AN INTEGRATED APPROACH FOR DISASTER RISK REDUCTION USING SPATIAL PLANNING AND SDI PLATFORM

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ABSTRACT
Disaster has serious impact to our society in many aspects. In the last decade more than 500,000 people were the victim of various natural disasters all over the world. Economic damage in terms of absolute amount and percentage to GDP was also very high. The risk of some types of natural disasters, such as flood and landslide, can actually be reduced provided appropriate policies and infrastructures exist. Efforts in reducing disaster risk involve many disciplines and can be seen from many perspectives, such as data sharing and integration, modelling, and management perspective.

As a result of interdisciplinary environment, therefore, there is a need for an integrated approach in disaster risk reduction. From the spatial science perspective, it is believed that long term success of disaster risk reduction needs to be formulated in spatial planning by, for example, applying certain measures in land uses allocation.

SDI facilitates data sharing and data integration through the arrangement of policies, peoples, organizations, and technology, necessary for spatial planning formulation. An assessment of the current practices of spatial planning and disaster risk reduction effort of local government in Semarang city, Indonesia, has been made. This paper proposes a conceptual model for an integrated approach in disaster risk reduction using spatial planning and SDI platform. This paper is based on an ongoing research using case study approach in a coastal urban environment in Indonesia.

Keywords: integrated approach, disaster risk reduction, spatial planning, spatially enabling platform

INTRODUCTION

The Emergency Events Database – EM DAT (available from http://www.emdat.be) shows that during 2000 – 2008 there were 177,268 casualties from seven types of natural disaster which hit Indonesia with more than eight million peoples affected. The high number of casualties and enormous economic loss raised awareness in the government and community of the importance of a more institutionalized away of dealing with disaster in an effort to reduce their catastrophic impacts. Two laws were enacted in 2007, dealing with Disaster Mitigation (Law 24/2007) and Spatial Planning (Law 26/2007), and both endorse the inclusion of spatial planning as one of the important tools in disaster risk reduction.

Efforts in reducing disaster risk involve many disciplines and can be seen from many perspectives, such as data, actors, modelling, and management perspective. Therefore,
there is a need for an integrated approach in disaster risk reduction which brings together all available resources and data available. Spatial planning is a long term tool which can play a key role in disaster risk reduction (Menoni, 2004). It is formulated through multi agency cooperation, and therefore SDI platform is needed to facilitate data sharing and data integration between many agencies involved. Although GIS has been widely used in formulating spatial planning in Indonesia but dedicated systems for supporting spatial planning are very limited or even do not exists at all. Another deficiency is that current spatial planning regulation and associated map are often not easily visible and available to general public through local government websites. This paper investigate the development of an integrated approach for disaster risk reduction in a coastal urban city using spatial planning and facilitated by spatial data infrastructure as an enabling platform, focusing on local government level.

**DISASTER RISK REDUCTION**

Disaster is a result of exposure of element at risk to hazards and the lack of capability of a community to tackle the situation (UNISDR, 2009; Misonali and McEntire, 2008). Statistics from the EM-DAT database shows a recent increase in disaster casualties and economic loses. This condition can be attributed to the exposure of people to hazards due to rapid urbanization (Sanderson, 2000) and climate change (Resurreccion, et.al., 2008). The later was thought to be a factor in increasing frequencies and magnitude for climate-related disaster. Urbanization lead to a pressure on already limited space and some people were forced to live in disaster-prone area. To minimize casualties and ensure sustainable development, a number of policy and efforts can be implemented in reducing disaster risk.

UNISDR defines disaster risk reduction as “the concept and practice of reducing disaster risks through systematic efforts to analyse 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” (UNISDR, 2009). According to this definition, there is a requirement for a systematic action which usually involving many government institution, NGOs and communities, as shown in Figure 1. Organizational management and participation method between these parties need to be carried out systematically, and not ad-hoc, to sustain its effectiveness.

Figure 1. Multidisciplinary elements of disaster risk reduction.
One of the key elements in disaster risk reduction is conducted by effectively managing land uses, and it is one of the efforts listed in The Hyogo Framework for Action 2005–2015 (2005). It has also been advocated to integrate disaster risk reduction in land use planning (Burby, et.al, 1999; Sengzezer & Koc, 2005). The framework also requested that risk assessment be incorporated in urban and rural land use planning, especially in mountainous and coastal flood plain area. Spatial planning is a common method in land use allocation and is important in improving disaster risk reduction effort. The lack of attention on to the spatial planning on disaster mitigation has been addressed by Sanderson (2000). More recently, researches has indicated that the use of land use planning for risk prevention has been implemented in some places, such as in France and Italy (Menoni, 2004). The following table provides an overview of what types of measures, specifically related to land use and spatial planning, have been used implemented or researched in the last 40 years.

Table 1. Methods of disaster risk reduction

<table>
<thead>
<tr>
<th>Period</th>
<th>Method and disaster types</th>
<th>Researcher / Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 – 2000</td>
<td>Local planning to address natural hazards – multi hazards 1998</td>
<td>The American Planning Association’s (Burby, et.al, 1999)</td>
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SPATIAL DATA IN DISASTER RISK REDUCTION

As disaster is occurs in a certain geographic location, spatial information is vital in disaster risk reduction. The locations at risk are, at least in part, predictable. It is therefore argued that mapping, as a visualization of spatial data, is a prerequisite for successful efforts in disaster mitigation (NRC, 2007). The function of spatial data in disaster risk reduction is, among other, for the creation of thematic maps on population and infrastructures as well as underlying hazards in a certain areas. These thematic maps are necessary input in developing elements at risk map. Examples of element at risk are people, building, agriculture field, economic activities, industrial complexes, road and railway, and bridges. The objective is to identify which elements of the society are at risk if confronted with certain of types of natural and man-made hazards of certain time and magnitude. The process of mapping elements at risk usually involving large scale map of infrastructure and utilities combined with small-to-medium scale hazard maps. Current practices show that a multi-hazards approach is more frequently implemented.
This situation made elements at risk mapping becoming more complex, since different characteristics of multiple hazards need to be taken into account. Elements at risk maps are media to communicate disaster risk to planners, politicians, and community. For land use planners, this information serves as input for putting the right uses for a particular location or to implement specific restriction for certain uses or even prohibited any modification to the existing condition. Politicians need this information in developing planning policy in order to make a better-informed decision. Community consists of ordinary neighbours, interest groups, and business association. They need specific information whether their place for activities is safe in the future to prevent potential loss in the event of disaster. The needs of different stakeholders in utilizing space are best accommodated in and facilitated by spatial planning. Plans should be formulated after input from multi stakeholders, multi agency collaboration and discourses. However, required maps for spatial planning formulation are not always available in time and needed format due to availability issues or data sharing problem. Thematic maps are coming from different agencies and sometimes having different technical specification. Arrangement in spatial data sharing is central for inter-agency cooperation and in engaging collaboration with community.

**SPATIAL PLANNING IN DISASTER RISK REDUCTION**

**Spatial planning support systems**

Spatial planning involving the process of allocation, forming, sizing, and harmonizing space (land) for multifunction uses (Albrecht, 2006). It is a task usually conducted by a planning agency with input from many disciplines such as an economist, transport analyst, and geo-information specialist. Planning Support System (PSS) is defined here, following Geertman & Stilwell (2004), as a dedicated framework to support planning task which consists of elements for information gathering, data modelling, and visualization. Hence, Spatial Planning Support Systems (SPSS) can be described as a PSS that is directed for any planning related to spatial aspects.

SPSS consists of different elements, such as information gathering, storage and retrieval, system modelling and analysis, communication, and visualization (modified from Vonk, et.al., 2007). In general, two types of information are required in SPSS, spatial and non-spatial (or a-spatial) data. These data are stored and maintained in database system to be used in modelling and analysis. Scenarios used in spatial planning formulation and alternatives policy should be communicated and consulted to stakeholders in various ways, including the web. Web technology is currently having an increasing in popularity as a tool in collaboration. Communication and collaboration can be effectively conducted supported by good visualization techniques. Batty (2007) highlighted that the planning process has been largely influenced by visualization and web map usage. The use of the web to disseminate city planning and gather input from stakeholders will enable online collaboration amongst them.

**Elements and the Development of SPSS**

Various PSS have been developed to date with diverse approach, application and scope. Wadbos and WEAP (Water Evaluation And Planning) are example of specific-purpose PSS. Wadbos is designed for a specific area, the Wadden sea region while WEAP is
specific in terms of the object being planned. Many more PSS are designed as general purpose such as What If?, CommunityViz, INDEX, and UrbanSim. There are still many examples of PSS available from research institutions and commercial sectors. These four PSS share some common characteristics such as their characteristic as a desktop based system. UrbanSim is the only system that is based on an open source platform, previously developed using Java and then Phyton language. The other three are extensions for ArcGIS. Customization is available for What if?, INDEX and UrbanSim. Users’ collaboration is facilitated by What if? and INDEX. The visualization aspect of CommunityViz is better than others. It can produce 3D visualization and export the result into SketchUp and KML formats for viewing in Google Earth. CommunityViz and INDEX are more directed for small area (large scale) spatial planning, while WhatIf? And UrbanSim are more for large area (medium to small scale) policy planning.

**Spatial planning and disaster risk reduction**

Based on the area under consideration, spatial planning can be classified into national, state or provincial, district level and detailed spatial planning. The classification is based on the administrative coverage of the planning. National to district level spatial planning provides general guidelines on how space is utilized, zoned, and controlled. Detail spatial planning covers sub-districts area with the output map at the scale of 1:5,000. It has detailed information on what type of uses can be assigned to a particular area. Parcel based spatial planning would be a better tool in formulation, analysis, modelling and controlling particular area.

However, some planning scenarios require less detailed information, and therefore very detail information might not be needed. Other situations shows that large detailed information were not available. For example, geological and hazards map usually not available in large scale. As disaster risk information needs to be incorporated in the spatial planning formulation, a strategy in dealing with utilization of spatial data at different scale, and therefore affecting their accuracy, should be developed. Figure 2 illustrated incorporation of multi hazards information in the spatial planning formulation in an attempt to reduce disaster risk. Another aspect to be considered is data sharing, given the fact that spatial planning formulation involves numerous agencies databases. Therefore, an SDI platform should also be developed to facilitate inter-agency data sharing and utilization.
SDI PLATFORM IN DISASTER RISK REDUCTION

Spatial Data Infrastructures (SDI) is framework for the exchange and sharing spatial data between stakeholders utilizing spatial data (Rajabifard et.al. 2003). It is aimed to maximize the use of spatial data among stakeholders and at the same time reducing duplication in spatial data acquisition and maintenance and any cost related to it. The core component of SDI is composed of people, data and technology. The technological component consists of three different aspects namely access network, policy and standards. It has a dynamic nature caused by changing people and people’s requirement (Rajabifard, et al 2003). SDI platform usually developed according to the level of government. It can be ranging from corporate SDI at the very basic level into global SDI at the highest level.

Requirements in developing SDI at different level will also be different because of different stakeholders, data, and needs. At the local level, SDI platform will mainly facilitating exchange and sharing of large scale spatial data of a single administrative unit. One of the main purposes of spatial data at the local level is to support local planning process. Spatial planning formulation is an inter-agency collaboration. Therefore, a good mechanism of spatial data access and utilization is unavoidable. With regard to the efforts of reducing disaster risk, SDI platform will facilitate the sharing of spatial data between different organizations involved in spatial planning formulation.

INTEGRATED APPROACH IN DISASTER RISK REDUCTION

Disaster risk reduction (DRR) is an effort requiring input from many disciplines, sectors and agencies. It has been argued by some researcher that there is a need for an integrated disaster management (Chen, et.al, 2003, Gopalakhrisnan & Okoda, 2007) or holistic approach (McEntire, et.al., 2002). However, there is a diverse definition of what
is considered to be an integrated approach. Chen, et.al. (2003) used a definition related to the capability of GIS, data integration, risk assessment and supporting decision making. This definition, although somewhat technical, is useful in developing conceptual framework. To implement an integrated approach, Gopalakhrisnan & Okoda (2007) proposed a new institution as a vehicle.

There are several key actors in DRR, as shown in figure 3. They have their own perspectives and expertise. Their focuses are diverse, such as on housing, others on ensuring safety of life, public infrastructures, continuation of economic activities, and environmental sustainability. All focuses and interests should be put together in one integrated approach that aimed to satisfy different needs. This integrated approach in disaster risk reduction makes use of existing knowledge, datasets, expertise, perspectives and existing institutional setting. In this context, SPSS is a tool to enhance the capabilities of actors involved in spatial planning formulation. It can provide for objective modelling of the land use allocation, based on certain parameters and aims in within a data and model driven process. However, since parameters, aims and model are created by people, some subjectivity may inherit in the alternatives solutions. In fact a choice on what will be the policy is a result from dialog between stakeholders. To ascertain high degree of participation and objectivity, collaboration among stakeholders need to be performed in a transparent way using web based systems.

PRELIMINARY ASSESSMENT

Study Area
This research employs a case study approach. The study area is Semarang city, Indonesia, typical of a medium size city in a developing country. The city is experiencing on-going land subsidence which increases the magnitude of river flooding and sea water inundation. In the southern part of the city, landslide occurs frequently in the hilly areas during rainy season. Pressure from population growth and limitedly available space has forced people to use marginal land on the hill slope for housing.
Semarang has a population of approximately 3.5 million people. The population in 2006 is 1,434,025 peoples, distributed unevenly in 16 sub-districts and concentrated in the middle-north of the lowland area. It has an interesting topographical setting, with lowland area stretching approximately 3 km to 10 from the coast. This area is very vulnerable to flooding given the elevation is just below 5m. Some parts of the city in fact are already situated below mean sea level. The southern part of the city has hilly and undulating terrain which has significance as a recharge area.

**Spatial Planning Formulation**

Spatial planning of the city was formulated by a private consultant but closely supervised by a governmental advisory team consisting officials from different agencies. The agencies involved are City Planning, Public Works, Local Land Administration, Environment, Mining, Investment Coordinating Agency, and Forestry. Public participation was encouraged by inviting some community and business organization to attend public meeting and focus group discussion. At the end, spatial planning policy requires approval from the local legislative body and provincial government, which then released in the form of government regulation.

**Incorporation of Disaster Information in Spatial Planning**

The city experiences several types of natural disaster, such as river flooding, tidal surge, land subsidence, mass movement and landslides. Some main rivers are becoming shallower and narrower because of the high erosion rate in the hilly area. This is the result of extensive land use change from forest and plantation into residential and industrial areas in the upper part of the city. In effect, magnitude and extend of flooding is increased. Land subsidence is another factor in enhancing the flood risk. Geodetic levelling measurement has been conducted in some parts of the city. The most obvious impact was abandoned houses, office building, industrial complexes and railway because of continuous inundation. Currently, the height of tidal surge reaches 1 meter and covers areas up to 4 km from the coastline. Figure 4 shows houses and industrial complexes around the port of Semarang suffering from high rate of land subsidence. Occasionally the area is inundated by sea water.
The risks of natural hazards are so severe and need to be addresses appropriately. The Final report of the Revision of Spatial Planning of the City of Semarang 2010 – 2030, has set general guideline for the development and utilization of available space. As this policy document is only at the medium scale, no reference is provided at the detailed level with to specific spatial planning policy to be implemented. In order to have more detail assessment in the planning process, land use data at parcel level is required. However, this data is currently having not been incorporated in it. The introduction of land parcel data will make finer spatial plans at detail level. To be able to achieve integrated approach in disaster risk reduction, the land parcel data will be the fundamental dataset in 2D spatial data. The third dimension, height or elevation, should be supplied by large scale topographic map or from airborne laser scanning data. This later component is very important in analysing and predicting natural disaster, in which most of them are terrain dependent. All potential disaster in the City of Semarang, disaster include landslide, flooding, land subsidence and sea level rise, are terrain dependent disaster.

These fundamental spatial datasets will then be combined with other thematic datasets from other sources. The thematic datasets component includes transportation, public utility and facility, population distribution, preserved area, and many more. Disaster risk information comes from multi hazards maps prepared by the government, academic institutions or NGOs. Local knowledge will also be incorporated, since the updating process of local knowledge is usually much faster than any published map. All of these input data are to be fed into the SPSS. Government regulations, as a-spatial data component, are to be interpreted in the scenarios development. All of the scenarios developed and alternatives spatial planning will be made public, to inform them and obtained feedback. Internet will be used for different place – different time geo-collaboration.
CONCLUSION

Efforts in reducing disaster risk involving many stakeholders engaging in different disciplines, requires data at different formats. All of these need to be approached in an integrated fashion and formulated in such a way for long term benefit. Spatial planning policy is the main medium to achieve this objective, while spatial planning support systems will help in enhancing the process of spatial planning formulation. An SDI platform provides facilitation in sharing spatial data among participants. Finding from the study area confirm that direction on reducing risk associated with natural hazards has been set in general terms. On the detailed level and operational level, spatial plans at larger scale need to be formulated. Parcel-based spatial planning is proposed to fulfil this objective.

ACKNOWLEDGMENT

The authors would like to acknowledge the support of the University of Melbourne. Data were obtained from the city of Semarang, Indonesia. Views expressed herein are those of the authors and do not necessarily reflected their institution.

REFERENCES


Planning Agency, City of Semarang, 2008, Revision of Spatial Planning of the City of Semarang 2010 – 2030


UNISDR (2009) UNISDR Terminology on Disaster Risk Reduction.


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