problem, announces its decision and defends it to any critics. This top-down approach worked well in the past, especially in countries implementing authoritarian-style governments with strong central-government control. However, this approach has been heavily criticised for ignoring people’s aspirations, assuming the community to be an object and disregarding local knowledge. As a response, a bottom-up approach has been introduced to overcome the top-down approach’s weaknesses and limitations.

The bottom-up approach aims for greater inclusion and to gather input from the people likely to be affected by the development, as well as grass-roots people and beneficiaries (Landstrom, 2006). Other objectives include information sharing, educating stakeholders and supplementing decision making (Burke 1968; Glass 1979). Community participation is an alternative to government-centred development planning, which seeks to empower communities and allow them to have greater influence in development activities. Internationally, the importance of public participation was highlighted in the Earth Summit, which was held in 1987, with an emphasis on sustainable development. Local participation is one of the methods used to achieve sustainable development objectives, along with greater government decentralisation. The functions of public participation also align with the five

components of good governance: accountability, legitimacy, respect, competence and equity.

Currently, public participation in spatial planning has been recognised as having higher importance and has become a legal requirement in many government regulations (Zhonga, Younga et al. 2008). Many steps in the spatial plan development must include community participation. This covers a broad range of activities in spatial planning, such as evaluating the previous spatial plan, visioning, identifying the push and pull factors, projecting the growth of the population and economic activities, estimating effects of certain scenarios, investigating and defining alternatives, and the decision of the overall plan (Boaden, Goldsmith et al. 1980; Brody, Godschalk et al. 2003; McCall 2003; Kingston 2005).

Evaluating the implementation of previous plans is a routine activity conducted by planning agencies. It involves assessing whether the previous plan has been implemented accordingly, evaluating whether any deviations have occurred, and setting a new approach to respond to development trends and requirements that were not previously anticipated. Residents have good local knowledge of the area and thus their input is beneficial.

In the visioning stage, residents are invited to share their concerns and expectations for the future of their city. Projecting population growth and economic trends is the domain of planning agencies; however, informing the public of the results is essential in spatial planning. Finally, the most important segment in public participation within spatial planning is assessing the alternatives of future development based on scenarios developed by planning agency officials.

The involvement is related to the fact that public participation is a continuum process (see Figure 4-1) that consists of informing the public, hearing public opinion and input, involving the public in problem solving and decision making, and developing agreements (Creighton 2005). Each element has its own objectives that support the overall objective of the plan.

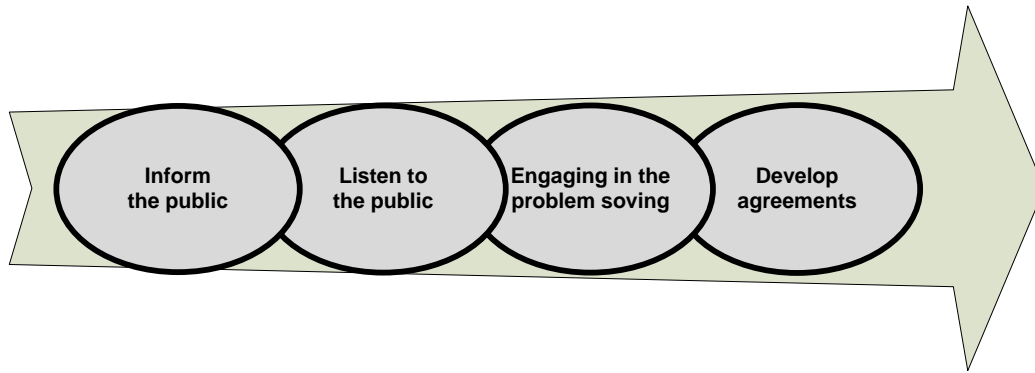


Figure 4-1 Public participation continuum (Creighton, 2005).

4.2.2. Benefit of public participation

Public participation is the realisation of democratic principles that aim to encourage the public to participate in the governmental decision-making process. The implementation of public participation is beneficial to the government, the plan and the participants (Irland 1975; Drew 2003; Halvorsen 2003; McCall 2003; Creighton 2005; McCall and Dunn 2012). The benefits include:

- improving the quality of the plan: theoretically, as more people are involved, there will be more input and corrections to the plan, which will eventually improve its quality.
- increasing the public acceptance: as the plan is developed through a deliberation process, with the public actively participating, it will partially belong to the public. Acceptance from the public will be higher than if the public had no involvement.
- increasing the credibility of the agreed plan: this can be achieved as the plan quality is improved and the public is well informed regarding the rationales behind the plan being discussed.
- increasing the legitimacy: if the public observes that government officials work hard for the public and are willing to listen to their input, they will trust the government's activities. The public believes that the government initiatives represented in the spatial plan can be trusted.
- increasing the ease of the plan's implementation and reducing resistance: as the public are involved from the beginning, the sense of ownership increases.

Further, they feel that the plan represents their interests and therefore that successful implementation serves their interests.

4.2.3. Methods of public participation

There are three classification methods for public participation. The first is based on the types of interactions among participants, the second is based on facilitating technology and the third is based on the relationship between the time and the place of the interaction. In the first category, participants can interact directly or indirectly. Table 4.1. lists common methods in public participation and the potential participants that can be accommodated in each method. The advantages and disadvantages of each method are typically caused by time and place dependency.

Table 4.1 Methods for conducting public participation.

Methods	Participants	Advantages	Disadvantages
Public hearing	Government officials General stakeholders Members of parliament	Solutions/agreements immediately found In-depth discussion is possible	Time- and place-dependent Limited number of participants
Seminar	Government officials General stakeholders	Solutions/agreements immediately found In-depth discussion	Time- and place-dependent
Workshop	Government officials General stakeholders	Solutions/agreements immediately found In-depth discussion	Time- and place-dependent Limited number of participants
Public survey	General stakeholders	Well documented Larger number of participants	May not receive expected responses
Web forum	Government officials General stakeholders	Time- and place-independent Wider audience	May not receive expected responses
Online digital charrette	Government officials General stakeholders	Time- and place-independent	Requires dedicated infrastructure

The second classification is based on the facilitation of technology, as proposed by (Walker and Daniels, 2011). In their classification, the higher the technology used, the smaller the audience involved:

- low-tech visioning: mainly focuses on obtaining consensus from the audiences of the likely future without too much discussion on the present situation. The process is usually facilitated by a series of printed photos, maps, graphics and charts. It results in a sketched map depicting the location of planned development.

- higher-tech visioning: scenarios for planning are prepared by planners. During public meetings, planners and the public will have opportunities to explore and analyse the outcomes and modify the models.
- high-tech visioning: plans and text are created by public planners or planning consultants, with a limited number of people involved. Their involvement is based on their expertise rather than engaging community representatives.

A range of media can be used to facilitate public engagement during spatial plan development, including web sites, leaflets, booklets, workshops, seminars and public hearing forums. Web sites have been used to disseminate the text and maps of spatial plans for some time. Barton, Plume et al. (2005) and Shen and Kawakami (2010) have shown how the Internet, particularly 3D visualisation was able to increase the interest of the participating public. To increase the effectiveness of the participatory process, knowledge on the local customs, goals and values should be taken into account (Golobic and Marušic 2007).

The third classification is based on the collaboration model. There are four possible combinations of time/place collaborations, as shown in Figure 4-2. The combinations are same time same place (STSP), STDP, different time same place (DTSP) and DTDP.

	Same Time	Different Time
Same Place	<ul style="list-style-type: none"> ▪ PSS in a decision room ▪ Web-based PSS ▪ Multimedia presentation ▪ Document sharing 	<ul style="list-style-type: none"> ▪ PSS in a decision room ▪ Web-based PSS ▪ E-mail ▪ Web forum
Different Place	<ul style="list-style-type: none"> ▪ Web-based PSS ▪ Document sharing ▪ Video/audio conferencing ▪ Computer conferencing ▪ E-mail ▪ Web forum 	<ul style="list-style-type: none"> ▪ Web-based PSS ▪ E-mail, ▪ Web forum ▪ Document sharing

Figure 4-2 Combination of Time-Place collaboration models.

The most common type of collaboration is STSP, as it is similar to the usual decision-making meeting. The public also has a high familiarity with this method. The DTSP type requires a collaboration room where participants can go at different

times and input data into the system. The STDP type accommodates situations where participants cannot gather at the same place. It has the most challenging requirement given that real-time collaboration needs to be conducted from different places. The DTDP type is useful when participants are located at different places and are unable to communicate at the same time. A web-based system will support a wide range of situations and stakeholders. However, the existing system does not have the full capability of the desktop-based PSS.

4.2.4. Challenges in public participation

Despite the benefits described in Section 4.2.2., some challenges need to be overcome. The challenges are caused by an increase in participants involved in the process and the new environment faced by government officials. Before public participation is conducted, the following aspects need to be addressed:

- definition of a clear framework and period for conducting public participation: it is possible that the involvement of a larger number of participants will result in a need for a longer-time period; however, the results do not usually need to be redone (King, Feltey et al. 1998).
- overcoming short-sighted benefits by some participants (Cupps 1977): there are always free riders that seek the highest benefit for themselves or their groups at the expense of the wider community.
- ensuring real representation and legitimacy of the participants: it is not possible to have 'one man, one voice' in the spatial planning and disaster risk reduction. Representatives must be chosen or appointed among the communities and interest groups. The representatives should voice the concerns of the community and not act as a rubber stamp for the government.
- overcoming power inequality among participants (Rakodi 2001): this relates to the asymmetric information held by, and the knowledge of, participants. Lay people should not be placed in a disadvantaged position based on their lack of knowledge and unavailable information.
- development of criteria to measure the quality of the output: as more participants, other than planners, are involved in the deliberation, measures regarding quality indicators should be developed

- clear definition of roles and responsibilities among the stakeholders: in the end, the planning agency will take responsibility for the plan rather than the public.

Despite many positive outcomes, the involvement of more parties in spatial planning will generate some difficulties. On the downside, the more people involved in the decision-making process, the more difficult it becomes to reach an agreement. Difficulties also arise due to the many diverse backgrounds of the participants. Parameters and scenarios may not be well understood by participants with different backgrounds, which can lead to prolonged discussions and deliberations. In the case of Semarang, the development of the new spatial plan took almost four years, although Law 26/2007 ordered that the process be completed in one and a half years. However, as long as the result is better, the delay can be accepted politically.

4.2.5. Focus on local government

While many development plans originate at the national or provincial level, the detailed development plan is the authority of the local government, which is responsible for preparing, developing and executing the comprehensive and detailed spatial plan at the district level. Greater involvement from the local community has been advocated internationally and nationally. As local spatial planning concerns the neighbourhood, which will be directly affected by development plans, the importance of influences on the spatial plan development is evident. The ability to provide inputs and modify or reject any development proposal will ensure the interests of the public are protected.

Another factor contributing to the increase is a reduction in the distance between planners and the public. Making acquaintances and facilitating communication between them is easier at the local level than at the provincial or national level. As face-to-face meetings are conducted more frequently than e-meetings, distance is important.

At the local government level, the scrutiny from mass media is usually less than that for national issues. This situation may lead to a decrease in the public's control on the government. In this situation, public participation gains relevance, as it can be used to influence public control over local government decision making.

4.3. Public Participation in Disaster Risk Reduction

4.3.1. Disaster risk analysis and modelling

Disaster risk analysis encompasses the following activities: gathering risk information, calculating its potential impacts and ascertaining elements at risk that will be affected. Spatial planning requires input from disaster risk modelling, while disaster risk modelling is concerned with activities of predicting the changes disaster risks coverage, intensity and frequency. Further, it estimates the potential impacts on the people and infrastructures. Both activities require a set of data on the past occurrences of disaster, their current characteristics and prediction on their progression.

Officially, the required data are kept at several government agencies. However, recent disaster occurrences may not be recorded in the database or the data may be missing. Therefore, the first objective of public participation is to fill the gaps in the government database. The second objective is to educate the public on the potential impacts of disasters in their neighbourhood. The latter is essential in spatial planning in order to provide early warning to the public regarding the importance of avoiding disasters that may disrupt public activities.

Many established software products are designed specifically for hazard and disaster analysis. HEC-RAS is a hydrological model that is useful for flood modelling. Hazus-MH, from FEMA in the US, is available for assisting estimations of the potential losses from earthquakes, floods and hurricanes. This software is available free, thus reducing investment costs for interested planning agencies. For simpler analysis, GIS software can also be applied. In fact, GIS software is currently employed by many planning and disaster management agencies in their analysis to help prepare hazard and disaster maps.

As disaster occurrences are spatially referenced, reliable spatial data and their visualisation tools are important. Public interest regarding potential disasters in their neighbourhood is usually high, while it is relatively low for other areas. The problem commonly found is map availability, since most natural hazard maps are produced as small- to medium-scale maps. Overlaying a small-scale hazard map with a large-scale map of buildings and infrastructures may result in unsatisfactory and

misleading conclusions. Therefore, the higher-scale natural hazard and disaster data are important to increase the credibility of the process.

4.3.2. Disaster risk communication

Disaster risks should be known by residents to enable them to prepare for potentially catastrophic events and to avoid new developments that are not suitable for disaster-prone areas (Dunbar 2007). The analysis and modelling of disasters may involve only a limited number of people, but the results should be communicated to wider audiences. The public should be informed well in advance regarding the potential occurrence of disasters so they can be protected from a speculation-type development.

Disaster risk information should be disseminated to residents using methods such as newspaper articles, government websites, leaflets, books and school lessons, as well as through seminars, workshops and other types of public meetings. Neighbourhood meetings are a good forum for disseminating information and discussing disaster risks—particularly disasters that have a direct local impact.

Regarding spatial planning, neighbourhood-level discussions on disaster risks are particularly important. Through these meetings, in-depth discussions can be conducted in a relaxed environment, thus reducing the power gap between those with knowledge and those without. A neighbourhood usually has important local knowledge on natural disasters and practical mitigation strategies. The public needs to be able to voice its concern regarding disaster risk information provided by the local government. Information from the public will enrich the disaster database by providing locally sourced information.

4.3.3. The use of planning support system

A PSS has several functions in public participation in relation to disaster risk reduction. First, as described in Section 2.6.2., it can facilitate analysis on future threats and development. By using this method, the public are able to understand the consequences of a development in a particular disaster-prone location. Further, a PSS can be a useful tool for communicating disaster risks. Its function is similar to the GIS software. However, it has its own advantage of being able to visualise not only the disaster risk itself, but also the elements at risk.

A PSS uses tools to simulate different types of developmental scenarios as well as the impacts of placing different types of regulations into the disaster case. The public will be able to explore and analyse different types of scenarios and parameters of the disasters, as well as to check the proneness of their neighbourhood and their city (Walker, Simmons et al. 1999; Godschalk, Brody et al. 2003).

4.4. Public Participation and PSS

4.4.1. Planning support system functions in public participation

Among the functions of PSSs mentioned by Berke and Godschalk (2006) was the facilitation of clear communication and provision of credible information to decision makers and stakeholders. Further, they argue that communication is a fundamental requirement in spatial planning that relies on a collaborative effort. In addition, a PSS allows planners, decision makers and the community to share their visions and examine the results of various parameters and scenarios for the future development. The functions of a PSS in public participation are shown in Table 4.2. The effects of different scenarios can be studied and the optimum alternatives for different planning objectives can be judged.

Table 4.2 PSS functions in public participation.

Planning stage	PSS function	Types of collaboration	Spatial visualisation	Aims of participation
Evaluation of the previous plan	Visualisation	STSP, STDP	Spatial plan v. actual development	Gather input from public on the execution of the previous plan
Envisioning new plan	Visualise existing situation and future potential	STSP, STDP, DTSP, DTD	Satellite and aerial photo images Spatial plan	Gather input of the types of futures the public has in mind
Scenario development	Manage spatial and non-spatial data	STSP, STDP	Spatial plan Analysis diagram	Share and improve modelling methods
Effect analysis	Provide tools to calculate possible effects of different scenarios	STSP	Existing condition, 2D and 3D visualisation	Gather input from public regarding the acceptable scenario
Decision making	Compare different scenario and effect analysis to facilitate informed decision	STSP	2D and 3D visualisation, animation	Gather input from stakeholders Build consensus Obtain agreement

PSSs are relatively new for many planning agencies in developing countries, and particularly for stakeholders. Conversely, to a degree, many stakeholders are acquainted with GIS software; therefore, the basic menus of the PSS will be easily understood. In this instance, the introduction of a PSS to stakeholders will not be difficult. Nonetheless, planning agency officials are responsible for operating the advanced functionalities of the PSS.

Using a PSS, the spatial data used to develop the plan, as well as the final designated land use, are to be visualised to the participants. These are also applied to the models, parameters and scenarios being employed. In this instance, the process of the plan development will not be in a black box hidden from the public, as interested stakeholders can inspect and evaluate them. This transparency will certainly increase the credibility of the plan.

4.4.2. Making use of planning support system in public participation

There is a loosely coupled link between a PSS and a public participation mechanism. A PSS itself can be effectively operated without public participation. However, public participation in spatial planning is necessary. Through this connection, the linkage was formed. A public engagement does not necessarily mean that all inputs from the community should be accepted. The link should aim increase the use of all PSS functions to facilitate collaboration between planners, decision makers and the community.

Here, the PSS's main function is to provide the results of different scenarios, which can be used to improve the deliberation process. The information contained herein is essential for informing the public of the spatial plan.

In the traditional method, the community can only share its concerns and inputs in the map. The result of changing parameters and scenarios are not immediately available to participants. The community may be provided with the result of these changes in the following meeting, whereby the context and atmosphere will be different. A PSS offers the capability to change the period for seeing the results.

In a workshop facilitated with a PSS, participants could interactively play with the draft of the plan and see the real-time effects of changing parameters in different scenarios (Al-Kodmany 2000; Stock, Pettit et al. 2005; McHugh, Roche et al. 2009).

Inputs from the public will require further PSS processing, and the result will be reflected in the revised plan.

The use of a PSS in facilitating public participation is mostly for supporting STSP collaboration. Here, it functions as a tool for displaying the scenarios, as a computer program to simulate the development scenarios, as a facilitating medium to exchange ideas and to search for different available options. Figure 4-3 illustrates the use of a PSS in facilitating public participation.

The website should be able to deliver high-quality communication materials that are essential for public participation. It can deliver high-quality graphics, animated pictures and maps, and 3D interactive displays. The Internet also offers several advanced ways of communicating the draft of the spatial plan to a wider audience. In particular, it can facilitate DTDP collaboration, whereby participants are not required to sit in a meeting room for a discussion and exchange of ideas. (Aditya 2010) tested the idea of using a portal as a tool for the community to participate in infrastructure planning and emergency response. In infrastructure planning, the input from the community mainly consisted of reports regarding areas in need of repair. In emergencies, the portal was mostly used to report the occurrence of disasters (e.g. locations, casualties, required aids).

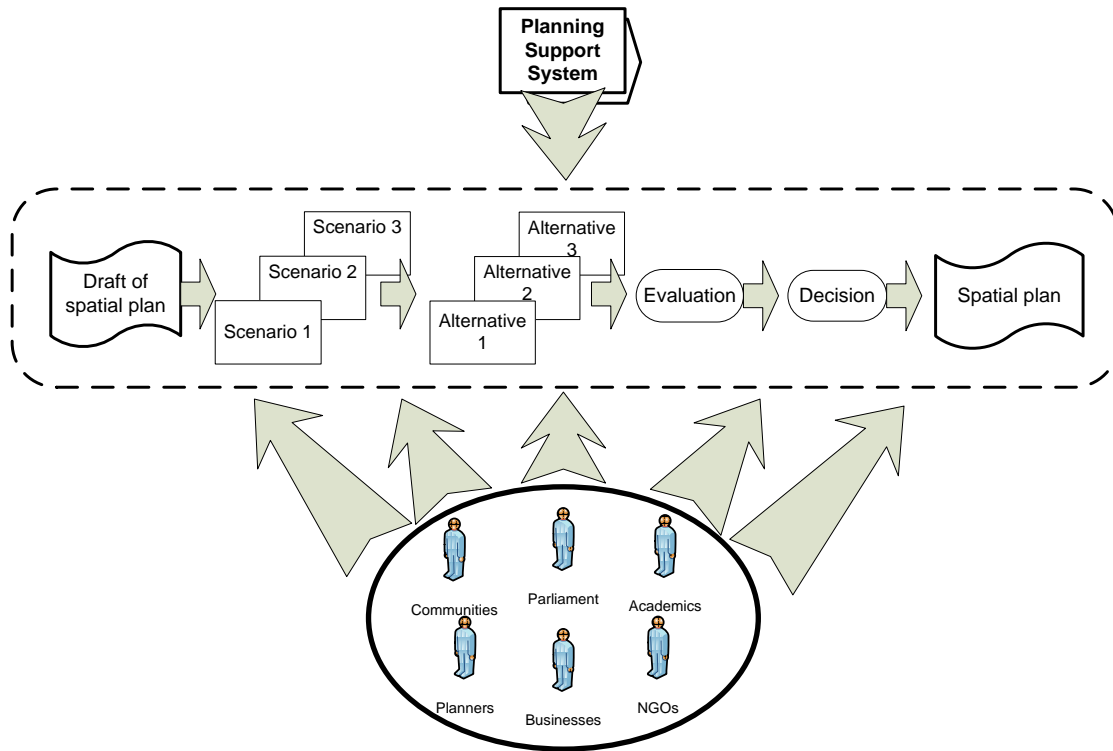


Figure 4-3 Schematic view of the use of PSS in the public participation.

In spatial planning, the situation and requirements are different. It requires in-depth discussions and intensive deliberations that can only be optimally fulfilled in a face-to-face meeting. There are some difficulties if the collaboration is conducted in a different place and at a different time. A different-place meeting, such as using video conferencing technology, can replace face-to-face meetings. However, in developing countries, the use of video conferencing techniques is rarely part of daily operational use due to limitations in the Internet infrastructures and bandwidth.

However, the Internet plays a fundamental role in spatial planning, although it is not used for online collaboration. It is required for disseminating drafts of spatial plans and gathering public input through websites. Online digitisation is also useful for obtaining other perspectives on land use designation. Nevertheless, a full spatial analysis of the impact of different people's choices could not be immediately visible in the Internet collaboration. The current practices of Internet collaboration show that the methods are mostly aimed at gathering input from the public. A connection with the PSS engine for impacts analysis is yet to be developed for web collaboration. In this instance, digital charrettes, which can be conducted in face-to-face meetings, cannot be run.

4.4.3. Spatial information

Two types of spatial information are relevant for public participation in spatial planning and disaster risk reduction: the spatial information of the existing situation and the predicted situation. The list of the spatial information is provided in Table 4.3.

Table 4.3 List of relevant spatial information

Existing situation	Predicted situation
Satellite images	Topography
Aerial photos	Land use
Toponym	Zoning
Infrastructures	Road network
Topography	Transportation network
Land use	Drainage network
Road network	Utilities
Transportation network	Buildings and built-up areas
Drainage network	Progression of natural hazards
Utilities	
Buildings and built-up areas	
Natural hazards	

In all situations, the up-to-date nature of the spatial information is essential. The public can be expected to provide input on the missing features due to obsolete data. However, in this situation, the credibility of the plan could be reduced.

4.4.4. Technology

Essentially, the technology required in the public participation process serves to support STSP and DTDP collaborations. In the face-to-face meeting, the PSS will need to be used in the live demo or to process some simulations. The aim is to show the participants models, parameters, scenarios, data and results. It is important to demonstrate that the processes and models are transparent and available for the public to inspect. It may not always be possible to demonstrate the process of the simulation for the whole city or region considering the limited time and processing steps required. However, a subset of the area or the macro model needs to be presented. During the course of public participation, it may not be possible for

participants to scrutinise all models or scenarios during the meeting, but they should be made available for later inspection.

Unlike back-office processing, which has more time available, public participation is usually constrained by time. Fast and reliable computers need to be employed to ensure that the process runs smoothly.

The Internet is significantly useful in public participation, and its uses are varied, including informing the public of the activities of the spatial plan process, disseminating the draft and product of the spatial plan, obtaining input and ideas, and engaging public debates regarding the draft of the spatial plan. The advancement of WebGIS in the late 1990s, followed by the growing use of mash-ups through Google Maps and other available online maps, changed the way the public interacts with maps. The public is not only able to query online maps to search for certain information, but it is also able to create online annotations to express its views. The public creates voluminous geographic information, which can be used to assist public participation. However, a method needs to be created to ensure the validity of the public-generated spatial information.

The backbone of online public participation is Internet penetration. The potential use of the Internet to support public participation is reflected in the increase of available bandwidth and the use of broadband-enabled tools. The widespread use of smartphones, especially in the younger generation, which is better educated, is particularly important. However, the younger generation's use of the Internet relates more to social media and less to tasks that are more serious, such as participating in government matters. Therefore, there might not be a positive correlation between the increased number of Internet users and the number of concerned individuals willing to participate in the spatial planning.

On the government side, the readiness of the government to employ ICT- and Internet-based public participation is reflected by The Economist's e-readiness index (Economist 2009) and the e-government readiness index of the Department of Social Affairs (DESA) of the United Nations (DESA 2008). Although it is not particularly focused on the local government, the index can be used to infer the state of the e-government readiness index of the local government in a particular country.

4.5. Indonesian Context of Public Participation

4.5.1. Institutional settings

Indonesia has just started greater regional autonomy after 1999, through the Law number 22/1999 on the Regional Autonomy. Local governments now assume a greater role in development planning, and spatial planning is part of the government authority delegated to the local government. In spatial planning, public participation formally began with the introduction of the first spatial planning law in 1992. However, before 2000, public participation activities were mostly ceremonial-type activities, as the public's involvement was limited in terms of participants and contents. The national-, provincial- and district-level spatial plans need to be approved by parliament before being enacted as a law or regulation. This process is claimed to be a reflection of public participation. After 1999, public participation was essentially implemented. The political landscape is becoming conducive to the full implementation of public participation practices. In addition to the law, there are three reasons for the increase of public participation in recent years:

- The awareness of public and government officials is increasing and needs to be accommodated formally in the governmental decision-making process.
- Spatial planning has become increasingly important, and many people feel that they may be directly affected by the spatial plan. This issue also relates to stricter regulation in the spatial plan. Therefore, involvement in the early stages of the spatial plan development will ensure that the public's interests will be protected.
- Decentralisation has given the responsibility of spatial planning to the local government. Consequently, the distance between planners and the community is decreasing.

The previous and current laws of spatial planning have mandated active participation from the public in spatial planning. Methods for public participation are described in the government regulations. Generally, it consists of workshops, public hearings and seminars. However, in the Indonesian context, the use of websites for disseminating drafts of spatial plan maps and text has only begun recently. The following findings were obtained from a survey conducted in 2008 on the use of local government

websites for disseminating spatial information, and a survey conducted in 2009 on spatial planning and disaster risk reduction.

Of the 33 provinces, only the special province of Jakarta, the Indonesian capital, provided drafts of the spatial plan on its website. Other provinces only used the ‘traditional methods’ of dissemination, such as workshops, seminars and public hearings. The documents and maps of the spatial plan are kept at the provincial planning agency, with copies available at each district or city in the province.

From the survey in 2009, it was found that at the district level, 62 per cent of the district’s RDPAs stated that the spatial plan regulation and its associated map could only be accessed in its office. Further, 22 per cent of respondents said that the public should make a request in advance before accessing the document. Only 16 per cent stated that they provided the documents on the website. Fifty-four per cent of respondents observed that stakeholders became aware of spatial planning revisions from the newspaper. Another 38 per cent found out from the announcement board located at the RDPAs’ office and only 8 per cent found out from the Internet. According to RDPAs, 88 per cent of the stakeholders were actively participating in the spatial plan development using various methods. Almost half of the RDPAs have a website facility to accommodate public participation—mostly in the form of forums, guestbooks and e-mail (sequence is based on ranking). Online chatting was never mentioned by respondents.

Respondents were divided when asked to what degree suggestions from the community were incorporated into the spatial plan. One-third of respondents stated that the input was sufficiently accommodated, one-third said it was highly accommodated and one-third said that almost all suggestions are accommodated. These findings reflect that the suggestions from the community are relevant, important and highly regarded by the RDPAs.

Three-quarters of the respondents indicated that they had never used any type of PSS in their office. Eighty-seven per cent of respondents had not used 3D maps in their spatial plan or in the process of its development. They felt that their current system and methods were sufficient for spatial plan development. The largest constraint they faced was a lack of in-house staff members able to operate a PSS, which was

indicated by half of the respondents. The second-largest constraint related to the limited availability of funding devoted to the installation of such systems. Surprisingly, 19 per cent of respondents stated that a PSS was not required in the spatial plan development. When asked about the period for adoption of a PSS, half of the respondents did not know when they would implement it, while half stated that they would consider the use of a PSS within four years.

4.5.2. Issues and challenges

Spatial planning affects, and is by, public activities in many ways. Therefore, public involvement is a necessary condition for developing a better spatial plan, reducing resistance and increasing public understanding, reaching consensus and creating a greater sense of belonging and responsibility. Public engagement and participation were addressed in the Law of Spatial Planning and further expanded in the Government Regulation (Peraturan Pemerintah [PP]) no. 68, 2010. The regulation describes how the public can participate in spatial plan development, implementation and monitoring.

The regulation defines the public broadly as inhabitants who will be affected by spatial planning activities, people who have expertise in spatial planning, and/or people whose activities are related to spatial planning. There are five aspects in which public involvement is sought, including:

- preparation of spatial planning
- defining the vision
- identification of opportunities and challenges
- formulation of concept for spatial plan
- enactment of spatial plan.

To facilitate public engagement, the government must provide detailed information on the draft spatial plan through face-to-face meetings and mass media. Face-to-face meetings include seminars, workshops, public hearings, discussion forums and exhibitions. Radio, television, newspapers and the Internet can also be used to inform the public. The use of the Internet is not imperative, and it has rarely been used by the local government to date.

Generally, the draft of a spatial plan has had limited distribution to key stakeholders. Although it may not be widely available or easily accessible via the Internet, a draft spatial plan can be requested at the RDPA office. The decentralisation process, which began in 1999, has increased the transparency of spatial planning, although hard copies are still used to disseminate the draft, the final spatial plan map and the documentation. The documents can be accessed at the RDPA's office and sub-district offices in the entire region. Some local governments erect billboards (see Figure 4-4) to disseminate the spatial plan map to the public. These billboards are placed in strategic locations throughout the city. Although detailed information can hardly be seen, the method is innovative in a society that has low Internet usage. Only a small number of RDPAs publish spatial plan maps and documentation via the Internet (Sutanta 2008). The quality of the map reproduction is generally low, thus limiting the possibility to read the detailed information. However, some RDPAs are able to publish high quality and complete spatial plan maps as well as the local government regulations on the spatial plan.



Figure 4-4 A billboard to publish the general planning map of Semarang City.

In this situation, public participation is mostly facilitated through public hearings and discussions with an invited audience. Most participants are from the real estate developer organisations, business and industry chambers, academic institutions and NGOs. Maps were limitedly used in all public hearings to support the presentation

and deliberation. Due to the non-existence of the PSS, maps and GISs were mostly used to create illustrations. Advanced spatial analysis and modelling were never used, particularly in the public hearings and discussion forums.

In summary, public participation was an integral part of formulating the spatial plan. The introduction of regional autonomy increased public participation. However, participation is still limited and is usually hindered by the limited availability of data and documents to study. There has been minimal, if any, use of the Internet to disseminate drafts of the spatial plan and invite wider participation.

4.5.3. Defining Who is “Public”

Representativeness is an important issue in the public participation. It is not always easy to determine who really represents the public involved in the spatial planning, for example, it is difficult to determine whether the representatives are self-claiming or not (Creighton 2005; Berke and Godschalk 2006). If nothing unusual occurs, such as major developments that affect a large number of people, the resistance from the public is usually low. Otherwise, the public will react strongly to oppose development plans that are against their values and that endanger their social and economic interests. For example, in the Central Java province, rallies were attended by thousands of people who opposed the designation of the Kendeng mountainous region as a mining region in the provincial spatial plan (Suara Merdeka, 2009). In the Kulon Progo district, in the Yogyakarta Special Region, several thousand people rallied against two proposals of land use designation in the district-level spatial plan (KedaulatanRakyat 2011). The first related to changing the land use designation from agriculture to mining, as a large volume of iron was found in the area. The second related to the development proposal to build a river dam in the mountainous area. Therefore, it is critical to have a real representative from the public.

The answer to the question of who can really represent the public is important. Being able to have a real representative who voices public interest ensures the originality of the public participation. It is also important to ensure that no part of the public is left behind. There will always be a debate if concerned individuals are not invited to the public meeting. In this instance, several local governments placed advertisements in the local newspaper announcing relevant meetings and inviting anyone to participate.

In doing so, the local government has legally put in the highest effort to ensure all residents are aware of the event. It is then up to the residents whether or not they participate. In addition, government regulations set up the definition of who can be considered relevant stakeholders.

In Indonesia, the definition of a member of the public is provided in the Government Regulation no. 68/2010, which relates to methods for the public to participate in the spatial planning. Article 7 of the regulation identifies three parties that can be classified as the public: residents who will be directly affected by the plan, people who have expertise in spatial planning and people whose activities are in the spatial planning. This broad definition is usually expanded to invite wider participation. However, many participants in the public participation process are, to some degree, self-selecting (Creighton 2005). Their concerns may not entirely represent the public; they may lean towards self-interests or organisational interests.

The public invited to participate in the spatial planning can be categorised into four groups: residents, business communities, NGOs and academics. Generally, the residents are only concerned with the development planning that directly affects their neighbourhood, and they pay little attention to proposals for other areas, which is known as the not-in-my-backyard [NIMBY]) syndrome. The business community consists of real estate developers and business chambers. They have a high interest in the development planning and are therefore eager to participate. They are interested in obtaining important information well in advance and influencing the spatial planning. The composition of NGOs is fluid and varies from environmental to social empowerment organisations. Academics from nearby universities are invited to provide scientific advice to the drafting of the spatial plan.

4.5.4. Implementation of public participation

In determining the most suitable methods, the following aspects are considered: working culture, technology, organisation and regulation. Understanding the local situation will determine the success of introducing the use of technology to support public participation activities. Working culture relates to how staff members work at the local government agencies. It is a realisation of the standard operating procedures

in the particular organisation. In many organisations, the use of information and communications technology (ICT) is low in the daily operation of the organisation.

The existing technology will determine the type of facilitation to be conducted. Individual organisations' arrangements, combined with the existence of visionary leaders and champions, play a significant role in the use of ICT. Findings from the survey in 2009 revealed that most RDPAs lack reliable hardware, bandwidth and capable staff for Internet-related activities. The words 'Internet' and 'web' were not mentioned in the government regulations on public participation. Implicitly, the public participation in the government regulation still relies on the traditional method.

Regarding the above factors, and considering the findings of the survey in 2009, the most suitable method for public participation is currently STSP, or face-to-face meetings. While other methods have been tested (Aditya 2010), their wider use in spatial planning is not feasible in the near future.

4.6. Summary

This chapter discusses the importance of public participation in spatial planning and disaster risk reduction. The need for public participation reflects the paradigm changes from the top-down to the bottom-up approach—the response to more democratic processes in governmental decision making directly affecting public life. Public participation provides benefits to spatial planning by improving the quality of the plan, increasing public acceptance, increasing credibility and legitimacy, and enabling easier implementation of the plan. That is, public participation supports good governance practices.

A PSS is not only beneficial for spatial plan development, but it is also essential in public participation activities. It provides transparency of the plan development and facilitates a technology-supported deliberation. The use of spatial information technology will ensure an informed decision-making process, increasing trust from the public and effectively improving the quality of the output.

In disaster risk reduction, a PSS is complementary to hazard and disaster modelling software. It functions in the disaster risk analysis and modelling, and disaster risk

communication. The advantage of using a PSS is that the analysis can be combined with future developmental scenarios, enabling participants to examine the possible impacts of disasters. In this respect, the public will benefit by being able to explore and analyse the disaster progression and the spatial plan development.

However, there are some challenges in employing a PSS for a public participation mechanism. These challenges appear both before the execution of public participation and because of public participation. Although public participation aims to listen to the public and reach an agreement, in some cases, conflict and confusion may arise.

The chapter then discusses the methods and technological requirements for conducting public participation activities. Although there are similarities in conducting public participation in developed and developing countries, a few differences remain. IT limitations and Internet infrastructures, combined with inadequacy in other resources, create an STSP-type collaboration, which is the most suitable method in developing countries.

The chapter concludes by observing that, for effective public participation activities, local situations need to be taken into account. This complements the common parameters that are implemented worldwide.

Chapter 5. SDI PLATFORM FOR SPATIAL PLANNING AND DISASTER RISK REDUCTION

5.1. Introduction

This chapter discusses the concept of SDI, the issues in its development for spatial planning and disaster risk reduction, and the conceptual model of the SDI for this purpose. It begins with a discussion of the concept and components of an SDI, followed by a discussion of the SDI in local government. The chapter then discusses the characteristics of SDI for spatial planning and disaster risk reduction. The Indonesian situation of SDI development is presented to provide context of how SDI for spatial planning and disaster risk reduction is developed.

5.2. Spatial Data Infrastructure: Concept and Drivers

5.2.1. Spatial data infrastructure concept

SDI is a framework for exchanging and sharing spatial data between stakeholders utilising spatial data (Rajabifard, Feeney et al. 2002). It aims to maximise the use of spatial data among stakeholders, at the same time reducing duplication in spatial data acquisition and maintenance as well as any related costs. In some countries, it is common to find that several government organisations develop and manage similar datasets. SDI helps to find relevant spatial data located at repositories in different organisations.

Similar to the adoption stages of a PSS, the development of an SDI should be preceded by the proliferation of a GIS. Indeed, the widespread use of a GIS in many government institutions, and with various technical specifications, led to the idea of an SDI. The isolated development of spatial data employed by various government institutions may result in data duplication.

As an infrastructure, SDI should be widely available, standardised, easy to use, flexible, multi-purpose and for the public good. SDI should be readily accessible and used by all participating members as well as the public.

SDI implementation varies in nature according to the level of government in which it resides. It ranges from a corporate SDI at the bottom level to a global SDI at the highest level. The functions, roles and content vary according to the respective levels.

Developing SDI at the local level will have different requirements compared to development at the national level. The differences are related to the objectives of the respective SDIs. As such, there are different stakeholders, data and needs.

At the local level, an SDI platform will mainly facilitate the exchange and sharing of large-scale spatial data of a single administrative unit. However, there are always situations that require the cooperation of the central or provincial government, such as in spatial planning.

SDI is an indispensable element in facilitating and streamlining the flow of data between government agencies. SDI is not only used in spatial data sharing, but also in discovering the types of spatial data that other agencies have developed.

5.2.2. Spatial data infrastructure components

The core components of SDI are the people, data and technology. SDI has a dynamic nature that is related to changing people and their requirements (Rajabifard, Feeney et al. 2002). Figure 5-1 presents the nature and relation between SDI components.

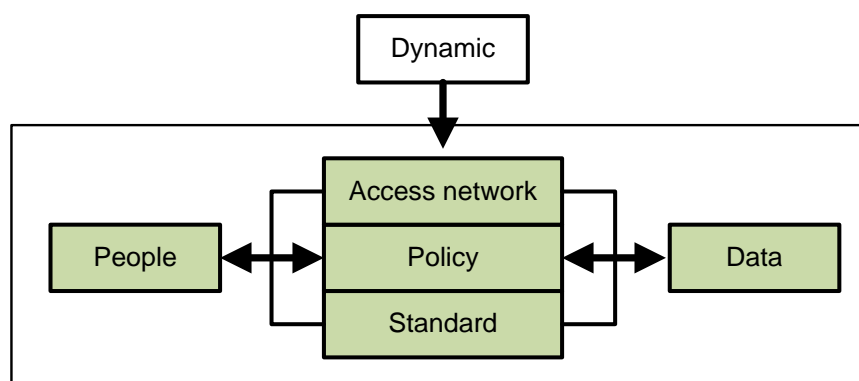


Figure 5-1 Relation between SDI components and its nature (Rajabifard et al, 2002).

SDI components include users, access networks and technology, policies, and the fundamental data. Users include producers, providers, users, administrators and

custodians of the data. Users may consist of the public, business entities, value-added resellers and particularly government agencies.

Access networks and technology are required to facilitate the sharing of data from one node to another. Before the advent of SDI, data sharing was conducted by physically moving the data using a tape or disk.

Policy is fundamentally required to provide legal protection, direction of use, development and regulation of use. In non-federated countries, SDI policy is issued by national governments to ensure national compatibility for all government agencies at all levels. In federated countries, each state has its own policy. SDI is to be combined at the provincial or national level.

Important data placed in an SDI is typically the fundamental dataset, and there are variations among countries regarding what constitutes this dataset. Generally, it consists of a geodetic control network, administrative boundaries, topography, geographic name, hydrology, road network and land use. In many cases, land parcel maps are indispensable but may not be part of the fundamental dataset. Each sectoral application may define additional datasets in this category to fulfil its specific needs. However, it is essential that all involved parties at all government levels are able to access the fundamental dataset.

5.2.3. Drivers for Spatial data infrastructure development

Drivers for SDI development derive from the organisation's internal needs and external pressures. Internal needs are applied to internal institutions and local, provincial, national and government levels. They need to be able to easily locate, access and use the spatial data from other government agencies. Spatial data sharing needs to be streamlined to achieve this outcome. Externally factors include globalisation, advances in ICT, sustainable development and community needs (Rajabifard, Feeney et al. 2002). All of these factors facilitate the development of SDI.

Ultimately, the drivers of SDI development are to support development activities to achieve prosperity for the people. Therefore, SDI is an essential component of a spatially enabled government (Kok, Rajabifard et al. 2008; Masser, Rajabifard et al. 2008), whereby the government not only manages spatial information, but also

manages information spatially (Williamson, Rajabifard et al. 2007; Williamson, Rajabifard et al. 2007).

5.3. SDI in Local Government

5.3.1. Issues and challenges

There are commonalities as well as differences related to issues surrounding the development of an SDI at the national and local government level. The development of an SDI in local government faces several challenges that are not present at the central government level. The issues arise from the nature of the socio-technical alignment of SDI implementation (De Man 2006). Generally, it covers the following issues: human resources, data, technology, organisational arrangement and funding. National-level agencies usually do not have any problems with these issues, unlike local government agencies, which have several limitations that slow them down in the development and implementation of SDI.

Data sharing is another challenge faced by local governments, particularly when they have to deal with their counterparts at a higher level. The problem is not only experienced in federated countries (McDougall, Rajabifard et al. 2005), but also in non-federated countries. For example, in many developing countries, local governments do not produce and maintain the land parcel database. Although the problem with integrating these data into the SDI exists at the national level (Jacoby, Smith et al. 2002), larger challenges are faced by local governments. These data are the domain of the National Land Agency (Badan Pertanahan Nasional (BPN) or the former Land and Property Tax Agency (Pajak Bumi dan Bangunan [PBB]), which do not have to report to the local government. Due to the nature of the data (i.e. privacy issues), national-level agencies are occasionally reluctant to share their data with the local government. Other reasons include power relations among government agencies and data availability concerns (Mansourian 2005).

Issues in spatial data that may affect the development of SDI are categorised in the technical and non-technical issues. For the technical aspect, the following issues need to be addressed:

- currency: the local government usually does not have enough funds to invest in spatial information, although it understands the importance of maintaining reliable spatial information. There is less justification for investing in the production of spatial information compared to investing in the development of physical infrastructures such as roads and drainage. Therefore, many local governments rely on old spatial information.
- scale and level of detail: each government agency maintains spatial data with specifications relevant to their intended use. Collated spatial information from different agencies will therefore vary in scale and level of detail. This situation can introduce difficulties and inaccuracies in the results.
- data format: numerous types of GIS software have been used by local and national government agencies. Shared spatial data may not be fully interoperable, and transformation and correction may be required. This process is time consuming and requires additional funding.
- tools to obtain data: IT infrastructure in local government agencies is not as good as in national agencies. Many local governments in developing countries still rely on paper-based databases.
- semantic: due to thematic requirements, different agencies may use different terminologies to denote similar features or similar terminology to refer to different things.

These issues are related to standards, access networks and data. Remedies to these issues mainly involve building capacity and upgrading the qualifications of the local government's staff members.

The non-technical aspect produces the following issues:

- visibility: relates to whether the information of the data held by government institutions is known by others. If one government agency believed that the required data were not available, even though they did exist, there is a chance of duplication.
- availability: relates to whether the required data are available in all government agencies participating in the local SDI.

- accessibility: relates to whether the available data are accessible to other government agencies. Some government agencies have strict regulations regarding data privacy, which prohibit them sharing their data with other government agencies.
- human resources: at the national government, the development of SDI is usually initiated by a national mapping agency or the national land agency, whose staff members are well qualified for SDI development. Many local governments have a lack of qualified staff to develop or maintain SDIs due to funding or the organisational structure.

These issues are related more to the policy and people. For the policy aspect, there is a requirement to have a national law and regulation to provide local governments with directives and guidance. More importantly, it is imperative to have national government agencies whose spatial data are essential for local government use (e.g. the BPN and the PBB) to make their data accessible.

5.3.2. Building capacities

Capacity building aims to strengthen organisational capacity to deliver its mandates. Regarding SDI, capacity development refers to increasing the capability of the organisation to develop reliable policies and deliver functional SDIs. Capacity building should focus on the empowerment of the local government to ensure that they are able to develop all SDI elements independently. Therefore, capacity building consists of:

- developing or maintaining fundamental and thematic datasets
- developing appropriate policies for the operation of SDIs
- developing IT infrastructures for accessing data
- developing standards to ensure smooth data transfers
- improving qualifications of the staff members who will administer the SDI.

5.4. SDI for Spatial Planning and Disaster Risk Reduction

5.4.1. The need for spatial data infrastructure

One of the main purposes of the use of spatial data at the local level is to support the planning process. It is generally agreed that 80 per cent of the decisions made at the

local government level involve some aspect of location (O'Looney 2000), including spatial planning. Spatial planning is an inter-agency collaboration that requires an efficient mechanism of spatial data access and sharing. Among the potential benefits of SDI supporting spatial planning as identified by, for example, (Phillips, Williamson et al. 1999), are:

- reducing duplication in data production, thereby reducing cost
- facilitating platforms for better-informed decision making
- improving data availability and accessibility
- facilitating public participation to response to increasing collaboration among relevant government agencies.

Reducing duplication in data production can be achieved, as the information regarding the available data is known to the other parties. SDI at the local or municipal levels will enhance spatial planning at the local level as well as at the higher level (Carrera and Pererira 2007).

On the disaster risk reduction, recent examples from large-scale disaster occurrence have provided lessons on the importance of having a good SDI in place (Asante, Verdin et al. 2007). It is required during all stages of the disaster management cycle: emergency response, reconstruction and rehabilitation, preparation, and disaster mitigation. The specification for each stage is different, especially related to the immediacy of access. SDI equips potential users with knowledge regarding whether the required data exist, where the data reside and how to obtain them. Emergency response is time-critical, while disaster risk reduction is not a time-critical activity. However, timely and compatible data are required in both activities.

For the emergency response, the spatial data are ideally available in as little time as possible, and with high currency, while the accuracy may be at the lower level. Conversely, during the preparation stage, the accuracy is highly important, while immediacy is not as urgent. In this respect, SDI for disaster risk reduction should be accurate, serve all stakeholders and provide detailed information.

5.4.2. Spatial data

Spatial data for spatial planning are sourced from different government agencies at different levels. Naturally, the data are specified in various formats, projection

systems, scales and semantic information. The SDI's function is to standardise the various formats to ensure that the end-user application can be run without difficulties.

Spatial data that are used in local government spatial planning vary in scale depending on the types of plans being developed. Typically, they are in the scale of 1:50,000–1:10,000 for comprehensive planning and 1:10,000–1:5,000 for detailed planning. The data characteristics are highly correlated to the data producers.

Most of the spatial data required in disaster risk reduction are similar to that of spatial planning. All data relevant for spatial planning will be used in disaster risk reduction. In addition, the specific data will be the existing hazard maps and the estimated progression. Natural hazard maps have been incorporated in spatial planning for a long time (Baker 1977; Kartez and Lindell 1987). Periodic disasters, such as flooding, have been widely considered in spatial planning (Menoni and Pergalani 1996; Petry 2002; Lavallo, Barredo et al. 2005). However, they are mostly regarded as a static disaster without any progression in the future.

The only problem relates to the scale of the hazard maps. Most hazard mapping is conducted at a small to medium scale. If all technical specifications are met, they are interoperable, but they may not be sufficiently accurate.

5.4.3. Policy

The engagement of disaster management agencies into SDI development is understandably late, after the land agency and mapping agency implemented it for some time. Even so, they consider SDI after the spatial planning agency. For the policy aspect, they usually follow what other, more relevant, institutions have done.

It is possible that disaster mitigation agency, such as BNPB in Indonesia or FEMA in the United States, developed their own SDI with their own specification. However, the specification may not be suitable if it is to be used in combination with external data. The reason is that the spatial data used at the local government level are more diverse compared to the national level, as the local government use spatial data from the national level agencies and the data produced locally. In pursuing an operable SDI, the policy should be developed at the national level.

In the disaster management cycle, disaster risk reduction can be categorised into two types of activities: preparedness and early warning. SDI functions in both activities are for facilitating hazards, vulnerability and risk assessment (preparedness), and supporting risk communication (Asante, Verdin et al. 2007).

5.4.4. Conceptual model

Spatial planning and disaster risk reduction require spatial data from different sources. The data consist of various thematic maps, such as topographic, parcel, hazards, infrastructure and land use. Various government agencies, the private sector, NGOs and universities produce the maps. Spatial planning and disaster risk reduction is not a time-critical activity; however, relevant and timely available information is essential. Therefore, an infrastructure is required for facilitating the discovery, sharing and access of spatial data.

The SDI for spatial planning and disaster risk reduction brings together different types of applications orientation and organisations involved, which is the fundamental role of SDI itself. However, if disaster risk reduction is implemented under the aegis of the local planning agency, the requirements will be simpler. Essentially, SDI is to be built for spatial planning, but with a disaster risk reduction component in place. The conceptual model is a slight modification from the one proposed by (Mansourian, Rajabifard et al. 2006).

SDI implementation is connected to the context (de Man 2007); therefore, understanding local context is indispensable. The context aspects also apply to the application. In this respect, every SDI will be unique, although the fundamental technical components are the same. SDI for spatial planning and disaster risk reduction are unique; however, if both activities are to be conducted through spatial planning, then it will be better to extend the capability of the SDI for spatial planning. Benefits of doing this include simpler bureaucracy and technical implementation.

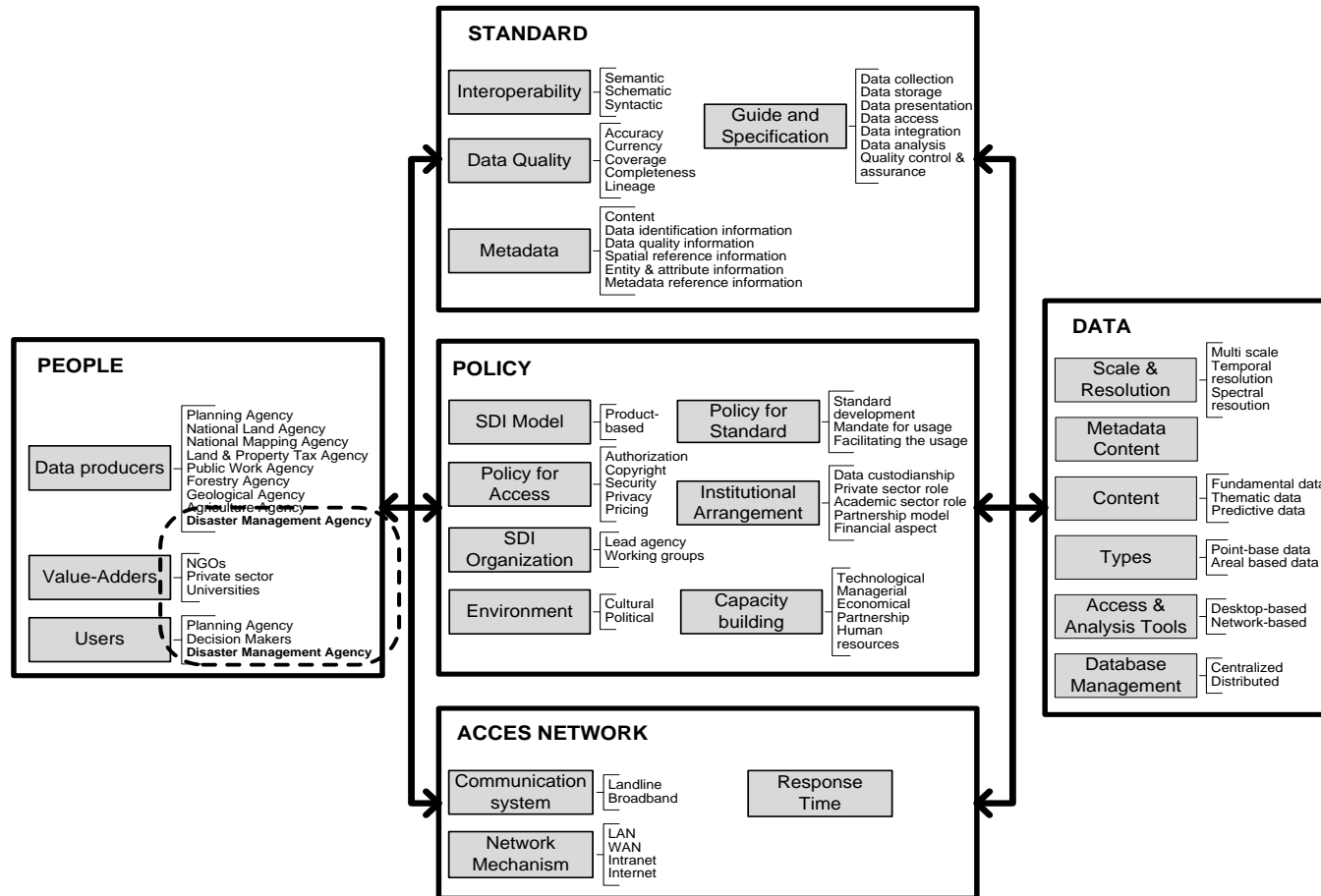


Figure 5-2 Conceptual model of the SDI for spatial planning and disaster risk reduction modified from (Mansourian, Rajabifard et al. 2006).

5.5. Indonesian Context

5.5.1. National policy

The development of computerisation of spatial information started in the mid 1980s, both in the National Coordination Agency for Surveys and Mapping (Badan Koordinasi Survei dan Pemetaan Nasional [BAKOSURTANAL]) and in the National Land Agency (Badan Pertanahan Nasional [BPN]). At the beginning, the aim was to have a digital map database instead of a GIS database. Therefore, CAD software was commonly used. The move to a GIS occurred in the 1990s after a considerable amount of the digital map database had been developed. The production of the new topographic maps and the land administration project marked the leap to a digital spatial database. The GIS was then deployed to other local and national government agencies. At the local government agencies, the first to be exposed to the GIS was the planning agency.

In Masser's classification (Masser 1999), Indonesia is considered the early adopter of SDI through the National Geographic Information System (SIGNas), which was developed in 1991 (Lilywati and Gularso 2000). An annual seminar and meeting is conducted under the name of SIGNas. The participants are officials from the national agencies and planning agencies at the provincial and district levels. In 1999/2000, the initiative was renamed to National Spatial Data Infrastructure (Infrastruktur Data Spasial Nasional [IDSN]) to reflect a paradigmatic shift and latest developments. It refocused again in 2011, and the current name is Indonesian Spatial Data Infrastructure (Ina-SDI), with the Ina-Geoportal launched on 17 October 2011 (Karsidi 2011).

The development and implementation of SDI at the national level has progressed rapidly in recent years. The issuance of the Government Regulation 85 in 2007 and the enactment of the Law on Geospatial Information in 2011 proved to be important factors in raising awareness and providing direction for the development of SDI across government agencies at all levels. The law also mandates the transformation of Bakosurtanal into a new organisation: the Geospatial Information Agency (Badan Informasi Geospasial [BIG]).

5.5.2. Local government situation

For many local government officials, SDI is a new concept that is not urgently required, as they have just increased their use of spatial data and the GIS. In this instance, the local government follows any regulations and directives issued at the central government level. Local governments have started to initiate an SDI, with many based on a gentlemen's agreement rather than coordinated policy. However, at the local government level, much still needs to be done. Based on the findings of the survey conducted in 2009, in the Indonesian context, the specific challenges faced by local governments are outlined below.

There is a lack of skilled staff members available to develop, operate and maintain the SDI. Among the 26 RDPAs that participated in the survey, 14 do not have staff members with a spatial science background. There are only 23 staff members with spatial science qualifications out of 1,172 in the participating RDPAs.

In addition, there is a lack of the fundamental dataset required for SDI. While topographic databases are easily accessible by local governments, geodetic control networks and land parcel maps are scarce.

IT infrastructure may not be sufficient to support SDI operations. Half of the respondents felt that their IT infrastructure was not efficient enough to handle current requirements.

In addition, there may be limited Internet connection and bandwidth availability. Although Internet penetration has increased significantly, the number of Internet users in 2008 was estimated to be around 25 million (APJII 2008), which increased to 30 million in 2010 (Internet World Stats, 2010). As of December 2007, Indonesia has 80 Gbps and 5 Gbps of domestic and international bandwidth respectively (Iskandar 2007). However, many local governments lack the necessary bandwidth for spatial data transfers. The loading time of many local government websites is slow, even without the spatial data visualisation.

Another issue is that the custodianship arrangement is not clear. This aspect needs clear direction of who will act as the local node for SDI. Bakosurtanal started to tackle this problem in the past five years. The RDPA is designated to become the lead agency for SDI at the local government level.

There is also limited funding available. Many local governments have difficulties in justifying fund investments in spatial information, as they do not directly benefit people, similar to the physical infrastructure project. Therefore, funding for spatial data development, management and dissemination can be considered small.

It is clear that all planning agencies require spatial data from other agencies. Ninety-four per cent also make their spatial data available to other government agencies. This finding indicates a high degree of interdependency among government agencies.

Only a small number (18 per cent) of planning agencies publish their spatial data or maps on their websites. This finding is similar to that of (Sutanta 2008), who evaluated the provision of spatial data on the local government's website. A greater number of planning agencies inform other agencies about the availability of their spatial data. However, existing practices observed in the field indicate that they do not use a formal mechanism in informing other agencies. They usually inform other government agencies in a meeting rather than through formal letters. The term 'metadata' might be relatively new for some planning agencies, although a working definition was provided in the questionnaires. It was found that 56 per cent of the planning agencies have created simple spatial metadata.

The findings of the survey indicate that formal cooperation is limited, as only 10 per cent has an agreement with other agencies. Almost all work within a 'gentlemen's agreement' framework regarding data sharing and exchange.

For government regulation, the finding is surprising. Only 17 per cent of the planning agencies were aware of the central government regulation on SDIs. Most planning agencies were not aware of the Government Regulation 85/2007. This situation revealed that more work needs to be done to ensure that planning agencies are more aware and ready to collaborate with each others.

Technical and non-technical difficulties affect the development of SDI at the local government level. Technical difficulties are encountered more frequently by local planning agencies than non-technical difficulties. These include data specification, projection system, differences in spatial data format, accuracy, no staff members able to use the data and the data is out of date. Non-technical difficulties include different procedures used among different agencies to obtain data, difficulties accessing data

from central government agencies (BPN and Statistics), lack of coordination and difficulty finding the person in charge of the data.

The issues and difficulties in implementing SDI at the local level in Indonesia are understandable, since the 400 districts and 100 cities have varying degrees of readiness. Many have been established for less than 10 years, while others have insufficient resources. In response, BIG has developed a capacity-building program in parallel with the Ina-SDI development.

5.5.3. Organizational settings

At the local government level, several agencies report to the local government (horizontal agencies) and some agencies report to their superiors at the provincial and national levels (vertical agencies). Horizontal agencies include the RDPA; Public Work; Education; Transportation; Fisheries; and Forestry. The BPN and the PBB are vertical organisations that have a strong presence in the local government. In 2012, the work of mapping and managing information on land and property tax was handed over from the PBB to the local government. Ideally, the data would be handed over as well. However, the spatial data are still kept at the PBB, and the local government is unable to benefit from them. Parcel mapping for legal land titling and rights remain with the BPN. These agencies have their own mandate and internal regulations that limit them to sharing their data with their local government counterparts.

The PBB has more complete parcel maps, but with lower accuracy. However, it cannot share its data with local government agencies. The privacy of the taxpayer is its main consideration, although this problem can be solved technically. The BPN and the PBB own the land parcel maps, which are indispensable for spatial planning; however, its data are inaccessible to the local government. Conversely, provincial agencies are willing to share their spatial data with the city government.

Two other agencies stationed in the city hold a substantial amount of spatial data: the BPN and the PBB. However, they are required to report to their provincial and national superior rather than the local government. Their relation with the local government mainly focuses on the coordination aspects.

This situation means that the local planning agency can only rely on its counterparts at the city or provincial level. This situation is not ideal for developing an SDI, and regulation from the central government is required to overcome this problem. Regarding the current situation and regulations, as well as to meet the future requirements in spatial planning and disaster risk reduction, the institutional arrangement of the relevant local and central government agencies needs to be established.

5.5.4. Discussion

A fully operational SDI is still in its early development at many local governments. Several issues and challenges need to be solved before an effective SDI can benefit from the local government activities. In this situation, data sharing and exchange were mainly conducted using a gentlemen's agreement, which was mostly facilitated by personal acquaintances. This situation hinders the effective conduct of spatial planning. For example, planners were unable to access the parcel maps produced by the BPN or the PBB. The effect of using lower-detailed data appears in the detailed spatial plan. Many zoning boundaries intersect with the parcel's boundary or even with the building's footprint.

Spatial data sharing mostly ran smoothly among the local government agencies, but faced problems with the national government agencies (BPN and PBB). Cooperation with national-level agencies was obstructed by the mandates of the different organisations. The BPN and the PBB were only answerable to their superiors in the provincial and national governments, and had no obligations to the local government.

Fortunately, internal and external factors are supportive of the SDI development. Internally, there is a growing awareness among younger staff members at many government levels regarding the importance of being able to access the required spatial data smoothly. The current practices are unable to accommodate future requirements in spatial data utilisation across the agencies. Formal arrangements need to be developed for better results and to ensure long-term sustainability. Externally, the issuance of the Government Regulation 85/2007 and the enactment of the Law of Geospatial Information will foster the utilisation of spatial data and the establishment of SDI at the local level. Bakosurtanal is actively promoting and

supervising the development of local SDI. A combination of internally motivated developments and external assistance will speed up SDI development.

Further, the capacity of local government agencies responsible for SDI development needs to be increased. Capacity building should be conducted for all aspects of SDI, including people, technology, data, standard and policy.

5.6. Summary

This chapter begins with a discussion of SDI concepts and components. It then discusses issues and challenges in developing SDI at the local government level. The clarity on these aspects supports the discussion of the development of SDI for spatial planning and disaster risk reduction.

Both types of SDIs have many similarities and few differences. The similarities relate to the model and the differences relate to the participants and data. This chapter asserts that, to make the implementation easier, both SDIs need to be developed as one SDI in the spatial planning domain.

The chapter also highlights the importance of developing capacity at the local government level. While the central government may have sufficient resources and infrastructures, the local government is lacking in both.

The chapter also discusses the Indonesian case of SDI development. It highlights several advancements and future prospects, but also notes some deficiencies that need to be addressed immediately.

Chapter 6. CASE STUDY

6.1. Introduction

This chapter tests the implementation of the conceptual and technical model developed in the previous chapters. It starts with a description of the study area, followed by an analysis of threats from natural disasters and the spatial planning process. The chapter also evaluates the state of SDI in the local government and the public participation mechanism currently practiced in the case study area.

The city of Semarang was chosen as the case study area as it represents a medium-sized city facing threats from numerous types of natural hazards. The city was in the process of spatial plan revision when the research started, although there was no relationship between the two. The chapter presents an analysis of the incorporation of disaster risk reduction into the city's spatial plan and compares it with the model developed in this research.

6.2. The Case Study

6.2.1. How the case study was conducted

The case study consists of two components. The first activity was an evaluation of the process of spatial plan development in the study area, analysing relevant documentation and conducting discussions with relevant parties. The second activity was the development of a PSS application using the CommunityViz software. A description of the procedures and an analysis of the results are presented in Section 6.7. Comprehensive analysis was conducted on the drafts of the spatial plan, which were developed in 2008, as well as the revised 2010 version and the final version. In addition, all associated maps and underlying data were assessed. The aim was to obtain information on: (1) sections that regulate disaster risk reduction, (2) disaster risk reduction strategies and (3) paradigmatic shifts towards the inclusion of disaster risk reduction in the spatial plan.

Seventeen meetings, discussions and in-depth interviews were conducted with government planners, consultants and local stakeholders. Table 6.1 lists the stakeholders interviewed in this research. In addition, two workshops were held to present the research findings on the use of PSSs for spatial planning, which also aimed to gather input and opinions from planners and stakeholders. Field visits were conducted to gather information on the extent of the problems in the disaster-affected areas.

Table 6.1 List of organisations interviewed.

Name of organisations	Category	Level	Number of people interviewed
BAPPEDA	Government	Local	4
DTKP	Government	Local	1
Dinas ESDM	Government	Provincial	2
Dirjen Tata Ruang	Government	National	1
REI	Business	Provincial	1
CV Piramida	Consultant	Local/provincial	3
BINTARI	NGO	Local/provincial	1

Notes:

- BAPPEDA Regional Development Planning Agency
- DTKP City Planning and Housing Agency
- Dinas ESDM Agency for Energy, Natural Resources and Mines
- Dirjen Tata Ruang Directorate General for Spatial Planning, Ministry of Public Work
- REI Real Estate Developers Association
- CV Piramida consulting company
- BINTARI NGO working on environmental and development issues

The interviewees are the main stakeholders in spatial planning in Semarang (1, 2, 5, 6 and 7), experts in natural disasters (3) and resource planners at the national level (4). The aim of the interviews was to gather information on the interviewees': (1) roles in spatial planning, (2) roles in disaster risk reduction, (3) opinion on incorporating disaster risk reduction into spatial planning, (4) views on the opportunities and challenges in incorporating disaster risk reduction into spatial planning and (5) views on the use of a PSS for facilitating spatial planning and disaster risk reduction.

The interviews were conducted on separate occasions during field visits in June–July 2009, June 2010, October 2010 and February 2012. A long time span was used in order to reveal the dynamics of the spatial plan development. Through time, new regulations were issued by the national government, which influenced the process of

spatial plan development. New data and information became available to planners, creating a new understanding and making revisions necessary. These additions, variations and amendments were recorded and analysed. The latest discussion was conducted during a workshop held on 13 February 2012, which also aimed to test the model developed in this research. Fourteen participants from four government agencies, a local university and an NGO attended the workshop.

6.2.2. Description of the case study area

A. Geographical setting and governance

Semarang is located on the northern coast of Java Island, between 6° 50'–7° 10' South Latitude and 109° 50'–110° 35' East Longitude (see Figure 6-1). The length of the coastline is approximately 18 km. The width of the coastal lowland is 3 km in the west and 10 km in the east. The total land area is 373.73 km². Thirty-four per cent of the land is situated more than five metres below sea level, with the highest elevation 348 metres above sea level. The lowland part in the north mostly consists of alluvium sediment made up of clay, sand and gravel.

B. Population

The population of Semarang in 2000 was 1.3 million (BPS 2001). The number of family units was 299,048, while the average size of a family was 4.39. The population growth of Semarang has been 1.32 per cent per annum, which has taken the population in 2010 to 1.55 million. The average family unit size has decreased to 3.77 (BPS 2010). According to the number of residential buildings and family units in the year 2000, there were 1.33 families in every residential building. Population shrinkage had already been detected in four sub-districts: North Semarang, Central Semarang, East Semarang and South Semarang. These four sub-districts are located in highly developed areas but are experiencing increasing floods and land subsidence.

The RDPA has projected different population growth scenarios for the different sub-districts depending on their characteristics and proposed developments (Semarang 2008). At the city level, population growth is estimated at the rate of 1.55 per cent

per year. The predicted population in 2030 will be 2.2 million living in approximately 450,000 residential units.

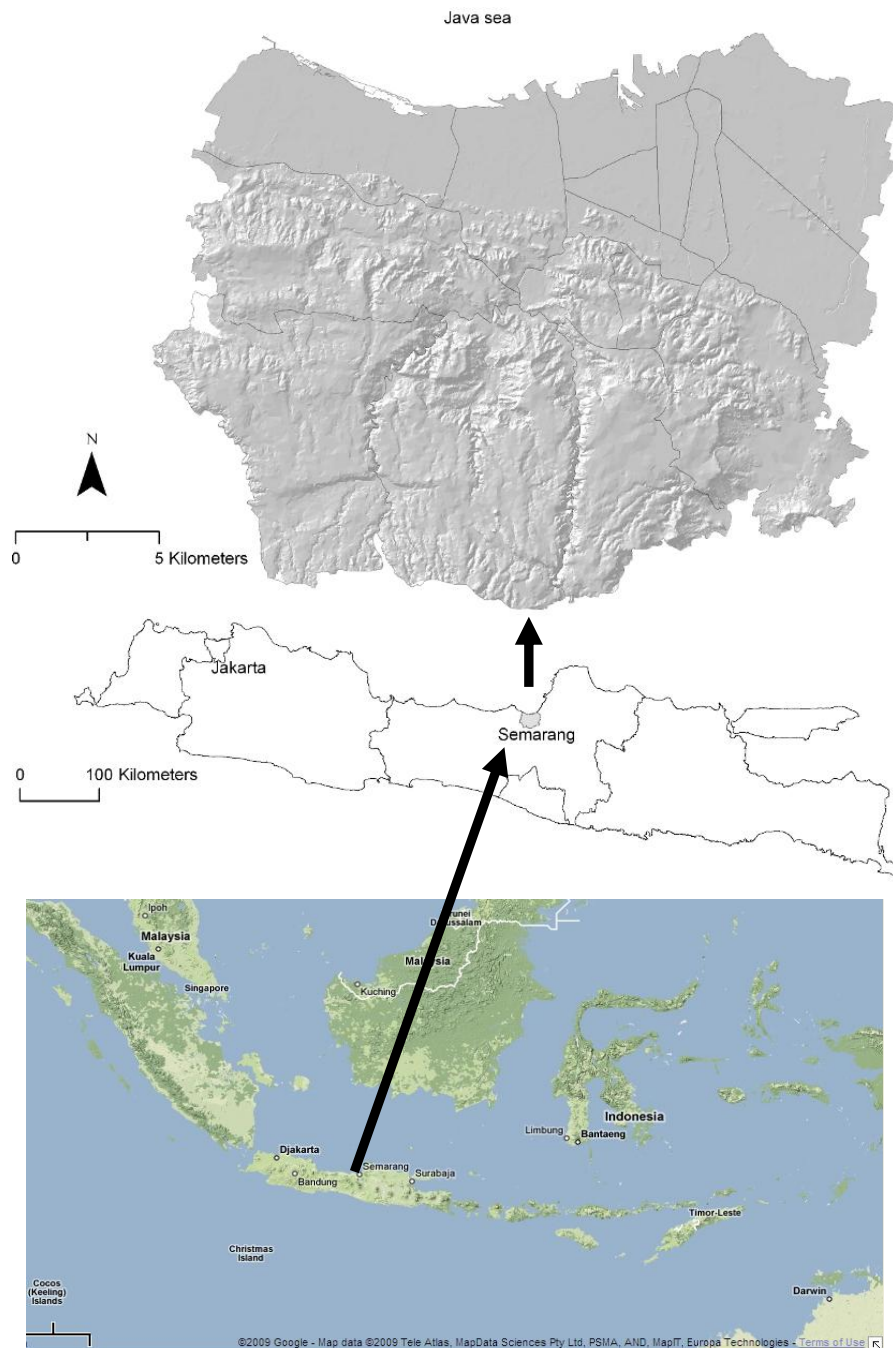


Figure 6-1 Location of the case study, Semarang city, Central Java, Indonesia.

6.3. Natural Disaster in Semarang

6.3.1. General characteristic of natural disaster

The coastal city of Semarang is threatened by six types of natural disasters: coastal abrasion, flooding, landslides, land subsidence, sea level rise, and typhoons (Marfai and King 2007; Abidin, Andreas et al. 2010; Kuehn, Albiol et al. 2010; Sutanta, Rajabifard et al. 2010; Semarang 2011). Their characteristics are presented in Table 6.2.

Table 6.2 List of natural hazards in Semarang.

Disaster	Severity	Affected Area	Remark
Coastal abrasion	Medium-high	Limited	Partially predictable
Flood	Medium-high	Wide	Partially predictable
Landslide	High	Small	Partially predictable
Land subsidence	Medium-high	Wide	Predictable
Sea level rise	Low	Wide	Predictable
Typhoon	Medium	Wide	Unpredictable

Coastal abrasion has occurred in the fishing village in the north and the fishpond areas on the western and eastern sides of the city's coastal zones, affecting villagers and pond owners. A limited amount of government infrastructure has also been affected. Due to the topography and soil type, the hilly areas in the southern part of Semarang are prone to landslides, which occur in the rainy seasons in relatively small and isolated areas. Between 1996 and 2003, landslides killed nine people and destroyed 91 houses (GeoRISK 2004). From 2003 to 2011, eight people were killed in 18 landslides (BNPB 2012).

Flooding is the most devastating natural disaster to date in Semarang, and has been recognised as such for a long time. A photo taken in the Dutch era shows an area in the city centre being inundated by floods in 1875 (www.semarang.nl). Participants of the workshop on PSSs and disaster risk reduction that was conducted on 13 February 2012 also consider flooding to be the most serious threat in Semarang.

Floods in Semarang are mainly caused by torrential rains that are made worse by the low elevation of the city. Floods are classified into three categories: riverine floods, flash floods and tidal inundation. Riverine floods occur in all rivers during the rainy seasons, while flash floods occur in the western side rivers, including the Garang and

Bringin rivers. The average annual rainfall in the Garang River can reach 4,000 mm (Sumarjo, Duchesne et al. 1999). Tidal inundation is caused by sea level rise and land subsidence. Although no casualties have been recorded, the economic cost is increasing. Tidal inundation has mostly occurred in April, June, July and August (Wirasatriya 2005). Many parts of the city are inundated by tidal floods eight times per year, with water reaching a depth of up to 40 cm. A survey by the Japan International Cooperation Agency (JICA) in 1997 indicated that around 11 per cent of household expenditure in the affected areas was used to fight the impacts of tidal inundation (Mechler 2005). This figure is likely to rise.

Sea level rise is a global phenomenon caused by global warming through the expansion of sea water due to heating and to the melting of glaciers and ice caps (Warrick 1993; Raper, Wigley et al. 1996; Titus and Narayanan 1996; Bindoff, J. Willebrand et al. 2007). In its latest estimates, the IPCC predicted that global sea level would rise by approximately 3.8 mm annually from 2000 to 2100 (Bindoff, J. Willebrand et al. 2007). Local sea level rise will vary depending on the sea bottom's topography, coastal geomorphology and the types of coastline. Rising sea levels will block water in the rivers from flowing freely into the sea, which will enhance the riverine floods. Absolute sea level rise in Semarang is amplified by the occurrence of land subsidence, which creates greater relative sea level rise. In this respect, land subsidence will increase the width of the area with low elevation and reduce the elevation of the rivers and their capacity to discharge storm water. Land subsidence affects a large part of Semarang and is discussed separately below.

Typhoons occur occasionally and result in limited damage to properties. However, occurrences and affected areas are difficult to predict. There is no early warning system available in Semarang. The mitigation strategies implemented include trimming trees and their branches, and ensuring the structural strength of billboards located alongside roads.

These six natural hazards are affecting the life of Semarang residents to various degrees. Land utilisation may be affected by the presence of natural disasters and can alter their occurrence. In the spatial plan, land use allocation needs to be adjusted to overcome the potential impacts of natural hazards and, if possible, to lessen their

occurrence. Particular characteristics of the hazards need to be assessed, including risks posed and their predictability.

Among these six natural hazards, land subsidence needs to receive special attention because it exacerbates two other hazards: floods and sea level rises. The lowering of land elevation increases the frequency and intensity of riverine floods and tidal inundation.

6.3.2. Land subsidence and sea level rise

Land subsidence in Semarang appeared to start in the early 1990s, with industrial development beginning to occupy the northeastern part of the city, increased use of the Tanjung Emas port and residential development beginning in the northwestern part. Groundwater extraction increased considerably, along with an increase in the building and infrastructure load. The number of registered wells rose from 600 in 1990 to 1,040 in 2000, with the amount of groundwater extracted almost doubling from 16.9 million m³/year to 38 million m³/year (Marsudi, 2001, cited in Abidin, 2010). People living close to Gate 4 of the Tanjung Emas port in the Kemijen village stated that they started to witness tidal inundation in 1993 or 1994 (Sutanta and Hobma 2002). The government started to monitor land subsidence in 1996. The Agency of Geology and Mines of the Central Java Province established control points and conducted annual surveys of the subsidence. The measurement was conducted using the levelling technique. It was found that, between 1996 and 1999, the subsidence rate reached 6.5 cm/year (Basuki 2000). Since then, a number of measurements have been conducted by many researchers (e.g. (Abidin, Andreas et al. 2010; Kuehn, Albiol et al. 2010; Lubisa, Satoa et al. 2011) to discover the latest rate of subsidence. Table 6.3 summarises their findings.

Table 6.3 The rate of land subsidence in Semarang.

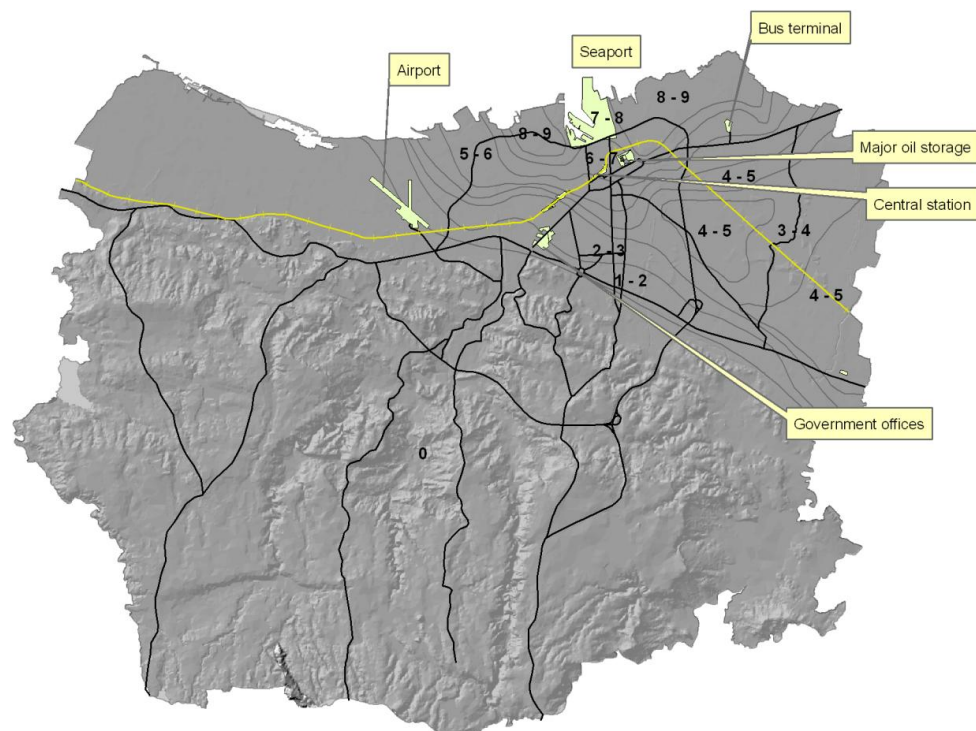
Time span	Method	Highest rate (cm/yr)	Reference
1996–1999	Levelling	6.5	(Basuki 2000)
2002–2006	Permanent Scatterer—SAR	10.0	(Kuehn, Albiol et al. 2010)
2008–2009	GPS	13.5	(Abidin, Andreas et al. 2010)
2007–2009	Differential-InSAR	8.0	(Lubisa, Satoa et al. 2011)

These measurements largely confirmed the prediction of the British Geological Survey (BGR, 1998) regarding the occurrence of land subsidence. The alarming aspect of the report is the prediction that the northeastern part of Semarang will subside up to 6 metres if the over-exploitation of groundwater continues at that pace. The subsidence is predicted to cease in approximately 2070. By that time, if no immediate action is taken, the city will lose a considerable amount of usable land and will face a high economic cost. This means that land subsidence is the most important natural disaster in Semarang.

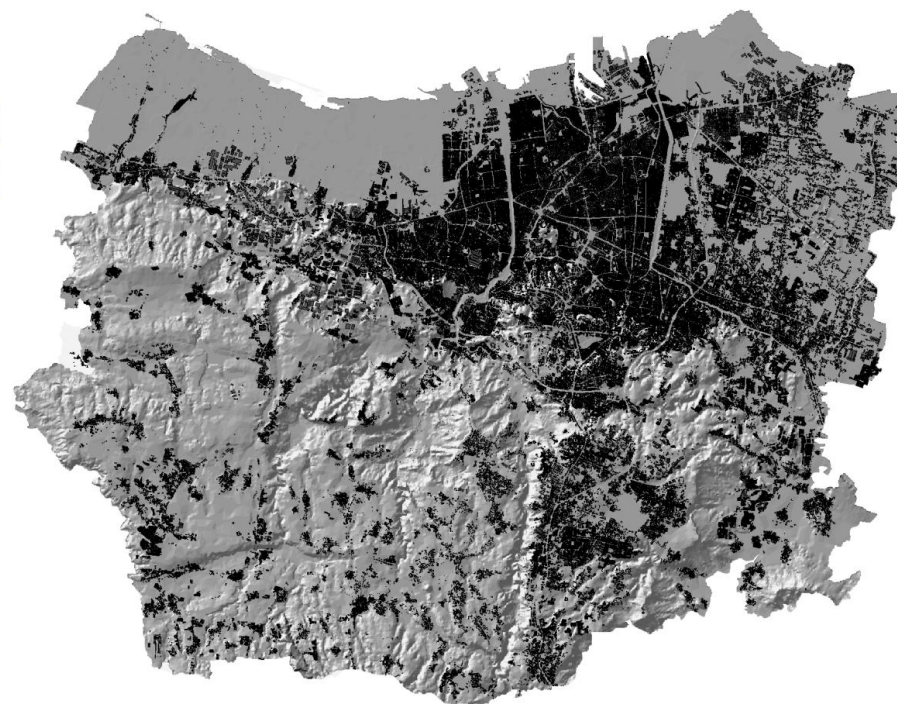
Currently, the area of land subsidence fully covers five sub-districts and partially covers three sub-districts. Eighty-four out of 177 villages in Semarang are located in the subsidence areas, covering approximately 7,600 hectares, and they are inhabited by more than 470,000 people. Approximately 42,000 residential buildings, inhabited by 150,000 people, are currently subject to frequent inundation because they are located in areas with an elevation below 0.5 metres. The subsidence covers the highly developed and inhabited areas of the city and affects the critical transportation centres (see Figure 6-2). If the subsidence continues at the present rate, or even at the predicted slowing rate, then the area affected will become much wider and more people will suffer.

One of the causes of the accelerated land subsidence in the area is the extensive extraction of groundwater by individual pumping (BGR 1998; Tobing, Syarief et al. 1999; Sutanta, Rustamaji et al. 2005; Marfai and King 2007; Abidin, Andreas et al. 2010; Kuehn, Albiol et al. 2010). The reduction of residential building in the areas susceptible to land subsidence will lead to the reduction of residential water usage of up to 1.67 million m³ by 2030. Currently, the local government-owned water company does not have the capacity to fulfil all household and industrial water requirements. It is likely that a large portion of the water used is obtained from individual water wells. A reduction in groundwater usage from individual wells will slow down the subsidence process, and was even shown to stop it in the case of Ravenna in Italy (Sestini 1996), but the slowing down rate has yet to be studied (Abidin, Andreas et al. 2010). However, land subsidence is not a reversible process (Doukas, Ifadis et al. 2004; Arthurton, Barker et al. 2007), even with the addition of

groundwater replacement. Nonetheless, a decrease in the speed of subsidence will provide valuable time to prepare better anticipation and adaptation strategies. The rate of subsidence should be a factor in the design of all new infrastructures. The development of several polders for water retention and pumping houses to replace gravity-driven drainage systems will help to reduce the impacts (Adhy 2007), although possibly not in the longer term.



(a)



(b)

Figure 6-2 Land subsidence rate (cm/year) and the critical infrastructures (a), the population concentrations (b).

6.3.3. Flood dynamics

The incidence of flooding in Semarang has increased significantly in recent years. During 1960–1980, there were only four floods recorded, while there were six floods recorded in the next 10 years, and the last decades show the sign of more floods (Kurnia, Sudirman et al. 2001; SuaraMerdeka 2010; BNPB 2012). Land use change in the upper Semarang catchment area is thought to be one of the factors (Kurnia, Sudirman et al. 2001; Dewajati 2003; Watung, Tala'ohu et al. 2005). Forests, rubber plantations and bushes have been converted into residential, commercial and industrial areas, leading to a reduction in the infiltration capacity of the soil and an increase in run-off. This condition also contributes to a higher subsidence rate, as the Semarang groundwater basin has a lower recharge, leading to a higher rate of consolidation. Land use changes also create a higher level of soil erosion, making rivers and drainage networks shallower and narrower. Water run-off is significantly increasing, and intense rain can lead to flash flooding. The most recent flash flood that killed seven people occurred on 10 November 2010.

Along with the progression of land subsidence and sea level rise, flood frequency will increase because of (1) a reduction in the coastal drainage capacity, (2) a rising of the water table by seawater infiltration in low-elevation areas and (3) a blockage of river water in the event of a high tide. Land subsidence and sea level rise will also make a number of areas more vulnerable to both river flooding and tidal inundation, and they will become unsuitable for development. The hydrologic estimation on the number of floods in the future is not available, but the inundation of lowland areas will inevitably increase. This situation will worsen if the frequency, depth and duration of flooding increase as the result of land subsidence and sea level rise.

6.3.4. Impacts of natural disaster

Natural disasters have human, infrastructure and economic impacts, which will vary according to the magnitude, frequency and destructive force of the disaster, as well as the characteristics of the affected area. Of the six natural disasters in Semarang, the biggest casualties to date were from flash flooding in the Garang River in 1990, which killed 77 people (Tempo 1990), and in the Bringin River in November 2010,

which killed seven people (SuaraMerdeka 2010). The occurrence of flash flooding is caused by the topography of the city, in which there is a wide catchment area with steep slopes, but only a narrow strip of lowland to drain the water to the sea. The second deadliest disaster was landslides. However, due its local nature, its impacts are limited in terms of location and people affected. Other disasters are less severe to the safety of people living or working in the area; however, the impacts on infrastructure and the economy are varied.

Several small-magnitude floods occur annually, which cumulatively result in a high economic impact. The economic losses from landslides were relatively small, as the disaster only affects houses or buildings in isolated areas. In the case of land subsidence, the economic impact is difficult to assess because of its slow progression, which is not immediately visible. This impact is combined with the impact from riverine floods and tidal inundation..Natural disasters have human, infrastructure and economic impacts, which will vary according to the magnitude, frequency and destructive force of the disaster, as well as the characteristics of the affected area. Of the six natural disasters in Semarang, the biggest casualties to date were from flash flooding in the Garang River in 1990, which killed 77 people (Tempo 1990), and in the Bringin River in November 2010, which killed seven people (SuaraMerdeka 2010). The occurrence of flash flooding is caused by the topography of the city, in which there is a wide catchment area with steep slopes, but only a narrow strip of lowland to drain the water to the sea. The second deadliest disaster was landslides. However, due its local nature, its impacts are limited in terms of location and people affected. Other disasters are less severe to the safety of people living or working in the area; however, the impacts on infrastructure and the economy are varied.

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Table 6.4 Economic characteristic of the disaster effect.

Disaster	Severity	Coverage	Object affected	Visibility of effect	Potential economic loss
Coastal abrasion	Low-medium	Small	All	Immediate	Low
Flood	Low-high	Large	All	Immediate	Low-high
Landslide	Low-medium	Small	Human-made	Immediate	Low
Land subsidence	Low-high	Large	All	Not immediate	Low-high
Sea level rise	Low	Large	All	Not immediate	Low-high
Typhoon	Low	small	Human-made	Immediate	Low

As the impact of land subsidence is not immediately visible, the assessment of the economic loss will be blurred by any secondary disasters generated by land subsidence. The following list provides an overview of the present and potential impacts of land subsidence on infrastructure and economic activities:

- damage to roads, drainages, storm waters and buildings
- damage to telephones and power lines, and drinking water pipes
- damage to vehicles and higher cost for maintenance
- disruption of economic activities due to inundation of ports, markets and factories
- disruption of transportation due to inundation of main bus terminal and central station
- loss of land and property
- decrease in land value and increase in unsalable property
- increase of operating costs for several pumping stations to pump water out to the sea
- higher cost for maintenance of physical infrastructures (repairing and heightening roads, bridges, stations and terminals)
- higher cost for preparing land for development, as additional earth material is required to raise the ground elevation. Bore piling is also required to protect high-rise buildings.

Figure 6-3 shows several impacts of land subsidence on housing and infrastructure. In Figure 6.3a, taken in March 2005, a residential building became uninhabitable because it effectively sank as the neighbourhood's land elevation rose, but the house did not. Figure 6.3b, which was taken in July 2010, shows the high rate of subsidence at a monitoring station, which had been built approximately six months earlier.

Figure 6-3c, which was taken in July 2010, displays extensive damage to the road infrastructures. In Figure 6.3d, which was taken in January 2010, a pond has been formed in an abandoned office building. Locals now use it as a fishpond.

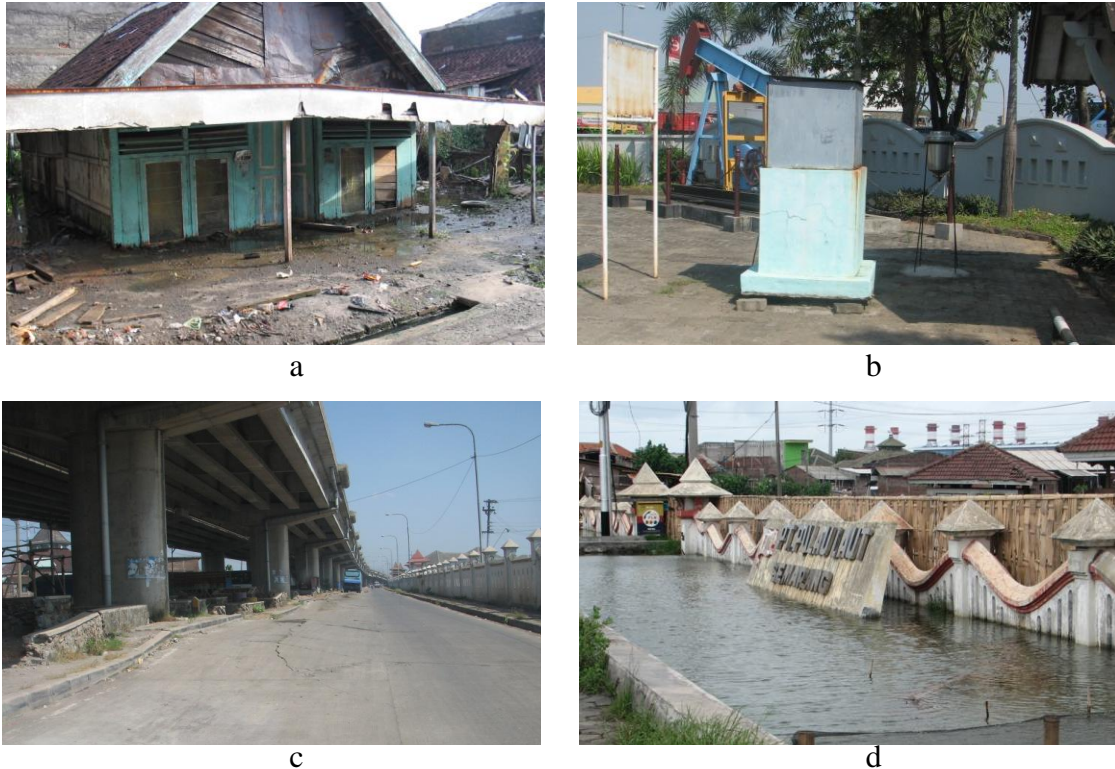


Figure 6-3 Impacts of land subsidence in Semarang.

Notes: (a) Residential houses become inhabitable, (b) foundation of monitoring well shows signs of rapid subsidence in around six months, (c) damaged road located near the port of Semarang, (d) continuous inundation forced an office building to be abandoned.

6.3.5. Disaster prevention and remediation

The occurrences of disasters in Semarang have seriously affected the lives of the residents. In response, residents, business entities and the government have created many projects to protect disaster-prone areas, rehabilitate affected areas and prevent future disasters. The local government is the party that is primarily responsible for reducing disaster risk and remediating the impacts. However, due to the scale of the impacts and the local government's limitation in financial capacity, not all impacts can be remedied immediately. In some cases, residents need to rely on their own

funding to reduce their vulnerability. Individual and collective activities have been created by people to overcome the impacts of disasters. Individually, people try to protect their property against disasters by:

- raising the land elevation of their land parcel to protect it from flood and inundation
- raising their house to two or three stories to reduce the impact of flooding
- developing protection walls to reduce the risk of landslides.

Communities raised collective fund to protect their neighbourhood, and the government usually gives a portion of the required funds as a stimulus. This practice is common in Indonesia, and it is a sign of developing community self-resilience. Examples of the collective action include:

- Heightening neighbourhood roads to prevent them from inundation. However, if not in synergy with the surroundings, this action will only move the floodwater from the roads to the neighbours.
- Raising money for the operational cost of a water pump. The water pump is provided by the government and includes portions of the operational cost. However, the funding for the daily operation of the pump is not sufficient. Therefore, the residents in the richer residential areas nearby contribute to the funding required to extend the operation time of the pump.

The government is undoubtedly the most responsible for overcoming the impacts of natural disasters. Local, provincial and central governments have been proposing and developing several projects for the protection, rehabilitation and reduction of future impacts of disaster. These include:

- rehabilitation of roads damaged by frequent inundation
- raising the elevation of many roads to protect them from future inundation
- development of higher river banks, as the old banks are frequently overtopped
- development of pumping stations, as the gravity-driven drainage no longer works properly
- development of Jatibarang Dam to control water discharge in the West Flood Channel and synchronise the river stream with the tide

- revitalisation of the West and East Flood Canal Project by digging and widening the river
- development of polders as a retarding basin. The polders would replace the natural retarding basin lost in the city development
- development of protection walls to reduce coastal abrasion.

These efforts have been partially successful in overcoming the effects of land subsidence. The development of the Jatibarang Dam, which is expected to be completed in 2013, will also play a critical role in supplying drinking and industrial water (Widi and Sinombor 2011). Groundwater use is expected to decrease, which will in turn reduce the subsidence rate. However, several rehabilitation projects will be obsolete in a few years' time due to the rapid rate of subsidence. The effect of several construction projects will only to delay the effect, as the sinking of the city is inevitable. The raising up of the Tanjung Emas port infrastructures by 3.5 metres in 2012 is a sign of the serious effect of past subsidence (Suara Merdeka 2012). Therefore, long-term remediation of the situation, based on effective spatial planning, needs to be conducted to reduce loss and suffering.

6.4. Spatial Planning in Semarang

6.4.1. Procedures and process

The development of a spatial plan at the district/city level is the responsibility of the RDPA. Several public hearings and consultations need to be conducted, with participants including academics and people from other government agencies, NGOs, business councils and real estate developers. The development of the spatial plan follows the process shown in Figure 3.10.

As ordered by Spatial Planning Law, the development of a new spatial plan at the local level was to be finalised by the end of 2010. However, due to several circumstances, the city of Semarang could only enact their new spatial plan on 30 June 2011 as local Government Regulation 14/2011. The plan will be used as a legal and technical regulation for any development proposal until 2031. Every five years, the government, with approval from local parliament, is required to make revisions and amendments to the spatial plan.

Other than the RDPA, 12 other local government agencies were involved in the spatial planning, as well as the local office of the BPN. From the private sector and the public, there were developers' associations, business chambers, NGOs, community leaders and universities.

The technical development was contracted out to a private consulting firm that worked under close supervision and direction from the RDPA. The planners and consultant worked collaboratively during different stages of the development. Relevant data were sought from other local government agencies as well as from provincial and central government agencies. Five development scenarios were evaluated in the spatial planning; however, they are not available for the research.

6.4.2. Stakeholders analysis

The identification and analysis of stakeholders are crucial steps in developing public participation. They involve identifying the stakeholders and their interests, goals and objectives, as well as their relationships with other stakeholders and the local government. Their position within the collaborative activities can be divided into three rings: inner, secondary and tertiary. The innermost ring consists of the decision makers and key stakeholders from the local government agencies, including planners. The secondary ring includes the stakeholders who are important but who are not part of the decision makers, such as community organisations and academics. The third ring includes the public. Their involvement can be ranked from very intensive to occasional participation. In Semarang, the stakeholders' classification is listed in Table 6.5.

Table 6.5 Stakeholders in the spatial planning in Semarang.

Stakeholders	Ring	Interest	Goals and objectives	Resources, power and influence
RDPA Other local govt agencies Provincial govt agencies National govt agencies	Inner	Serving the people	Prosperity and sustainability	Authority Information Knowledge Respect
Real Estate Indonesia (Developer)	Secondary	Profit Predictability	Predictable development regulations	Lobbying budget Network
KADIN (Business Chambers)	Secondary	Profit Predictability	Predictable development regulations	Lobbying budget Network
LSM Lingkungan (Environmental NGOs)	Secondary	Environmental protection	Preserving environmentally sensitive areas	Relation to media Advocacy and media pressure
Academics	Secondary	Sustainability	Sustainability and long-term vision	Information and knowledge Respected
Kelompok Masyarakat (Community Groups)	Tertiary	Stability Security Liveability	Protecting local community interest	Large membership Fragmented, Focused on locality

6.4.3. Spatial Plan Regulation

The new spatial plan contains 16 sections and 182 articles. The spatial structure plan is covered in Section 2, which consists of 57 articles, while Section 3 covers the spatial pattern plan, which consists of 44 articles. The zoning regulations are covered in Section 7.

Civil and criminal charges for those who breach its conditions are new to the spatial plan. The charges are applicable to members of the public who develop projects in violation of the plan, as well as to government officials who issue development permits that deviate from the plan. This regulation gives more power to the government to enforce any development in the disaster-prone area, while introducing a dilemma for them. The inaccurate spatial data used in the spatial plan might lead to confusion and inappropriate policies in the future. Further, the spatial plan devotes considerable sections to disaster risk reduction. Disaster risk areas are classified as protected areas and are discussed in articles 72–75. Article 72 lists five disaster risks in Semarang: tidal inundation, coastal abrasion, flooding, mass movement and

landslide, and typhoon. The subsequent articles describe the sub-districts or villages that are declared to be in vulnerable to each hazard.

In the attachment document, which is an integral part of the plan, the detailed zoning regulations that are applicable to each disaster risk area are described. For example, in the area vulnerable to tidal inundation, only new buildings that can adapt and overcome the impact are permitted. The detailed building codes are administered in the relevant agency's regulation. Only in this section does land subsidence appear in the spatial plan regulation.

The plan is a significant advance compared to the previous one regarding disaster preparedness. Article 52 lists the roads that are to be used for evacuation routes in the event of floods, landslides and typhoons. Temporary shelters locations have also been defined.

6.4.4. The use of planning support system

Semarang does not have a PSS in the RDPA or another agency. It is still at the beginning of developing a better GIS operation. Currently, the City Planning and Housing Agency is the most developed agency for managing and utilising spatial data. The RDPA still relies on the old database that was developed in 2000 for its daily operation. No dedicated unit is established in the RDPA for GIS operation. However, the use of GIS has increased significantly compared to the previous plan. In the 2004 plan, the maps were still hand-drawn, although the digital spatial data were available.

The terminology of PSS was known to only three people attending the workshop on 13 February 2012. None of them has used or seen other people operating a PSS. However, they are interested in implementing a PSS for future spatial planning. As they have finished the current spatial plan development, there is no immediate need to adopt the technology. The first opportunity to implement a PSS in the future is during the five-year evaluation process in 2015.

The planners and workshop participants realise the usefulness and benefit of using a PSS to facilitate spatial planning. Planners are considering the use of a PSS in the

near future. However, they are concerned about their capacity, resources and data availability if a PSS was introduced into their daily operation.

Spatial planning in Semarang has been guided by several new laws resulting in significant improvements compared to the previous plan. Through public participation, the city has been able to attract public input for the betterment of the plan. Although a PSS has not been used, GIS use has significantly increased. The plan has also devoted many sections to disaster risk reduction.

There was a tension between the short-term gain and long-term vision of sustainable development. However, in the debate, there was no meaningful comparison between scenarios and the cost-and-benefit evaluation of each alternative. The planners lack the necessary technology, data, methods and systems necessary to present the case before the politicians and decision makers.

6.5. Disaster Risk Reduction in Spatial Planning

6.5.1. Statement from local government plan

One new requirement in spatial planning is the explicit incorporation of disaster risk reduction, as ordered by two laws: Law of Disaster Mitigation (24/2007) and Law of the Management of Coastal Zone and Small Islands (27/2007). Article 47, verse 2 of the Law 24/2007 stated that spatial planning is the first tool in disaster mitigation, followed by hard engineering methods such as physical infrastructure development.

With no local precedent on how to incorporate disaster risk reduction into spatial planning, planners needed to look elsewhere for best practices on this matter. The impact of two major disasters (the tsunami in Aceh in 2004 and the earthquake in Yogyakarta in 2006) influenced the way of thinking in the development of the early draft in 2008. Geologically, the north coast of Central Java is safe from tsunamis, but the first version of the plan listed several precautions related to tsunami hazards. Earthquakes were also listed in previous documents, although the risk of a large earthquake is small. This situation reflects the lack of reliable and timely information on the threat of natural disasters in Semarang. The local government previously only conducted limited natural hazard mapping. The final version has revised the list so

that only relevant disasters are included. Eventually, the LGR listed five natural disasters in article 72, as follows:

- tidal inundation
- coastal abrasion
- floods
- mass movement and landslide
- typhoon.

These disasters are evident in Semarang, affecting the lives of residents and resulting in economic losses to varying degrees. However, land subsidence was excluded. It is only mentioned once in the zoning regulation—in the attachment section of the spatial plan document—as one of the causes of tidal inundation. It appears as though the severe consequences of land subsidence have been ignored. However, city planners explained that they fully understood the severity of the problem but were afraid of the consequences if they listed it (Prakosa, B. 2012 pers. comm., 7 February). Article 32, verse 1a stated that, in its disaster mitigation activities, the government might prohibit residential development in disaster-prone areas. The aim was to prevent people from becoming the victims of natural disasters.

Planners are concerned that if a large number of villages are declared disaster prone, there will be two consequences: first, new residential developments should be prohibited; second, existing houses should be relocated. This conclusion was drawn from the Law of Disaster Mitigation. Since the law is newly enacted and the current spatial plan is the first to be enacted based on this law, planners are uncertain of the direction they should follow. Further, the declaration may reduce the city's investment grade, therefore reducing its attractiveness for new investment and development. In effect, the city may be transformed into a ghost town if there are no new developments.

As a result, the local government decided that land subsidence should be excluded from the spatial plan, but efforts to overcome the impact will be thoroughly reviewed and physical development will be continuously pursued to protect the city. To the local government, this appeared to be the solution. However, as the spatial plan becomes a local government regulation, there will be legal and policy consequences

to excluding the land subsidence. Without explicit delineation of the area to be affected by land subsidence in the future, the residential and business communities will not be bound by any prohibitions and forced to rely on unauthoritative information. Development is likely to continue with few considerations of mitigation strategy, leaving all existing and new land users in a vulnerable position.

6.5.2. Response from the spatial plan

Disaster mitigation is the responsibility of the BPBD. It is not clear what agency is responsible for disaster risk reduction. The newly created agency mostly works in emergency response, with limited involvement in disaster risk reduction. It has a limited budget (Djalante, Thomalla et al. 2012), leaving it to rely on the BNPB. An integrated approach to disaster risk reduction, which makes use of perspective and expertise from broad disciplines, stakeholders and agencies, is not yet in place. Therefore, sectoral and individual agency resolutions are mostly used. Even so, the spatial plan has developed risk reduction strategies.

These mitigation strategies are mainly based on zoning regulations and include limiting and prohibiting development in disaster-prone areas. Further, emergency evacuation routes and shelters are planned and general building codes are suggested. Only new buildings that can adapt and are resilient to the disasters are allowed. No existing buildings will be affected by the new regulation, and residents can continue to utilise all existing buildings in the area.

However, at the comprehensive plan level, the zoning regulations were not accompanied by associated maps depicting the location of where limitations or prohibitions apply. Only the names of the sub-districts and villages with disaster risks are listed. In effect, detailed inspections of where disasters may strike cannot be conducted accurately. Conversely, the names of roads and places to be used for evacuation shelters have been defined in detail.

The provincial government has been involved in determining the disaster-prone areas. The decision to include typhoons was influenced by a request from the Provincial Planning Agency, according to one of the RDPA's planners. Input from the public and community on this aspect was minimal. On the other hand, there was

strong opposition from investors when the RDPA floated an idea to relocate industrial land from the disaster-prone area in the northeastern part of the city (Prakosa, 2010 pers. comm., 3 November). The maximum subsidence in this area was predicted by the BGR to reach 5–6 metres below the land elevation in 1997 (BGR 1998). However, the previous spatial plan had designated the area as an industrial complex. Therefore, many business owners and investors had bought considerable areas of land for their business. They strongly opposed moves to change the land use designation to any use other than industry. The local government will face a difficult task if it wants to change the land use designation, as a considerable amount of money is at stake.

During several discussions with local government planners, residents, the business council and real estate developers, the occurrence of land subsidence was acknowledged. The latest discussion was conducted during a workshop held on 13 February 2012, which was aimed to test the model developed in this research. Fourteen participants from four government agencies, a local university and an NGO attended the workshop. Among the biggest threats from natural hazards, flood was mentioned by 12 participants, tidal inundation by 11 participants, and land subsidence only four participants. It appears that most participants examine the visibility of the disasters, rather than their fundamental characteristics, before drawing their conclusions.

The city's proposal to change the land use designation in flood-prone areas (because of land subsidence) from industrial to conservation has failed because of pressure from the business community. Although it is aware of the problems and their consequences, the business community insists on the right to utilise and invest in high-risk areas. They argued that the land should be kept open for industrial use because the previous spatial plan designated the area as industrial. Conversely, real estate developers have moved in the right direction by downsizing investment in subsidence-affected areas. Their moves were driven by the fact that many exclusive residential complexes have been abandoned or were not sold.

Compared with the previous spatial plan, a number of significant improvements have been made. These include the explicit listing of natural disasters that threaten the

city, zoning regulations, evacuation routes, temporary shelters and building codes for the disaster-prone areas. All of these were largely absent in the previous plan. The mandate from the Law of Disaster Mitigation clearly has a significant influence on this matter.

On the negative side, the spatial plan does not project the progression of disaster and elements at risk in the future, and it particularly excludes land subsidence. The first drawback may relate to the limited availability of data and resources at the RDPA. Disaster data are scattered in many local, provincial and national agencies. Some data are delivered to the RDPA, but many are missing from the RDPA repository. Formal mechanisms for data sharing are absent. Further, there is no dedicated section for the daily operation and maintenance of GIS in the RDPA.

A map-based simulation of future development was not conducted during the spatial plan formulation. An estimation of the population growth and new land use requirements was reported in tables without being plotted on maps. There is no visual expression of the estimation of future growth that can be used to facilitate deliberation during public meetings. A GIS was in place, but its use was limited to creating base thematic maps.

The exclusion of land subsidence was mostly based on the assumption that an inclusion could be interpreted as a prohibition on new development in areas assigned as prone to land subsidence. City planners interpret article 32 of the Law of Disaster Mitigation as prohibiting new development in areas declared as disaster prone. However, this article should be interpreted such that prohibition is only applicable for threatening disasters. Careful reading of article 32 of the Law of Disaster Mitigation reveals some flexibility. Areas declared as disaster-prone do not automatically become unusable for new residential development. By law, prohibition should only be implemented if the disaster is life threatening, such as a volcanic eruption. For slow onset disasters that do not pose a threat to human life, the spatial plan should have a different interpretation. Adaptation strategies are better suited to respond to slow onset disasters.

Planners also worry that if large areas of the city are listed as prone to land subsidence, investors will move away and the area will be left empty. Unfortunately,

detailed and comprehensive analysis regarding the cost of abandoning the area, protecting it or doing nothing has never been conducted. The City of Semarang is now focusing on a physical infrastructure project to alleviate the obvious impact. This includes building polders, widening rivers, raising road elevation and developing dams in the upstream catchment. Reducing the cause and preventing the extension of the impacts received limited attention. A situation of here-and-now urgency (Godschalk, Brody et al. 2003) is emerging, but it is not sufficient.

Scientific evidence based on past monitoring activities and predictions of future trends should be used to assign the most appropriate land use allocation and zoning regulations. The rate of land subsidence can be used to define different land use designation. Different categories of subsidence rate will determine different response strategies that should be applied. Land use allocation should consider the coping capacity of the use and the users, the characteristics of the use and the resiliency of the user. Areas with high subsidence rates and with the current land elevation is already low should get a different assignment to similar elevation areas with lower subsidence rates. This differentiation can reduce disaster risk to the residents in the future, while recognising the present importance and economic value of the areas by not abandoning them. In response to slow onset disaster, economic analysis plays an important role. It is not the lives of the residents that are at stake, but the economic development.

Planners in the RDPA have applied the right course of action of do something, instead of do nothing, with regard to disaster risk. Two options are pursued: adaptation and protection. Several internal and external situations limit their ability to achieve optimal solutions. Internally, they have limited data, funding, capacity and technology to respond to all natural disasters. Externally, their choices are limited. They do not have available land to relocate vulnerable activities in their jurisdiction. Harmonisation with three neighbouring districts is required, but not yet fully implemented. It requires a directive from the provincial government.

The possibility to change land use designation is rather slim. The fundamental requirement of changing land use designation in the sinking areas from industrial or residential to other is that the new use should have the financial capacity to protect

the industrial development, and it should be profitable enough to ensure its sustainability. Given the characteristics of the industry and service sectors in the city, specific types of uses that have a high resiliency towards land subsidence have not been found.

Externally, the RDPA receives pressure from politicians and business groups to develop a favourable land use designation that suits their interests. There were debates in the media and during meetings regarding long-term vision versus short-sighted interest to obtain quick benefits. A PSS is required that can facilitate the planning process and visually show the results of the simulation using different types of scenarios in a deliberation. It can provide planners and decision makers with a neutral assessment of the problems with visually attractive maps of what the future will look like under different scenarios.

6.6. Public Participation

6.6.1. Existing public participation

Public participation is an essential element of spatial planning. Laws and government regulations mandate local governments to initiate public participation. Two different settings for public participation exist: for the public and for the lawmaker in the parliamentary hearings. Public hearings were conducted in Semarang, as part of the spatial plan development process, to gather information, input, suggestions, opinions, considerations and responses from people and experts. The public invited to the meetings consisted of local government agencies' officials, community leaders, business chambers, real estate developers, NGOs, academics from local universities and eminent figures in the city.

There were four seminars, eight public hearings, five workshops and 17 parliamentary hearings. In addition, there were 12 consultations with the provincial government and 15 consultations with the BKTRN at the central government. These data show that public participation has been fully implemented in Semarang. Hundreds of people participated in many public participation activities. The city's planners stated that input from the public was highly regarded and was beneficial to the improvement of the spatial plan.

The draft of the spatial plan was available for inspection at the RDPA office by the public. However, during the development stage, no drafts were available on the Internet. Semarang only published the final product of the spatial plan. The findings from questionnaire distributed on 13 February 2012 revealed that 62% of the participants regarded FGD is the most effective way to gain public input, followed by public hearing (stated by 38 respondents).

6.6.2. Public participation facilitated by planning support system

Maps were already used in many public meetings, and an evaluation of the presentation materials revealed that maps were an integral part of the meetings. Different types and themes of maps were used extensively. However, considering the limitations of those meetings, an interactive map-based simulation was not possible; only maps as final products were used. As the city has never had a PSS, it was never considered a public participation tool.

To evaluate the method developed in the research, a public participation mechanism using a PSS was tested on 13 February 2012. Fourteen participants from four government agencies, a local university and an NGO attended the workshop. Participants were first introduced to the concept of using a PSS to facilitate spatial planning and the functionalities of CommunityViz. Participants were then invited to evaluate the conceptual model developed in the research and use the PSS in CommunityViz. However, due to time limitations, participants were only able to browse the main functionality of the software. Nonetheless, during the discussion, the following findings were revealed:

- The participants agreed that disaster risk projection has not been adequately included in the existing spatial planning process.
- The participants had not previously been exposed to PSSs. Only three knew the terminology before the meeting.
- The participants found that PSSs offer many potential benefits for spatial plan development, such as the ability to simulate future development and compare outputs from different scenarios.
- The implementation of a PSS is possible and considered important for improving the plan quality.

- The participants agreed that PSS can be used to facilitate public deliberation, such as in FGD, to improve the plan quality.
- However, there are some challenges for operational use in the RDPA when considering the following conditions: human resources, data, funding and continuity.

In this respect, there is a good opportunity to implement a PSS in the future. This new approach was accepted as being able to facilitate deliberation, including interaction with the public, to support a better informed, and more disaster-resilient, spatial plan. Short- and long-term development objectives can be analysed, while different scenarios and possible impacts can be evaluated using sound scientific evidence.

6.6.3. Implementation of public participation in Semarang

The state of the ICT infrastructures in Semarang is still in the development stage, and Internet bandwidth is relatively low. Therefore, public participation was mostly conducted via face-to-face meetings. To disseminate spatial plan information, the local government engaged newspapers, radio and television. The advantage of using these media is that they have a wider coverage, although it limits in-depth discussion.

A PSS was not used in all meetings, and interaction with spatial information was mostly supported by maps and GIS software. Deliberation facilitated by interactive GIS processing or a PSS did not exist.

Public participation has been conducted for a long time in Semarang. Local government agency officials and stakeholders are familiar with the method. Several models of public participation were employed during different stages of the spatial plan development. Maps were an integral part of the activities, as shown in the presentation files.

The live use of the GIS in the deliberation was not attempted. Maps were presented as the final product of back-office processing. Amendments to the maps could not be directly executed during the public meeting. Therefore, a comparison of the results from two different scenarios cannot be presented to the participants immediately. If

the results are presented in a different meeting, the context, atmosphere and participants may be different.

It is more important for the city that public participation has been conducted according to the regulation, and a wide range of participants has been invited. The essence of giving the public an opportunity to voice their concerns has been delivered. According to the planners, input from the public is highly regarded and is beneficial to improving the plan. Although the public did not have an opportunity to assess any scenarios and the underlying spatial visualisation of the plan, their input was important to improve the quality of the spatial plan. The influence of the public was reflected in the policy on zoning and environmental regulations.

6.7. PSS for Disaster Risk Reduction

6.7.1. Method and dataset

A. Method

To test the applicability of the concept developed in this research, a PSS was implemented. CommunityViz was used, along with ArcGIS 9.3 as the PSS software. It was used to simulate future development using two scenarios: the business-as-usual (BAU) and the disaster-resilient spatial plan (DRSP). In both scenarios, the comprehensive and detailed plan from the city was used as the starting point. The number and locations of future residential buildings in different years were predicted using an exponential growth model. CommunityViz uses exponential growth expressed in the following equation:

$$F_n = (F_{(n-1)} + F_{initial}) * (1 + r) - F_{existing}$$

where

n is the number of years

F_n is the number of features built in year n

r is the exponential growth rate

$F_{initial}$ is the number of features at year 0

$F_{existing}$ is any number added to $F_{initial}$ to obtain a larger basis for the growth rate calculation.

The BAU scenario simply follows the land use designations of the city's plan, while some changes were implemented in the DRSP scenario. The land use designations that do not meet the acceptable criteria were changed to designations that are more

resilient. In some cases, the risk should not be accepted; however, several exceptions may apply based on locational requirements, such as the location of a seaport and its facilities. In this respect, although the acceptable risk level is exceeded, the interim land use plan can be accepted. If the risk cannot be accepted and no exceptions exist, an alternative land use designation should be sought. Any land use alternatives should proceed again through the acceptability evaluation stage. If this is not acceptable, restrictions on use may be assigned.

In a coastal lowland area facing possible effects from continuous inundation because of land subsidence, the risk level is a function of elevation. The lower the land elevation, the higher the inundation risks. The combination of different coping capacities and risk levels resulted in three options in the acceptability evaluation: accept, make an exception or and reject the land use. Acceptable and exempted land uses can proceed further as part of a final spatial plan. The unacceptable land uses can be relocated or changed to another land use designation that can withstand the impact of future disasters.

The system development and processing strategy is shown in Figure 6-4. An initial land use designation plan was evaluated against existing and predicted natural hazards to discover the current and future risk levels. This was followed by mapping elements at risk in the current and future situations. The projected future situation was calculated using projected development based on the land use designation and the remaining capacity of the land. The location of any building and the time of construction are predicted in the growth projection model or from a large-scale development proposal.

To evaluate the benefit of incorporating disasters into a spatial plan, a comparison between a BAU and a DRSP were conducted. The evaluation is based on the comparison between elements at risk obtained from the two models.

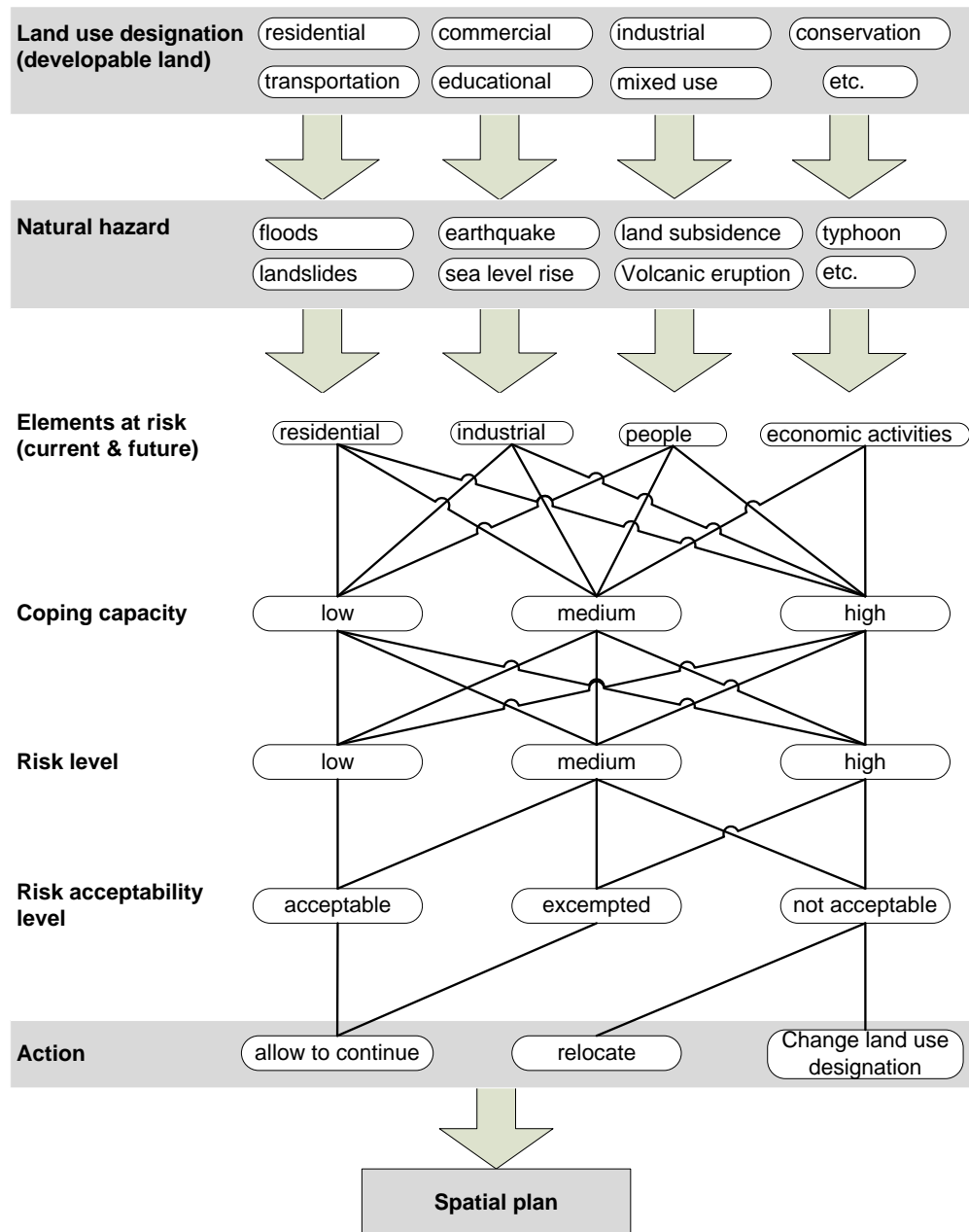


Figure 6-4 The land use change model.

B. Dataset

The spatial data used for PSS development were obtained from the RDPA of Semarang. The topographic maps were based on aerial photo mapping conducted in December 1999. Originally, they were used for developing a master plan for drainage improvement, but were subsequently used to revise the Spatial Plan 2000–2010. There has not been a large-scale mapping project conducted in the past 10 years in the city. The data were not up to date but were sufficient for this case study.

The Digital Terrain Model (DTM) was created from the topographic map of scale 1:5,000. The contour interval is two metres, with dense spot heights in the coastal lowland. The spot heights were used in the interpolation, mostly for the coastal lowland located in the northern part of the city where the land elevation is less than three metres above sea level. A linear interpolation method was employed to create a DTM with a five-metre cell size.

Building footprint data received from the RDPA contained no information relating to building attributes. Visual interpretation was used to assign the most probable use of individual buildings. Three supporting data sources were used in the interpretation: Google Earth image, IKONOS image acquired in 2004 and the Detailed Spatial Plan (DSP) of the city developed as part of the revision process. In total, there are 277,651 individual buildings in the city that currently have the attributes listed in Table 3. The RDPA does not have parcel maps at their spatial data repository; therefore, the parcel maps from BPN were the main source of reference data to create GIS-ready parcel coverage. Eventually, 336,063 parcels were digitised (see Table 6.6).

Developable parcels are land that still have the capacity to accommodate new development, and they have designated uses assigned by the RDPA. To determine whether a parcel has the capacity for new buildings, the map of existing buildings was overlaid. Parcels that are currently fully occupied by buildings are not developable. The total number of developable parcels was 14,804, and these parcels were then classified into seven land use classes: commercial, industrial, mixed use, office, and high-, medium- and low-density residential. Neighbouring vacant lands with similar classification were merged.

Table 6.6 Buildings and parcels in Semarang in 2000.

Use/land use	Building	Parcel	Parcel (Ha)
Residential	240,972	289,251	15,312.26
Commercial	10,983	8,722	768.49
Mixed use	10,374	12,160	852.91
Industry	5,873	3,539	2,200.79
School/university	3,114	924	526.01
Office (including government)	3,340	2,081	605.40
Sport / recreation	516	261	579.05
Transportation	674	195	461.21
Conservation	-	1,957	3,970.10
Agriculture	681	15,633	9,380.12

Other datasets employed include conservation zones, river systems, existing land use, slopes, road centrelines and individual hazard maps. A conservation zone map includes forests, mangrove forests, rivers and parklands. The flood map shows the locations affected by riverine flooding, along with their depths and durations. The risks from landslides are localised in scattered positions in the southern part. A land subsidence map obtained from GeoRisk was used to project future elevation.

6.7.2. Projecting future elevation

Due to land subsidence, the land elevation will be significantly lower in the future than it was in 2000. The existing DTM was lowered using land subsidence and sea level rise predictions to obtain the projected DTM of 2020 and 2030. The end time of the projection was chosen to be similar with the end time of the new spatial plan of the city (which was originally intended to be 2030) to provide a comparison to the no-land subsidence scenario used by the planners. The BGR (1998) found that 90 per cent of the consolidation of three testing locations would have occurred by 2030, one in 2010 and the remaining three in 2040–2050. The subsidence in Semarang is estimated to be settled by 2070.

Ideally, the projection of disaster extent and spatial planning should be modelled until 2070. Although the existing spatial plan does not sufficiently cover the duration of the land subsidence, the model developed still provides insight into the usefulness of the approach. It can be inferred that the longer the time frame, the more severe the impact to Semarang. From this, planners and decision makers can learn the severity of impacts if they ignore the problems. The subsidence map was developed by the GeoRisk Project using the PS-SAR method (Kuehn, Albiol et al. 2010) on 54 radar datasets from ERS-SAR and Envisat that were taken from 2002 to 2006.

Sea level rise has a smaller share in making the land lower relative to the previous elevation. The rate of the global sea level rise for this century is predicted at 3.8 mm/year (Bindoff, J. Willebrand et al. 2007), while the local sea level rise in Semarang is 2.65 mm/year (Wirasatriya 2005). In the local context, the effect of this rise is similar to an additional subsidence of the same amount. The only difference is that it does not have a ‘contour of subsidence’; therefore, the same value of rise will

affect the entire DTM. To provide a safety margin, the rate of sea level rise used in the calculation follows the global prediction. The calculation was performed to obtain the DTMs of the years 2010, 2020 and 2030 using the following equation:

$$DTM_{t1} = DTM_{t0} - ((t1 - t0) \times (LS + SLR))$$

where t_0 is the year of the initial condition (2000), t_1 is the year to be estimated, LS is the land subsidence rate and SLR is the rate of the sea level rise.

6.7.3. Acceptable risk level

The most prominent impact of relative sea level rises due to land subsidence are flooding and inundation. To calculate the acceptable level of a possible inundation depth for different land uses, the DTM was reclassified based on the elements at risk, their risk levels and their coping capacities. Three response categories, based on elevation risk levels for new land use designations, were identified thus:

- Residential areas and health centres should be located on land higher than 1 metre.
- Commercial, school, sport or recreation should be located on land higher than 0.5 metres.
- Government offices, industrial and transportation facilities can be located on land higher than 0 metres.

These three categories have different types of uses or continuation of uses based on their preparedness and financial capacity to minimise the effects of tidal inundation. The 50 cm threshold was chosen based on the tide data at the Semarang port. The normal high water level is 45 cm above the zero elevation (Jaya 2007), although it can occasionally be higher. Considering this tidal range, any location with an elevation below 50 cm will certainly be subject to seawater inundation during high tide in the absence of engineering works such as sea walls. Any location above this elevation will be safe now but may be subject to inundation in the future.

Residential areas will be occupied continuously during the day and night. A location is not liveable if it experiences frequent floods, tidal inundation or standing water. This can affect the health and wellbeing of the inhabitants. The financial capacity of the residents will be seriously tested if they need to raise their houses to confront the

long-term impact of subsidence. A survey by JICA in 1997 indicated that around 11 per cent of household expenditure was used to fight the impacts of tidal inundation (Mechler 2005). The figure is now likely to be higher and still increasing. Therefore, residential zones need to be located in low-risk areas.

Users of developments in the second category (commercial, school and recreation) will not be continuously present. Although the areas and buildings might be affected by inundation, there is a time during the day when they are not in use. Compared to residents, the institutions have, or will receive, better financial resources to develop protection measures. Therefore, these designations can be located in a moderate-risk area. In line with coping capacity indicators, new schools should only be built to accommodate the children of existing inhabitants. The third category (offices, industry and transport facilities) is for buildings or infrastructures that can withstand greater risk. Some simply need to be located in that particular area (e.g. ports, customs, road networks and train stations), or they may have better financial resources to raise buildings and infrastructures above the inundation level. Transportation facilities are part of the critical infrastructure that should ideally be kept undamaged in a disaster event. However, as the nature of the disaster is not life threatening and the government will always be willing to repair them, they can still be located in a high-risk area. They are also required to serve existing residents and link points of development in the city.

6.7.4. Calculating future impacts of disasters

The potential impacts of the progression of natural hazards were calculated using ArcGIS software. In the two scenarios, the growth of buildings in all classes was modelled using CommunityViz for the years 2011–2030. In the first scenario, the original land use designations from the RDPA were used as the development constraint. In the second scenario, the land use designations that were not met the acceptable risk level were replaced by the more resilient land use. Figure 6-4 The land use change model. shows the example of the modelling results in the development zone 5. This area is experiencing moderate land subsidence of approximately 3-4 cm/year.

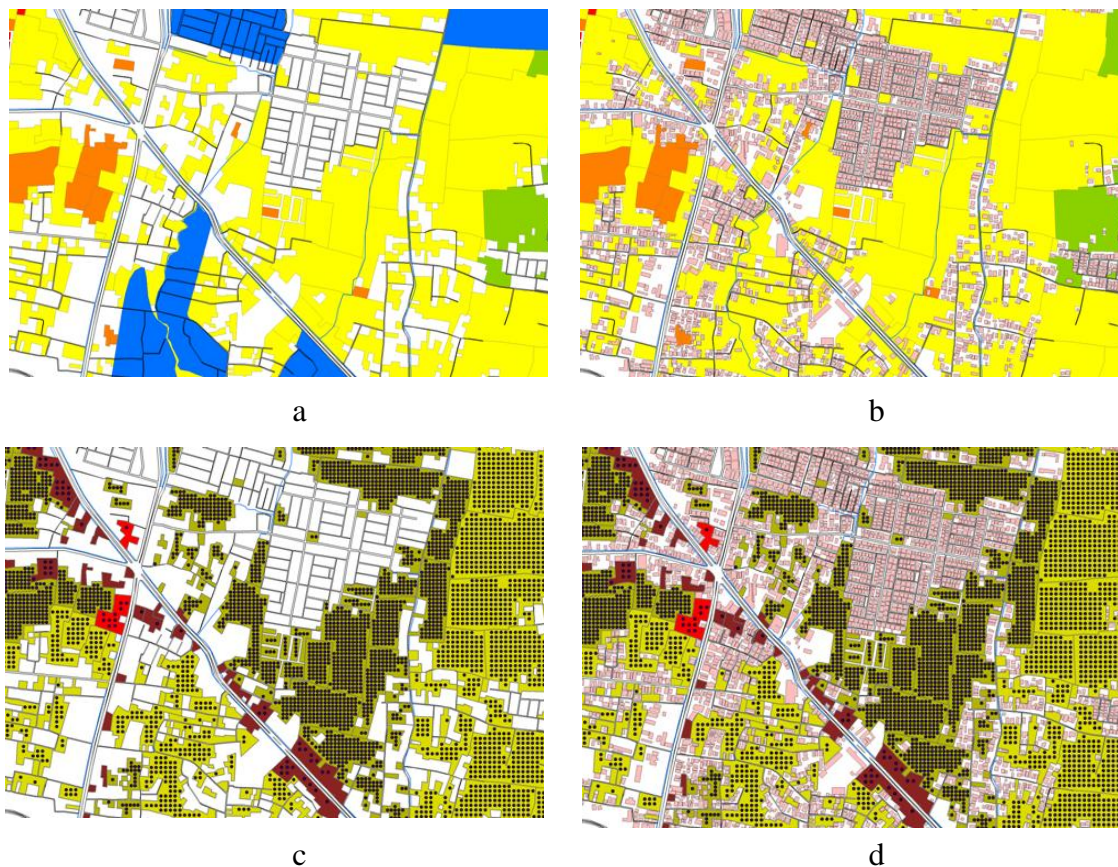


Figure 6-5 Results of a simulation of future development

Notes: (a) Initial situation with developable parcels in different designations, (b) existing buildings overlaid on the developable parcel, (c) projected buildings in 2030 for different land use settings, (d) projected situation in 2030 with existing and new buildings.

The results were then evaluated against the future land elevation based on the land subsidence rate and sea level rise. Using a spatial join operation, the number of buildings from different classes were categorised according to their elevation categories. Visualization using Google Earth was developed to facilitate better understanding of the existing and projected situation (see Figure 6-6 Visualization of the results in Google Earths).

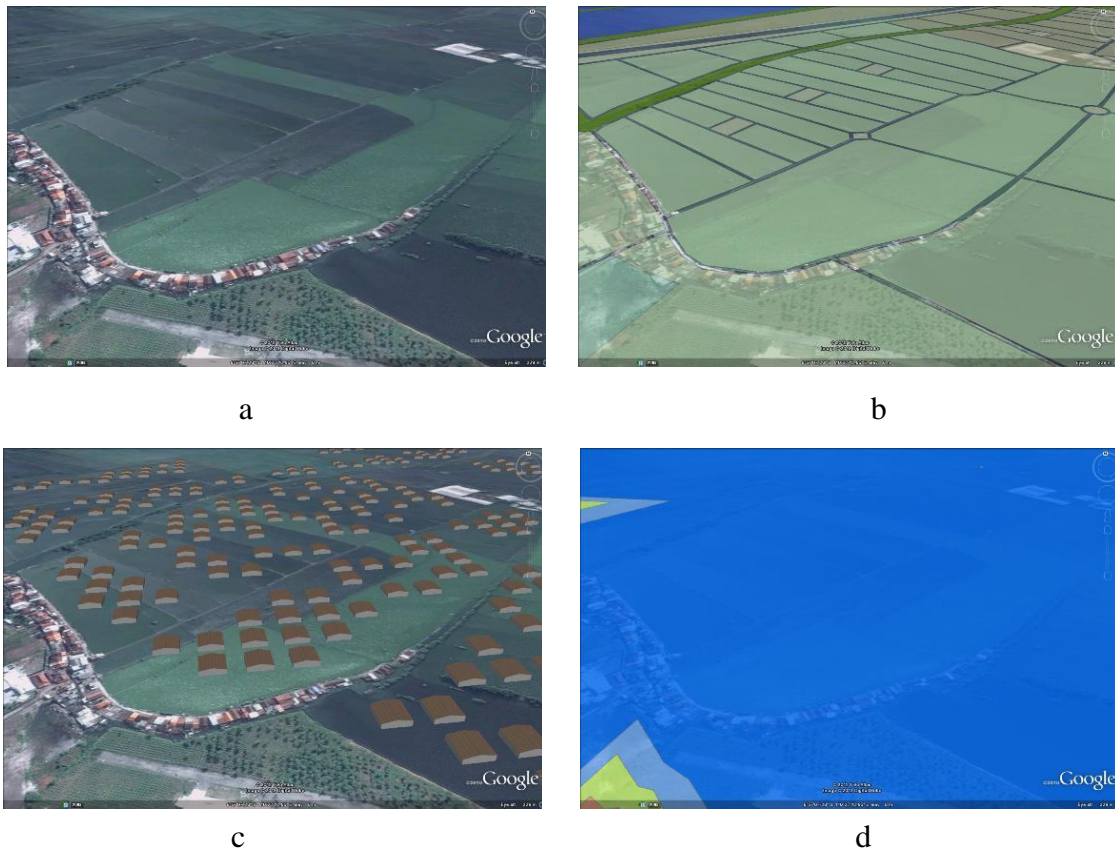
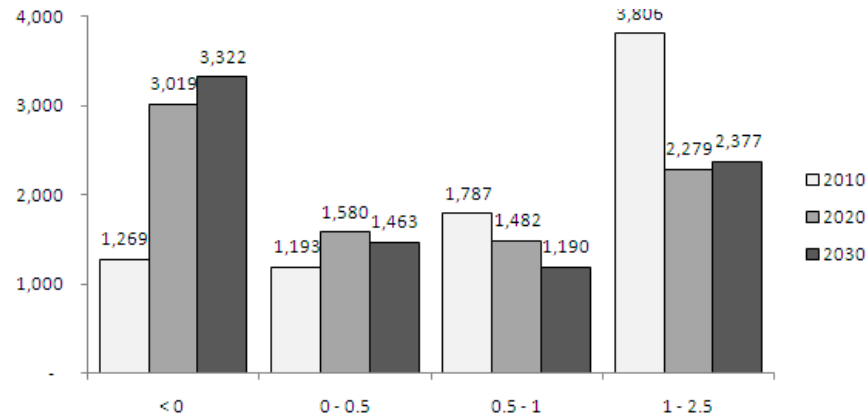


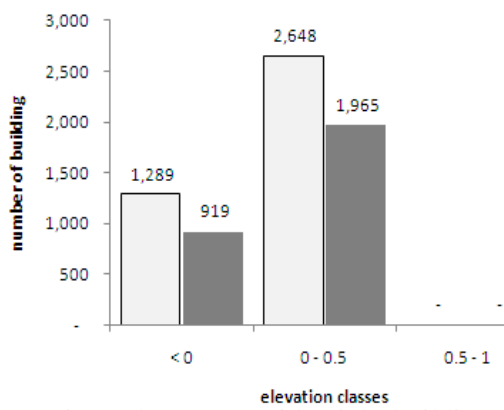
Figure 6-6 Visualization of the results in Google Earths

Notes: (a) Initial situation as captured in Google Earth, (b) land use designations, mostly for industrial, ware houses and conservation- on the far right, (c) projected industrial buildings in 2030, (d) projected elevation in 2030, showing that without intervention the area will be submerged.

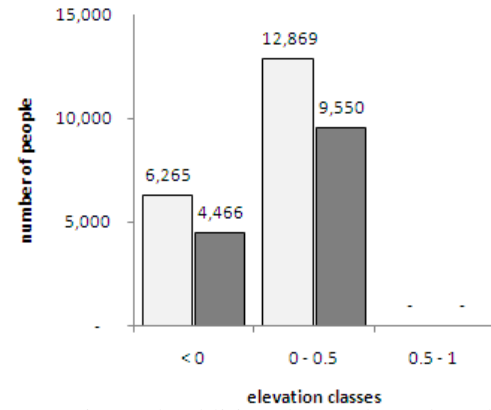
The results from the spatial join operation were then used to calculate the potential economic investment at stake and the number of people potentially affected. The first products were estimated or projected elevation for the years 2010, 2020 and 2030. Figure 6-7.a shows that, in 2010, there were more than 1,250 hectares of land already situated in areas with an elevation below the mean sea level. Almost 1,200 hectares had an elevation from 0 to 0.5 metres, which are already affected by tidal inundation. More than 150,000 people were then living in 42,000 houses located below 0.5 metres. In the projection, areas of 3,000 and 3,300 hectares will be below 0 metres in 2020 and 2030 respectively, significantly increasing the degree of vulnerability among buildings, infrastructures and people.



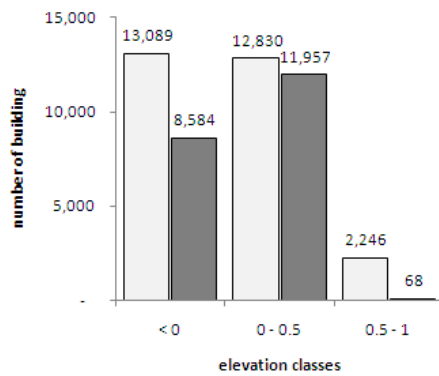
a. Projected areas situated in different elevation classes for 2010, 2020 and 2030



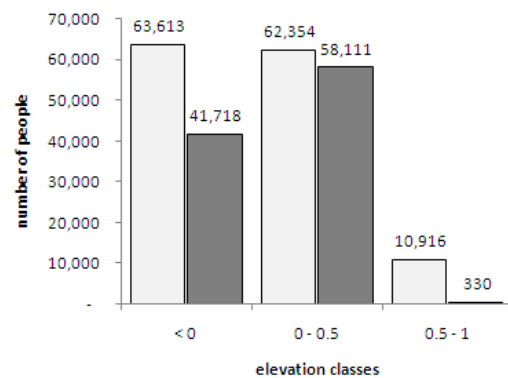
b. Estimated new residential building situated in flood prone area in 2020



c. Estimated additional people vulnerable to flood in 2020



d. Estimated new residential building situated in flood prone area in 2030



e. Estimated additional people vulnerable to flood in 2030

□ business-as-usual
■ disaster resilient

Figure 6-7 The comparison between the estimated impacts of the business-as-usual and the disaster-resilient scenarios.

In the BAU case, in 2020, 4,000 new residential buildings with 19,000 inhabitants will be at risk (see Figure 6-7.b and Figure 6-7.d). After modification of the land use designation, the number of new residential buildings can be reduced to less than 3,000, with a population of approximately 14,000. In 2030, the number of buildings and people affected will be significantly reduced in the disaster-resilient model. In the BAU case, the numbers of residential buildings that may be located in highly vulnerable areas is 28,000, with around 136,000 inhabitants. By employing risk-based land use modifications, the number of vulnerable residential buildings is reduced to 21,000, with 100,000 residents (see Figure 6-7.c and Figure 6-7.e). The number of people potentially affected can be reduced by 5,000 in 2020 and 36,000 in 2030. Note that this is in addition to the existing residential buildings and people in the at-risk area. They are not helped by either scenario and require more dramatic government interventions. There are limitations in making these changes relating to location, shape and inter-relation with neighbouring land. Moreover, the required vacant land was not always available.

The differences between the two scenarios regarding the estimated construction costs for residential and industrial buildings at risk were then calculated (see Table 6.7 and Table 6.8). The estimated construction cost of residential buildings vulnerable to inundation will be reduced by US\$31 million in 2020 and US\$68 million in 2030. For industrial buildings, although the disaster-resilient method will result in a lower cost of US\$13 million in 2020, there is a higher cost of US\$1.2 million in 2030 due to the conversion of residential use to industrial use. This outcome is unavoidable because, under this scenario, there are several land use changes from residential to industrial. The industrial sector, which has better financial resources, can afford better measures to overcome flood hazards, thus reducing their risk.

Table 6.7 Estimated numbers of industrial buildings in different elevation classes.

Elevation class	2020		2030	
	BAU	DRSP	BAU	DRSP
<0	216	240	2,001	2,009
0–0.5	177	111	1,149	1,146
0.5–1	35	18	435	437

Table 6.8 Estimated economic value of residential and industrial buildings (construction cost only) vulnerable to flooding, in US\$m.

Year	Residential		Industrial	
	BAU	DRSP	BAU	DRSP
2020	87.60	56.12	95.04	82.32
2030	349.66	281.29	756.00	757.2

By incorporating disaster considerations, the impact of the possible inundation of residential areas can be lessened. However, this approach still creates potential losses in the future, mainly due to the conversion of land use, which allows the more resilient land use designations to override the less resilient designations. To completely remove the risk, either the land must be raised or all development must be relocated. Raising land elevation can only be conducted for empty land, with the height of reclamation depending on the land subsidence rate in the area and the current elevation. Habitable ground elevations and minimum floor levels should be defined to protect the occupants from the threat of floods. This requirement will result in a higher initial development cost for preparing better infrastructure, but the total cost in the long run will be cheaper, as the degree of inundation could be reduced significantly. However, raising the ground level of a single parcel located in an already-occupied area will deepen the water inundation of the neighbouring parcels. This is similar to the impact of raising the existing road levels, which would result in water inundating adjacent areas.

The additional cost of raising land elevation to offset 20 years of subsidence, with different subsidence rates in different areas, would involve approximately 14.6 million m³ of earth material, which would cost approximately US\$37 million at the current value. In addition to the high cost, sourcing such a large amount of material would not be easy and would endanger the environmental conditions elsewhere.

In terms of long-term safety, the ideal solution would be to relocate all planned development into higher locations that would not subside to below 0.5 metres in the future. However, the availability of vacant land that is safe from land subsidence is limited, and the costs would be immense. The costs of full relocation are impossible for Semarang and very likely apply to other cities affected by similar disasters. The situation and level of threats in Semarang is quite different from Christchurch, New

Zealand, where the relocation of more than 5,000 houses is being considered (Anonym 2011) in response to earthquake vulnerability.

6.7.5. Implication

In this study, a new model for incorporating a disaster risk reduction strategy has been developed based on the acceptable risk concept. Every land use designation has different levels of risk, vulnerability and coping capacity. The estimated impacts of future natural disasters have been predicted, with the focus on the likely impact of accelerated land subsidence. The estimated future elevation was obtained from the subtraction of the DTM produced in 2000 by the land subsidence map. The result was in agreement with other predictions available for the area.

In the BAU case, the number of additional buildings and people to be affected is high. When the future land elevation is taken into consideration in the disaster-resilient scenario, the numbers declined significantly. In the second scenario, several changes were applied to the land designation to conform to the acceptable elevations.

The change of the land use and relocation strategy is classified, among the generic strategies identified by (Klein, Nicholls et al. 2003), as ‘choosing change’. Natural hazards are accepted as reality, and living with hazards is inevitable. Success in land use change and relocation depends on inter-related factors in the surrounding areas. Much of the vacant residential land is located within existing residential areas. It is not always possible to find an alternative land use as a replacement; the size, shape, location and characteristics of adjacent land parcels need to be considered. The limited availability of vacant and suitable land is made more complicated by the implementation of regional autonomy, in which each district or city is responsible for managing its own jurisdiction only. A higher level of government needs to be engaged to facilitate transfers of activities between jurisdictions.

In response to limited land availability, and as an alternative to the relocation of residents further from the activity centre, the development of apartment buildings of three or four stories could be expanded. Density modification will be beneficial in reducing the need for vacant land. The area will be able to accommodate more residents, especially those who cannot afford the higher cost of transportation. The move to

taller buildings will have a further benefit of reducing vehicle travel, traffic and carbon emissions. However, the counter effect is that denser and higher buildings mean higher loads, which may accelerate subsidence. A careful engineering review would be necessary before this solution is adopted.

Some land use designations cannot be easily changed or moved due to the current usage. The most difficult part is the existing residential areas located in low elevations. However, many residents have already taken voluntary action to escape the impacts of land subsidence, as indicated by the population decline in four sub-districts that have been severely affected. The rate of voluntary departure will likely be higher in the future. Observations in the field have found that several areas that were previously inhabited by medium- to high-income earners have been abandoned. Less affluent people with limited financial capacity were forced to remain in these highly vulnerable areas.

Prohibiting usage in environmentally sensitive areas and reducing land use conversion that affects the recharge of the Semarang groundwater basin (Kurnia, Sudirman et al. 2001; Watung, Tala'ohu et al. 2005) is part of the spatial planning function. Spatial planning can be useful as a non-structural measure to overcome the impacts of land subsidence. It can produce outcomes with less environmental impact and economic costs. Conversely, the benefits are not easily visible in a short time, and it will create pressure on other locations—if land is even available—that are safe from natural hazards. In this situation, cooperation with neighbouring districts should be sought to develop a regionally harmonised spatial plan.

From the results, it is clear that neglecting the dynamics of disaster will result in a higher economic and social cost in the future. In coastal cities experiencing land subsidence due to their geological settings, the development and utilisation of vacant land should consider the acceptable risk of inundation due to lowering elevation. Section 6.8 discusses how the public can participate in detailed spatial planning with disaster risk reduction in mind.

6.8. Summary

This chapter discusses the implementation of the concept developed in this research in the case study area. A description of the study area has been provided based on official opinions and this investigation. Types of natural hazards affecting the city, based on this research and official publications, have been analysed and compared. There are differences in viewing the main cause of the disaster. The city of Semarang does not recognise that land subsidence is the root of many disasters; therefore, the remedy for the impacts appears to neglect this causal factor. Estimations of the future progression of hazards have not been conducted. This research aims to bridge the gaps by incorporating all relevant hazards into the spatial planning.

Land subsidence is thoroughly investigated and modelled to estimate its future impacts on population and infrastructures. The results indicate that an early response to the potential disaster will add additional costs to the development; however, in the long run, there will be a greater financial benefit for the people, government and private entities.

SDI has not been implemented in Semarang, and the SDI terminology is unknown to many of the planners and officials in the RDPA. Data sharing and exchange has been conducted physically by using a compact disc (CD), hard disk or flash disk. SDI development has been not planned for the near future.

Public participation has been practiced for a long time, and it is currently ordered in the laws and other government regulations. It has not been facilitated by a PSS with time interaction between stakeholders and the PSS. Scenario development and assessment have been conducted at the office, without involving the public to inspect and evaluate. The introduction of a PSS is considered beneficial; however, several obstacles need to be solved. Facilitation by a PSS has increased the understanding of the planners of the real-world situation through better visualisation, consequences of different scenarios by analysing estimated impacts and creating a better decision-making environment by allowing participants to interact directly with the models.

Incorporating disaster risk reduction into the spatial planning in the local government requires a solid and operational SDI that is facilitated by a PSS and conducted with

the inclusion of public participation. This research contributes an understanding of these aspects in the context of local governments in developing countries.

In mainstreaming the incorporation of disaster risk reduction into spatial planning, particularly at the local government level, several important elements must be present. They include legislations and directives from the central government; data availability, technology and resources; a spatial-enabling platform for facilitating deliberation; collaboration with neighbouring jurisdictions; and a long-term vision for ensuring sustainability. These elements will support the development of a disaster-resilient spatial plan, mainly by reducing collisions between future developments and natural disasters, and thus reducing disaster risk.

Chapter 7. DISCUSSION

7.1. Introduction

This chapter presents the major findings and discusses the contribution of the study. It summarises the findings of each chapter, followed by the findings of each step of the research. This is followed by a discussion of the responses to the research aims, objectives and questions. The final section discusses the contextualisation of the research findings for wider situations.

7.2. Summary of the Findings

Chapter 2 investigated the concept of an integrated approach to disaster risk reduction, as well as its issues, challenges and methodological options for development. It began with a discussion about natural disasters and their characteristics and was followed by arguments for the importance of elements-at-risk mapping. Several methods for developing an integrated risk map were discussed. The integrated approach proposed in this research consists of a PSS, SDI and public participation. Chapter 2 argued that elements at risk should be assessed for the present time and for the future, as a projection of the possible progression of natural hazards is crucial for developing a disaster risk reduction strategy. The investigation revealed that, in many cities, development in disaster-free areas is hindered by a limitation in land availability. Further, high population growth and urbanisation complicate the situation. Therefore, acceptable risk measures were suggested to use all available land while eliminating or minimising threats from natural disasters.

Chapter 3 discussed the development of a PSS to facilitate spatial planning, with a particular focus on disaster risk reduction. The chapter began with a review of spatial planning and the function of a PSS in spatial planning. It was found that PSSs are mainly used in developed countries such as in European countries, the US and Australia. The proliferation of PSSs in developing countries is low. This chapter also discussed the potential use of spatial planning and PSSs in disaster risk reduction. The fundamental element is that spatial planning is able to manage long-term

relations between people and infrastructure, and natural hazards. Spatial planning at the local government level is strategic for disaster risk reduction, as it has the power to direct land utilisation, with a legally binding status, at the operational level with high detail. In developing a PSS, users' requirements and their challenges needed to be assessed and addressed. The investigation found that the main challenges faced by local governments are related to human resources, funding, spatial data availability and IT infrastructure. Many local governments have insufficient resources to deal with these challenges, and they require assistance from the central government. The chapter also discussed the situation in relation to the Indonesian context to provide a bridge to the case study.

Chapter 4 investigated the concept of public participation and its importance in spatial planning and disaster risk reduction. Public participation in spatial planning began more than 50 years ago in order to provide the public with an opportunity to voice its concerns and allow it to influence the decision-making process for the greater benefit of society. This research argued that public participation is also important in disaster risk reduction. Not only is it beneficial by increasing public knowledge and understanding of the potential occurrence of disasters in their areas, but it also increases the credibility and acceptance of government programs to reduce disaster risks, even if it affects their neighbourhood.

The role of PSSs in public participation is to facilitate deliberation in face-to-face meetings. Current capabilities of PSSs do not support web-based collaboration, as PSSs require considerable computing power, which cannot be accommodated on the Internet. The definition of who constitutes the public, and who can represent it, is particularly important.

Chapter 5 investigated the concepts of SDI, followed by the roles of SDI in spatial planning and disaster risk reduction. Currently, spatial planning and disaster risk reduction are two separate activities conducted by two or more different agencies. To link them, it is necessary to have greater cooperation regarding policy, organisation, data and platform components.

Chapter 6 tested the method developed in this research. The case study area is the coastal city of Semarang, in the Central Java Province in Indonesia. The city is

facing severe, and occasionally neglected, threats from the slow onset disaster of land subsidence. This research investigated the elements of an integrated approach in the study area, as well as assessing the process and output of the spatial planning. The chapter discussed the model's development and modelled comparisons between BAU scenarios and disaster-incorporation scenarios. It was found that, by using the latter scenarios, the vulnerability of the economic investment would be reduced significantly, along with the number of people at risk.

7.3. Discussion

7.3.1. Integrated approach to disaster risk reduction

As discussed in Chapter 2, many recent statistics have revealed that the casualties—that is, the number of people affected and economic losses due to natural disasters—have been increasing significantly in the past two decades. It is true that many of these impacts result from rapid onset disasters such as flooding, earthquakes, tsunamis, hurricanes and volcanic eruptions. Many statistics ignore the impact of slow onset disasters such as sea level rise and land subsidence. Although these two natural hazards are not life threatening, their economic effects are staggering, although they are not easily visible. In this respect, the integrated approach addressed slow onset disasters.

Central to the integrated approach is the integration of all disciplines and stakeholders in disaster risk reduction through long-term measures. An integrated approach can be implemented by developing a new responsible agency or by refocusing an existing organisation. This research argued that the latter is better, as it will not create another layer of bureaucracy. Further, it is asserted that a spatial plan is the means to develop an integrated approach, as it manages long-term interactions between people and infrastructure on one side, and natural hazards on the other. Possible collisions between future developments and the progression of natural hazards can be avoided by taking advance action, thus reducing potential economic losses. Projections regarding where and when future developments will occur are essential, as well as simulation of the progression of natural hazards.

The problems faced by many cities include limited available space, high population growth and urbanisation. These create additional pressures, which in turn lead to the unavoidable situation of living with disaster risk. Nevertheless, the situation where the disaster risk is unacceptable should be prevented. Defining the acceptable risk level is a delicate matter, as people's different knowledge, experiences and capacity will influence their perceptions. Several indicators can be used to determine the acceptability level; however, the final decision should come from an agreement between the government (which has knowledge and information) and the people (who will be affected by the decision).

7.3.2. Planning support system in spatial planning and disaster risk reduction

Spatial planning is an activity that relies heavily on spatial data and information, as does disaster risk reduction, since all disasters occur in a particular location. Facilitation from GISs in these activities began some time ago. In the spatial planning arena, PSSs have been used in the past two decades in many countries, although the proliferation in developing countries has been small.

The implementation of a PSS requires the mature use of a GIS in the particular agency or local government. While this may be true for many similar-sized cities in developed countries, it is an issue for developing countries. Therefore, PSSs to be introduced into developing countries should be easy to operate without existing mature skill levels.

The importance of having GIS maturity prior to the implementation of a PSS is also related to the spatial data requirements. PSSs use spatial data extensively, and can be considered an extension of the GIS application specifically for spatial planning.

Extending a PSS application for disaster risk reduction through spatial planning can be considered a straightforward process. It requires information on the potential progression of future natural hazards to be included in the modelling. It is different from placing restrictions on areas that may be affected by 50- or 100-year recurrence periods of flooding. The slow onset disasters investigated in this research do not have recurrence periods; rather, they are continuously progressing. Their impacts will increasingly cover wider areas and affect more people over time.

The challenge faced by local governments is to obtain timely information on natural hazards with sufficient accuracy and detail. Relevant data are available but are not easily visible. Planning agencies can obtain estimates of the progression of hazards from other government agencies; however, having staff members with relevant qualifications is more beneficial. Staff members with an earth science background that have practical training in spatial planning are preferred in the Semarang situation.

7.3.3. Public participation

Public participation is not a new practice, as it has been implemented in both spatial planning and disaster risk reduction for quite some time. However, in Indonesia, its implementation in the spatial planning is generally more mature than its specific application to disaster risk reduction, which only became a mainstream activity in the late 2000s. The degree of public involvement is varied, as well as the methods and tools for implementation.

PSSs play an important role in public participation as a platform for planners and the public to sit together and inspect, evaluate and deliberate the planned future. An impediment to using PSSs for public participation is the system's availability in many local governments' planning agencies, particularly in developing countries.

7.3.4. Spatial data infrastructure platform

SDI has been in place for more than 20 years in many countries, although the state of implementation and the degree of maturity vary. Again, the wide use of GISs and the utilisation of spatial data will determine the internal pressure to develop SDI. If the data are limited, the users are small in number, and the formats are already homogenous, then the need to have SDI might not be high.

The SDI required for spatial planning and disaster risk reduction is similar, and can even be accommodated by one system. As the focus is on the local government level, the SDI would be designed mainly to serve local government agencies.

As the main stakeholders come from local government agencies, the standards, policies and organisational arrangements will be relatively easy to develop. On the other hand, disaster risk reduction usually involves higher-level government agencies

that may implement different spatial data specifications and access policies. In disaster risk reduction matters, spatial data sharing is usually easier than in spatial planning, as it deals with public safety. The potential problem relates to the scale and detail of the data, as many hazard mappings have been conducted at a small to medium scale.

Local governments exhibit limitations in developing SDI due to funding, resources and technical expertise. It is essential to have guidance and supervision from the central government, particularly from the national mapping organisation. Without this support, there will be a long wait for local initiatives and the build-up of the necessary capacity.

7.3.5. Case study

The situation and problem of the case study area was familiar, as contact with city planners and other stakeholders was initiated in 2001. Throughout the research, five field visits were conducted to obtain the data, discuss the development with planners and present the findings to obtain feedback. In 2009, questionnaires were distributed to other local governments in Indonesia to obtain insights into the issues and challenges commonly faced. Data collection was conducted during the field visits in 2009 and 2010. The City's Planning agency was supportive and provided all its available data, including all the relevant documentation. However, these were not sufficient to implement the hazard reduction PSS in this research.

The case study provided an opportunity to gain an understanding of the situation and drivers related to incorporating disaster risk reduction into the spatial planning. During the spatial plan development and the conduct of this research, a number of important central government regulations were issued. The local government responded accordingly, although there was some confusion at the beginning. A comparison was made between the draft of the spatial plans developed before and after the issuance of these regulations, which revealed a significant improvement. Further, the improvement also related to the supervision from higher-level government and the availability of new data.

In terms of PSSs, the case study revealed that the technology is new to many planning agencies in Indonesia and in the case study area. Therefore, the spatial plan

development was not facilitated by a PSS. A GIS was widely used, but mainly for creating maps for visualisation, and limited spatial analysis was conducted. The use of the GIS was also hindered by a lack of spatial data, as the SDI was not yet in place. Although spatial data sharing could be conducted without the SDI, the discovery of the relevant spatial data was impeded by its absence. The power-play relation between the central government's agencies and their local partners proved to be an important factor in sharing spatial data. Without strong regulation from the central government, spatial data sharing among different levels of government may not run smoothly.

The lack of spatial data affected the development of the PSS. It was difficult to conduct detailed and accurate modelling of the city's growth and probable collisions with natural hazards. The parcel-level assessment of the potential impacts of disasters required land parcel maps produced by the BPN or the PBB. Such detailed analysis is important for the planners and communities to discuss the best way to avoid the negative consequences. In this instance, public participation activities were not only directed to fulfil the formal requirement, but also to substantially address the problems resulted from the progression of natural hazards.

7.4. Response to Research Aims, Objectives and Questions

7.4.1. Response to research aim

As stated in Chapter 1, the research aim of this thesis is to 'Design and develop an integrated approach for disaster risk reduction using acceptable risk measures and spatial PSSs for use in developing countries'. The thesis has identified relevant issues and challenges, and it has developed a framework and model for an integrated approach for disaster risk reduction.

7.4.2. Response to research objectives

This research has achieved the research objectives set in Chapter 1. The research objectives were:

- i. To identify issues and challenges of current practices in disaster risk reduction.

The thesis has identified issues and challenges in disaster risk reduction and, in response, it has developed a model to overcome the deficiencies. The literature review provided a basis for understanding the current situation in disaster risk reduction activities in developed and developing countries. The case study added further insight into the strengths and deficiencies in the practices of disaster risk reduction.

- ii. To design and develop a model for an integrated approach to disaster risk reduction.

The thesis has developed a model for an integrated approach to disaster risk reduction based on the optimal use of spatial planning. The model incorporated a multidisciplinary approach, combining perspectives from multiple parties and considering the present and future situations.

- iii. To design and develop a method for incorporating a PSS for an integrated approach to disaster risk reduction.

In order to implement an integrated approach to disaster risk reduction using a PSS, a new method and tool were developed. The method was developed by extending the current practice of developing an integrated risk map. The integrated risk map was augmented with a projection of the future progression of natural hazards. This projection was then combined with the simulated development because of the PSS operation.

- iv. To investigate the role of spatial enablement and SDI in the integrated approach to disaster risk reduction using spatial planning.

Chapter 5 discussed the roles, development and conceptual model of SDI for an integrated approach to disaster risk reduction. Many models and tools have been developed to support an integrated approach to disaster risk reduction using spatial planning; however, there is room for improvement. The roles of spatial enablement in the different stages of spatial planning were highlighted, and a conceptual model of an SDI for spatial planning and disaster risk reduction was presented.

- v. To test the applicability of the integrated approach in a case study approach using a prototype PSS.

The method was tested in the case study area of the city of Semarang in Central Java, Indonesia. The integrated approach was able to reduce potential economic losses as well as the number of people to be affected by future natural disasters. This method was appreciated by the city planners.

7.4.3. Response to research questions

In relation to the objectives, five questions have been devised:

- i. How can disaster risk reduction be conducted considering the many parties, disciplines and policies that are involved?

This thesis argued that spatial planning is the tool for disaster risk reduction, as the process involves a large number of stakeholders and considers perspectives from many relevant disciplines. The main role of spatial planning in disaster risk reduction is to avoid possible collisions between future development and the potential progression of natural hazards. This role can be achieved, as the spatial planning function is to manage the long-term relationship between people and the environment.

- ii. How can a PSS be used for disaster risk reduction?

A PSS is indispensable in the process of spatial plan development, as it can facilitate better-informed decision making by assessing the current situation and simulated future development based on different scenarios. However, it should be noted that the proliferation of PSSs in developing countries is still limited.

- iii. What are the roles of SDI in spatial planning facilitated by PSSs?

SDI's roles in disaster risk reduction include facilitating spatial data discovery and exchange between agencies responsible for spatial planning. It is an essential component that is currently not well developed in many cities in developing countries.

- iv. What are the roles of SDI in disaster risk reduction in the framework of an integrated approach?

The ultimate objective of SDI development is to provide the relevant and timely spatial data required in spatial planning and disaster risk reduction. Although disaster risk reduction is not a time-critical activity, the receipt of relevant and timely data is indispensable.

- v. Can the concept of an integrated approach be implemented in the case study area and the result generalised?

The case study has shown that the concept can be implemented. However, full implementation was not attained, as Semarang has its own approach that was taking place during the course of this research. More importantly, it was beyond the scope of this thesis to change the course of the spatial planning in the case study area. Nevertheless, the model of an integrated approach that was developed in this thesis was appreciated by the planners and could be implemented in other locations with similar settings.

7.5. Contextualization of the Research Findings

The integrated approach method developed in this research was initially aimed at developing countries. However, with some adjustments the method could be implemented in other countries. Particular attention should be paid to the planning system, which differs from country to country, as federated and non-federated countries have different methods of developing spatial plans and conducting disaster risk reduction. Differences also occur among countries with similar governance models.

In mainstreaming the incorporation of disaster risk reduction into spatial planning, particularly at the local government level, several important elements must be present. They include legislations and directives from the central government; data availability, technology and resources; a spatial-enabling platform for facilitating deliberation; collaboration with neighbouring jurisdictions; and a long-term vision for ensuring sustainability. These elements will support the development of a disaster-resilient spatial plan, mainly by reducing collisions between future development and natural disasters, and thus reducing disaster risk.

Chapter 8. CONCLUSION AND FUTURE RESEARCH

8.1. Conclusion

This thesis discussed the development of an integrated approach for disaster risk reduction that makes use of spatial planning as a means to integrate multiple disciplines, actors and objectives of development. The central issue is how to functionalise spatial planning to regulate safe relations between people and infrastructures on one side, and natural hazards on the other.

The model was developed based on the acceptable risk concept. This concept considers that every land use designation has different levels of risk, vulnerability and coping capacity, which should be taken into account when developing a spatial plan. The determination of the acceptable risk level should be a result of public consultation; however, as the government has better knowledge and resources, it should lead the process. Considering the physical and psychological distance between people and the government, the process is best conducted at the local level. Local governments require guidance and direction from the relevant central government agencies, as they have limitations in resources, funding and capacity.

This study presented the method and requirements for predicting the potential impacts of future natural disasters. The research differentiated between slow and rapid onset disasters, and it focused on slow onset disasters. While slow onset disasters are not life threatening and rarely produce noticeable signs and immediate impacts, their long-term economic consequences are enormous. The findings revealed that neglecting the possibility of disaster progression would result in a high economic cost in the future. The economic cost will likely be unaffordable for less affluent people, who may be forced to live in the marginal land that is highly vulnerable to a number of disasters. To overcome the limitation in available space, cooperation with neighbouring jurisdictions is required to transfer activities from disaster-prone to disaster-free areas.

A PSS is essential for delivering the method, and particularly for obtaining the information on where and when the projected development will be realised. SDI is

required to facilitate data discovery and exchange among local and national government agencies working on the topic. However, the use of a PSS has been limited in local government agencies. In the event that a PSS is to be introduced, it needs to be cheap, have high compatibility with existing GIS software and a shallow learning curve.

Many recent statistics from national and international agencies revealed an increasing number of natural disasters, along with greater numbers of people affected and higher economic losses. Advanced preparations will benefit both the government and the people, leading to sustainable development. This research fills the gap in linking risk mapping and disaster risk reduction.

8.2. Future Research

During the course of the research, several issues emerged that require further investigation; however, their nature was beyond the scope of this project.

Parcel level disaster risk reduction: this thesis focused on the neighbourhood level, but it was found that, to obtain better results, a more detailed assessment is required. Parcel level spatial planning, which also functions for disaster risk reduction, will provide more accurate and precise outcomes.

Disaster impacts on land values and ownership: the liveability of many disaster-affected areas was found to decrease significantly, with many residents choosing to leave the areas. Thus, land and property values are likely to be affected. The disappearance of land is another problem. An assessment of how to address the problem of ownership of land taken away by disasters is challenging, as well as how to deal with decreases in land values.

Extending the method for rapid onset disasters: issues and challenges faced in reducing rapid onset disasters are different from those of slow onset disasters. While some components in the method are relevant, others issues have not been explored.

Extending the acceptable risk measures to include social perspectives: people who are living in disaster-prone areas might have different perceptions from government officials, who only visit the location occasionally. Locals might think

that they can adjust to the disaster risk and do not need to be relocated. The social science insight into people's risk perspectives is important.

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APPENDIX: LIST OF PUBLICATION

1. Sutanta, H., A. Rajabifard, I.D., 2012, Bishop, "Disaster Risk Reduction using Acceptable Risk Measures for Spatial Planning", Journal of Environmental Planning and Management, DOI: 10.1080/09640568.2012.702314
2. Sutanta, H., A. Rajabifard, I.D. Bishop, 2012, "How Local Government Response to Disaster Risk Reduction in the Spatial Planning: Lessons from Semarang City, Indonesia." Submitted to the Journal of Natural Hazards.
3. Sutanta, H., A. Rajabifard, et al. (2011). Envisioning the Future and Mitigating Impact of Natural Disaster Using Planning Support System. Pertemuan Ilmiah Tahunan PIT XVIII MAPIN: Geospasial dalam Pembangunan Wilayah dan Kota, Semarang, Diponegoro University.
4. Sutanta, H., A. Rajabifard, et al. (2010). Integrating Spatial Planning and Disaster Risk Reduction at the Local Level in the Context of Spatially Enabled Government. Spatially Enabling Society, Research, Emerging Trends and Critical Assessment. A. Rajabifard, J. Crompton, M. Kalantari and B. Kok. Leuven, Leuven University Press: 205-218.
5. Sutanta, H., Rajabifard, A., Bishop, I., (2010). Studying Spatial Plan in Coastal Urban Environment, facing global threat and adapting to local condition. (Peer-reviewed). FIG Congress 2010 - Facing the Challenges - Building the Capacity. Sydney, Australia, 11-16 April 2010
6. Sutanta, H., Rajabifard, A., Bishop, I., (2010). Impediments in e-Planning in Local Government - Indonesian Case Study. FIG Congress 2010 - Facing the Challenges - Building the Capacity. Sydney, Australia, 11-16 April 2010
7. Sutanta, H., Rajabifard, A., Aditya, T. (2010). Implementing Spatially Enabled Government (SEG) Concepts in Indonesian Local Government - Challenges and Opportunities. in MS Zein (ed.). Contribution Matters: Insights of Indonesian Students in Australia.
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9. Sutanta, H. (2008). "An Evaluation on the Use of Internet for Spatial Data Dissemination in Indonesian Local Government Websites." Jurnal Ilmiah Geomatika **14**(2): 38:49

Presentation

"Implementation of Acceptable Risk Measures in Planning Support System for Reducing Disaster Risk in a Coastal Urban City" The 1st World Delta Summit, Jakarta, 22-24 November 2011.