Integrating Disaster Mitigation Strategies in an Integrated Land Use and Transport Plan for Urban Transport Sustainability

by

Fahmi

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LS2 9JT

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The candidate confirms that the work submitted is his own, except where work which has formed part of jointly authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

The work in chapter III of the thesis has appeared in publication as follows :

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I was responsible for the first author. The contribution of the other authors were as the Co. Authors that gave suggestions about the structure of the paper.

Acknowledgements

The embryo idea of this research was born as a response to the reality condition of poor land use and transport plan in Banda Aceh city as a high-risk city to natural disaster and the lack of studies that involved the combination concept of urban risk reduction and urban transport sustainability in an academic context in order to promote the concept of sustainable development for high-risk cities in developing countries. In this context, I would like to express my special appreciation and my gratefulness to Dr. Paul Timms and Prof. Simon Shepherd who have kindly helped me to develop the ideas for this research in the first place until this research has been completed as in this thesis. Their enthusiasm and encouragement during the process of Ph.D journey was very helpful and gave me the new insight in many aspects regarding how to think to find the innovative ideas, which would be impossible without trying to think out of the box.

I would also like to express my gratefulness to Dr. Paul Pfaffenbichler and Prof. Guenter Emberger who gave me permission to use MARS LUTI model, which was applied to the city of Banda Aceh in this study. I hope that this is a starting point to promote the application of land use and transport models in the context of sustainability for helping cities worldwide to reach their sustainable city agendas, not only for the normal city like Vienna or Leeds, but also for Banda Aceh city and other high-risk cities throughout the world using evidence-based policy based on scientific approach. I am also particularly grateful to Prof. Greg Marsden, Dr. Arif Gusnanto, Dr. N. Balijepalli and Dr. John Nellthorp who gave me helpful support at different stages of the development of this thesis.

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Abstracts

High-risk cities worldwide face problems regarding increases in vulnerability to natural disaster combined with urban-transport problems. Up till now, there has been no study that was specifically concerned with these two issues simultaneously regarding how these cities should define their sustainability concept and formulate their land use and transport strategies in the framework of sustainable development.

This study presents an approach for integrating concepts for disaster mitigation strategies into the land-use transport interaction (LUTI) plan by combining the disaster mitigation strategies with the conventional land use and transport strategies in the framework of urban risk reduction and urban transport sustainability. There were 18 combined alternative policy measures selected, which were classified into three different land use strategies and five alternative different transport policy measures. The land use strategies consist of (A) accommodation (BAU), (B) planned-retreat with strict zoning, and (C) planned-retreat with pricing policy. The alternative transport policy measures consist of (1) Bus rapid transit (BRT), (2) parking charge, (3) cut fuel subsidy, (4) combination of BRT and parking, and (5) combination of BRT, parking and cut subsidy This innovative approach is the first original contribution of this research.

MARS LUTI model was modified by adding disaster risk factor in its sub land use of model, which become as the second original contribution of this research. In the level of strategies evaluation, all of the strategies tested were measured using four indicators, which consist of (1) vulnerability, (2) environment, (3) economic and (4) efficiency indicators. The additional of vulnerability indicator the framework of urban transport sustainability is the third original contribution of this research.

The main finding for the case study are as follows : (1) the application of the two land use policy measures (strict zoning and pricing) gave significant contribution in reducing city vulnerability to potential tsunami disaster in the future, which could be applied to promote the concept of urban risk reduction. (2) The combination of “push and pull transport strategies” application through the combined BRT, parking and cut subsidy produced the best performance compared to the others alternative policy measures selected. The push and pull transport strategy succeed to direct the evolution of urban transport condition in the framework of urban transport sustainability in order to reach the sustainability objectives.

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Chapter 1
Introduction

1.1 Background and rationale

Recently, sustainable development has become one of the new issues that have been discussed by many scholars in both academic and practical session, from the early conceptual stages up until policy making processes. There are several versions of the concept of sustainability that can be found from the classical text (WCED, 1987a) until the latest version of the sustainable future development vision from the United Nations Conference meeting in Rio (UN, 2012b). In general, the principle concept of sustainable development has the objective to fulfil the needs of the present generation without jeopardising the needs of future generations.

In fact, we live in unsustainable urban condition (lack of planning) in fast growing urban agglomerations as a result of rampant economic growth that on the one hand, we expect, but on the other hand, cause severe urban transport problems that potentially reduce the quality of life. Moreover, there are many cities in the world that are becoming more vulnerable to natural disaster in the future in associated with the issues such as sea level rise, flood and tsunami (IPCC, 2007, UNEP, 2007, Millennium-Ecosystem-Assessment, 2005, World-Bank, 2010a). In developing countries, the lack of planning for rapid development with high population growth has contributed to an increase in disaster vulnerability for the high-risk cities, where areas of these cities are located in areas prone to disasters from natural hazard (Hamza and Zetter, 1998, Rannow et al., 2010).

Therefore, there are two serious problems that are faced by the high-risk cities, which are related to increases in (1) vulnerability to disaster risk and (2) urban transport problems. In response, integrated land use and transport strategies in urban planning are needed that simultaneously consider the adverse impact of potential disaster risk and urban transport problems in order to promote the sustainability concept. To do that, the aspect of disaster mitigation needs to be integrated into the land use - transport plan strategies in order to meet the city objectives in the framework of sustainability.

There are several alternative strategies that can be applied for promoting the concept of sustainability. In the aspect of disaster mitigation strategies, planners can be choose between (1) accommodation, (2) protection or (3) planned-retreat strategies (Dronkers et al., 1990, Rannow et al., 2010). In the accommodation or protection strategies, the high-risk areas of the city are allowed to be used as residential and development areas. In the accommodation strategy, the authorities can provide evacuation route and evacuation buildings as alternatives to reduce the potential risk and losses from a disaster. In the protection strategy, hard structures (e.g. sea walls for tsunami) are built to reduce the potential impact of the disaster risk. On the other hand, in the planned-retreat strategy, the alternative strategy implemented could be in the form of a relocation strategy banning new development in high risk areas and forcing new development to be built in low risk areas of the city or it can be also done through promoting the concept of decentralized concentration by reducing the number of residents in high-risk areas of the city (Rannow et al., 2010). However, all the strategies proposed above will in some ways affect energy use and other transport factors in urban areas as a result of changes in the urban structure and transport infrastructure.

From the aspect of land use planning strategies, there are several land use policies (e.g. land taxes and urban growth boundaries), which have been applied to promote the sustainability concept (e.g. for restricting growth and preserving green space against the problems of urban sprawl) (Anas and Pines, 2008, Gihring, 1999, Marin, 2007, McDonald-Buller et al., 2010). From the aspect of transport strategies, the implementation of public transport systems have been implemented and improved to solve the urban transport problems such as congestion and pollution (Cervero and Mason, 1998, O'Flaherty, 1997, Grava, 2003, Wright, 2002a). Besides that, transport demand management have been also implemented through parking charges or fuel pricing strategies to solve the urban transport problems (Broaddus et al., 2009).

From the various points of view above, there are two different dimensions that are discussed in this study. First, it is related to the concept of implementing “disaster mitigation strategies” in the framework of urban risk reduction. Second, it is related to the concept of implementing “land use and transport strategies” in the framework of urban transport sustainability. Furthermore, it is important to combine these two different concepts as a response to solve the problems that are faced by high-risk cities worldwide in the framework of sustainable development.

1.2 Context of study

This research focuses on the issue of development of land use and transport plan in the framework of urban risk reduction and urban transport sustainability. In this context, this research was developed as a methodological approach that could be applied to a certain group of high-risk cities in order to promote the concept of sustainable development.

The group of high-risk cities are defined as where some part of the cities areas are highly vulnerable to the potential disaster of natural hazards (e.g. flood, tsunami), which then make these cities need to consider the incorporation of adaptation strategy in urban planning. Moreover, these high-risk cities also face the urban transport problems in common with all other cities worldwide, which encourage them to include and integrate their land use adaptation strategy with their urban transport strategy as a way to reach the vision of city agenda for sustainable development.

The concept plan developed in this research might give benefit to these cities (e.g. the city strategic plan, which has an objective to reduce number of people that reside in high-risk areas of the city in the future) in order to attract more people to reside in less vulnerable parts of the city rather than in city areas, which are particularly vulnerable to natural disaster. In this context, the city of Banda Aceh, which is located in high-risk area to natural tsunami disaster, was selected as a case study area for this research because after tsunami tragedy, several parts of the city of Banda Aceh have been identified as at risk or vulnerable to tsunami disaster in the future, whilst other parts of the city are less vulnerable. This is the reason why the Banda Aceh is a good example in this case study. It is expected that the concept plan to be developed, which will then be applied in this case study, could help other cities, which have similar problems, in order to meet the sustainability city agenda in the framework of urban risk reduction and urban transport sustainability.

1.2.1 Cities vulnerable to natural disaster

There are many cities worldwide that vulnerable to potential natural hazard (e.g. Table 1.1), where, they need to incorporate the concept of adaptation strategies in their urban planning in order to reduce the potential effect from the disaster threat as shown in Figure 1.1. This issue is important to be discussed because according to

United Nation Development Programme (UNDP), every dollar ($1) investment in a disaster risk prevention program might save seven dollars ($7) of budget allocation to rebuild after the disaster (UNDP, 2012).

This research focuses only on the disaster risk issue related hazards from a Tsunami, which is possibly one of the most severe but also one of the least frequent disasters. These tragic events have happened in the past at several places in Indonesia (e.g. Banda Aceh, Padang and Bali) and in Japan (e.g. Sendai, Tohoku, Yokohama), which are shown figure 1.1. The quantitative evidence from the past has shown that damage from earlier tsunamis has also been very bad and destructive (Atwater et al., 2005, Kates et al., 2006). For instance, the total the losses of from the 2004 tsunami disaster, which mostly hit the coastal areas of Aceh in Indonesia, reached Rp.41.4 trillion or US$4.45 billion (BAPPENAS, 2005).

In this case, it is undoubtedly that these high-risk cities need a long term city strategic plan in order to reduce the potential risks from a tsunami disaster. In other words, the issue of incorporating the concept of disaster mitigation into the city planning is very important to be addressed by the city planner and the city stakeholders in order to reduce the number of fatalities and loss (Hallegatte et al., 2013). Figure 1.1 below shows several high-risk cities in the world, which need to incorporate the concept of urban risk reduction.

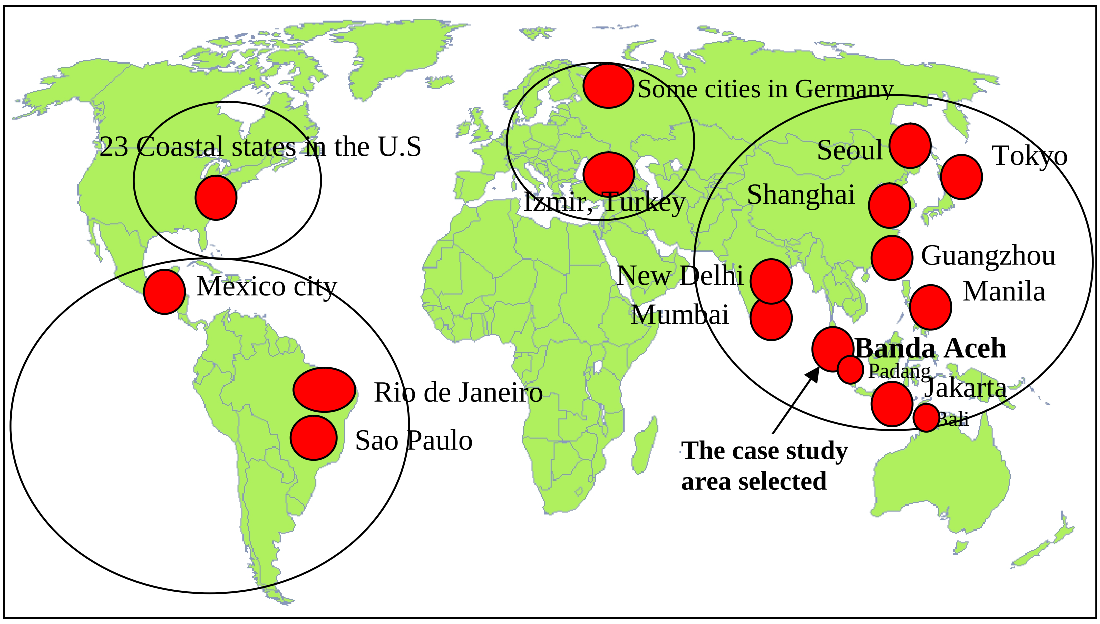

Figure 1.1: Location of several high-risk cities in different continents in the world (APN, 2009, IAI, 2010, World-Bank, 2010a, Kutluca and Ozdemir, 2006, Rannow et al., 2010)

Table 1.1 below shows the typical form of natural disasters that can threaten several high-risk cities, which refer to the Figure 1.1 above.

High-risk cities	Type of disaster	Recommendation
23 Coastal states in the U.S	Storm Surges	Incorporating adaptation in urban plan (IAI, 2010)
Several cities in Germany	Floods	Incorporating adaptation in urban plan (Rannow et al., 2010)
Some Asian Cities	Floods, storm surges, tsunami	Incorporating adaptation in urban plan (APN, 2009, World-Bank, 2010a)
Banda Aceh	Tsunami, floods	Incorporating adaptation in urban plan (RTRW, 2009)

Table 1.1: Several high-risk cities in the world based on types of hazards selected

1.2.2 Urban transportation problems

Urban transportation problems are common problems to all countries throughout the world, which potentially increase carbon emissions from the urban transport sector. However, generally, there are different transport problems that are faced by stakeholders in developed countries than in developing countries (Anastasiadis, 2002, Kaltheier, 2002, Cervero, 2013). For instance, in general, the public transport systems in developed countries are better than those in developing countries as a result of lack of planning in developing countries (Broaddus et al., 2009). Moreover, the car ownership in developed countries is generally higher than that in developing countries (Kenworthy and Laube, 1996).

However, it should be noted that due to fast economic growth, several developing countries will significantly increase the number of vehicles in the next few years because these countries have implemented policies to encourage people to buy private vehicles (e.g. through tax and government incentives) such as in China, India, South-East Asian countries, including Indonesia and several Latin American countries. These policies are related to efforts to boost economic growth through stimulating automotive industry sector (Zhou et al., 2010, Kemenperin, 2013, Jirón, 2011, Heymann, 2011).

According to data from UN Habitat, it was projected that the number of vehicles worldwide will reach 2.6 billion in 2050, which will be more than double the number in 2011. Moreover, the most rapid increase in motor vehicles will be in the developing countries such as China, India and other Asian countries (UN-Habitat, 2011). For that reason, one of the focuses of this research is transport problems in developing cities of developing countries.

In order to solve the problem mentioned above, there are also growing interest to discuss the transport strategies alternatives, which fit with the characteristics of developing cities in developing countries. For instance, there have been several pilot projects as an effort to improve urban transport in East Asia and Pacific regions countries such as in China, the Philippines, and Indonesia (World-Bank, 2010b, SUTIP-Project, 2011). Generally, these projects have had an objective to introduce the concept of urban-transport strategies in the framework of urban transport sustainability in order to take a part in reducing global carbon emissions from the urban transport sector.

1.2.3 Two dimensions of high-risk cities problems

According to the discussions in sections 1.2.1 and 1.2.2, there are two issues that will be discussed in the context of this research. On the one hand, this research will focus on the aspect of disaster mitigation related to land use planning in the framework of urban risk reduction. On the other hand, this research will also focus on urban transport problems in developing cities of developing countries that face problems related to efforts by the city to reduce the carbon emissions in the framework of urban transport sustainability.

According to the latest study, most of the developing cities in Asia will face problems related to increases in disaster risks from natural hazards mentioned earlier in sub section 1.2.1. Moreover, they will also face the more serious common urban transport problems, where in this context, these cities need to strive to reduce carbon emissions as part of the global coalition to promote the concepts of sustainable development. In fact, the lack of long term urban strategic planning in the framework of urban risk reduction and urban transport sustainability, has attracted more people to reside in high-risk areas of the cities and at the same time, it might also increase carbon emissions from urban transport sector (Hallegatte et al., 2013, UN-Habitat, 2011, Sundermann et al., 2013).

Therefore, this research will focus on developing land use and transport strategies for a group of developing cities, which need to incorporate adaptive strategies (as part of their urban risk reduction strategy) into their urban planning and also have common urban transport problems, in the light to achieve the city objectives in the framework of urban risk reduction and urban transport sustainability.

To be more specific, Figure 1.2 below shows coastal cities in Asia that face problems from potential disaster risks to natural hazards (e.g. floods, storms, earthquakes and tsunami). On the other hand, they all also have a vision to reduce potential carbon emissions from the urban transport sector in the future as part of the global coalition program

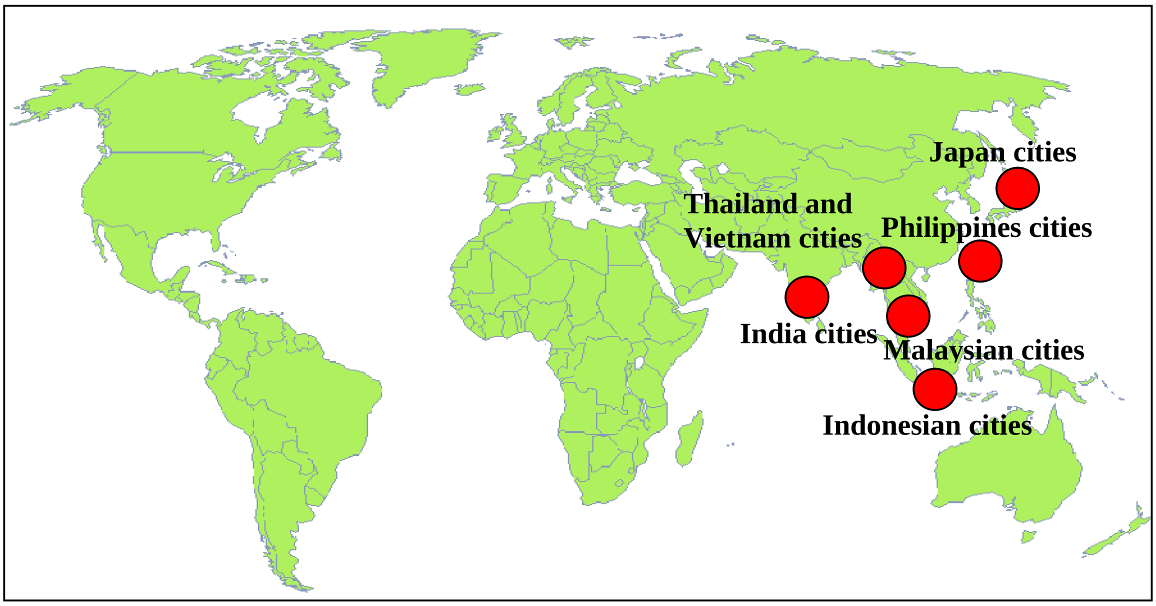

Figure 1.2: Vulnerable coastal cities in Asian developing countries with urban transport problems (World-Bank, 2010a)

Moreover, the discussion in this research will focus on the issue of urban transport problems in the context of developing cities in developing countries, especially in ASEAN (Association of South East Asian Nations) countries. The reason behind this premise is related to difference urban transport problems of developed countries and those of developing countries (Dimitriou and Gakenheimer, 2011). Therefore, this issue is important to be considered in order to address the land use and transport planning process of this research in the right context. Moreover, for the meaning of the term developing countries refer to the World Bank classification. Thus, the low and middle income countries were referred to the group of developing countries (World-Bank, 2013b).

Banda Aceh city, which is located in Indonesia (a member of ASEAN), was selected as the case study area to represent a high-risk city, which has the typical urban transport problems of a developing city in a developing country. Moreover, this city is also located in the natural hazard prone area that has potentially high-risk to earthquake and tsunami disasters (Government-of-Aceh, 2011).

To be more specific, this research will only focus on tsunami disaster risk analysis as input information in the process of city long term strategic planning related to land use and transport plan. It is assumed that the city has a plan to minimise the risks from a tsunami disaster. In addition, the reasons, why a tsunami disaster was selected in the problem identification stage of this research (mapping of risk in the case study area selected), are as follows :

1) The level of damage from a tsunami can be very destructive compared to that from any other natural hazard (e.g. floods, storm surges, etc.) in the case study area selected. Moreover, the 2004 tsunami was identified as one of the worst disasters worldwide in modern times (Schiermeier, 2005).
2) The tsunami risk reduction has become the highest priority government program in the case study area selected in the context of urban risk reduction (Pemerintah-Republik-Indonesia, 2007, RTRW, 2009, BNPB, 2010).

1.3 Motivation for study

The lack of planning related to land use and transport planning in high-risk cities in the world has contributed to the increase of vulnerability to natural disasters and to high urban transport carbon emission as a result of the increase of urbanization in urban areas and rapid motorization, especially in the context of developing countries.

In the context of the case study area selected, after the Pittsburgh summit, Indonesia as a member of the G20 countries has been committed to implement the world action plan regarding the program for carbon emission reductions. The Indonesian national action plan program has a target to reduce by 26% (minimum target) up to 41% (maximum target) fall carbon emissions in the years up to 2020 (PP-Republik-Indonesia-No.61, 2011). As explained earlier in sub section 1.2.1, the city of Banda Aceh, as one of the west coast cities in Indonesia, is a high-risk city that faces the problems with the increasing new housing development in high-risk areas to a tsunami plus increasing carbon emissions from urban transportation sector. Consequently, the interpretation of the concept of sustainability for this city not only has to deal with the issue of carbon emission reduction as part of the national action plan, but it should also consider the aspect of disaster mitigation in the local context as can be seen in Banda Aceh spatial planning (RTRW, 2009), which refers to the national action plan for disaster risk reduction (BAPPENAS and BNPB, 2006).

Banda Aceh needs an integrated development plan concept that can be applied to achieve the city objectives in the framework of sustainability in order to reach the local (reduction of vulnerability to disaster) and national action plan (reduction of carbon emission). In this context, it needs combined land use and transport strategies, which can be implemented to direct the urban development process in the framework of sustainability mentioned earlier. Up till now, there has been no research that we know of specifically concerned with this issue. Therefore, this research proposes a new concept of land use and transport plan in the framework of urban risk reduction and urban transport sustainability, which can be used by the high-risk cities like the city of Banda Aceh to reach their sustainable city agenda. It is also expected that the initiatives in this research can make a significant contribution to fill the knowledge gap between the issue of disaster mitigation and that of urban transport policy regarding designing long term strategic planning for high-risk cities in the framework of sustainability.

1.4 Research questions

Based on the explanations in sections 1.1, 1.2, and 1.3, there are several main questions in this study that can be raised as the research questions. These are :

1) What do we need to do today to reach a city long term strategic vision for reducing vulnerability to disaster risk and for reducing carbon emissions from the urban transport sector ?
2) How to put the issue of sustainability into the framework of urban risk reduction and urban transport sustainability ?
3) How to interpret the concept of urban risk reduction and urban transport sustainability into the strategic planning issues in order to reach the sustainable city agenda ?

4) How to apply the prospective strategies proposed in a LUTI model that can be applied in the in context of a high-risk city ?
5) What are the possible policy measures that should be implemented to reach the high-risk city objectives in the framework of sustainability ?

Explanations about how to answer these research questions above are set out in the sub section on objectives for this study which follows. The answers to all the research questions are also summarized at the last in the “Conclusions Chapter”.

1.5 Objectives of the study

The main purpose of this study is to give a new perspective in the aspect of land use and transport plan in the framework of urban risk reduction and urban transport sustainability by combining a generic planning of disaster mitigation strategies with conventional land use and transport plan. This issue is important to be discussed in order to give new insights for finding the appropriate land use and transport strategies, which can be used to direct the urban development process in the framework of sustainability. In more detail, the objectives of this research consist of six main parts as follows :

1) Understanding the concepts of urban development planning related to land use and transport plan in the framework of urban risk reduction and urban transport sustainability to be applied in the context of a high-risk city (refer Chapter 2).

2) Developing a development planning concept through a combination of disaster mitigation with conventional land use-transport strategies, including its framework assessment to be applied in the context of a high-risk city, which refers to the concepts of urban risk reduction and urban transport sustainability as mentioned in the first objective of this research (refer Chapter 3).

3) Implementing the concept plan in a case study area selected. The concept developed, which consists of several alternative land use and transport strategies, was then applied in a high-risk city, where Banda Aceh city was selected as the case study area. The integrated concept plan, which was implemented in the case study area selected, was then called as Banda Aceh Integrated Land Use and Transport Plan (BILT) (refer Chapters 4 and 5).

4) Modifying and calibrating a land use and transport interaction model (LUTI Model) to be applicable for high-risk cities. In this part, a conventional MARS model (Metropolitan Activity Relocation Simulator), which was originally developed for Vienna city, was modified to be applied in Banda Aceh city, which is located in a developing country (Indonesia). The conventional MARS model modified for Banda Aceh city was then called as Banda Aceh MARS Model (refer Chapter 6).
5) Implementing the development planning concept of the BILT in Banda Aceh MARS Model. In this context, the BILT represents an integrated development concept for the high-risk city, which consists of several alternative land use and transport policy measures proposed, while, the Banda Aceh MARS model was used as a tool to predict the impact of the application of the BILT strategies (refer Chapter 7).
6) Evaluating the results of all the policy measures proposed when applied to the Banda Aceh MARS model using the framework assessment as mentioned in the second objective of this research (refer Chapter 8).

All of the objectives mentioned above will provide new insight in the aspect of land use and transport plan interaction thus breaking out of being trapped within the hard shell of current practice conventional transport strategies, regarding how to make better long term strategic planning for a high-risk city in the framework of urban risk reduction and urban transport sustainability.

1.6 Originality of the research

In both academic and practical way issues of policy implementation, there has been no research looking into the joint problem of disaster mitigation and land use and transport plan strategies because at the level of concept, the sustainability concept in the framework of urban risk reduction and urban transport sustainability has not been discussed in an integrated way. Consequently, strategies proposed in these two different areas work in isolation to achieve their separate objectives, which are separately implemented. This research aims to address that gap.

At the level of strategy implementation, the gap mentioned above frequently causes errors or misinterpretation in finding the right strategy for the high-risk cities in the framework of sustainability since the strategies proposed in the aspect of urban risk reduction simply ignore the other important aspects in the context of urban transport sustainability or vice versa. In fact, there is a strong relationship between the issue of disaster risk and land use-transport plan, which are connected through land use planning. Therefore, several combined land use and transport strategies were proposed by referring to the concept of urban risk reduction and urban transport sustainability. The combined strategy (disaster mitigation with conventional land use-transport strategies) is called the Banda Aceh integrated land use and transport plan, which is the first new finding from this research.

At the level of strategy implementation for the model, land use and transport strategies proposed in the LUTI model only refer to the urban transport sustainability indicators, without considering the aspects of disaster risk indicators (Wegener, 2003, Pfaffenbichler, 2008). Consequently, there has been no research that considers the disaster risk factor as one of the important variables besides the other variables like accessibility or rent in the sub land use of the LUTI model.

Furthermore, there have been no LUTI models available that can be used for simulating the prospective strategies to be applied in high-risk cities, which are located in natural hazard prone area worldwide in order to reach the sustainable city objectives. Therefore, it is also important to modify a conventional LUTI model by adding the disaster risk factor, which can be applied in the context of the high-risk city for promoting the concept of sustainability. The MARS model modified, which is then called the Banda Aceh MARS model, is the second new finding from this research.

At the level of evaluation of strategies, the vulnerability indicator as an indictor in the framework of urban risk reduction was added together with other indicators selected in the framework of urban transport sustainability (environment, economic and efficiency indicators). In the reality, there has been no research focus on this specific issue since strategies assessment in the framework of urban risk reduction and urban transport sustainability have been conducted separately. In this study, all of these indicators were used to evaluate the performance of the combined land use and transport strategies selected, which were directed to reach the city objectives selected in the framework of simultaneous urban risk reduction and urban transport sustainability. This became the third new finding from this research.

1.7 Contributions of this research

As mentioned in sub section 1.6, there are three novel aspects of this study, which make significant original contributions in designing the application of land use and transport strategies for high-risk cities in the framework of sustainability. This sub section discusses the contributions from this research, which are given by the three novel aspects mentioned earlier, at the levels of (1) academia, (2) planning practices and specifically in the context of (3) the case study area selected.

At the level of academia, there are several contributions that are given by the three novel aspect of this research. Firstly, the first is that this research gives new insights into the development of urban land use and transport planning in the framework of urban risk reduction and urban transport sustainability, which are defined as sustainability objectives for high-risk cities. For instance, this research breaks the isolation between city planning for urban risk reduction and planning for urban transport sustainability by providing new concept for combining alternative land use and transport strategies. Secondly, this research provide new insights for urban land use and transport modelling that consider the important aspect of disaster mitigation, which has potential to be applied in other high-risk cities worldwide. Thirdly, this research provides a new approach for assessing and evaluating the performance of land use and transport strategies, to consider the important aspect of disaster mitigation without ignoring the important aspect of urban transportation in the framework of sustainability.

Furthermore, there are also several contributions provided by the three novel aspects of this research. Firstly, the concept of the Banda Aceh Integrated Land use and Transport plan (the BILT) is the first new approach from this research which provides new insights into how to design combined land use and transport strategies to reach the objectives for sustainability for a high-risk city which can be applied worldwide. Secondly, the application of the MARS model for Banda Aceh using a disaster risk indicator (the second novelty of this research) in the context of a high-risk city can provide a quick description about the behaviour of land use and transport plan in the past, which can be used to project future conditions in order to find the right policy measures in the framework of urban risk reduction and urban transport sustainability. In this context, the output results of strategies tested in the model can be used to help the high-risk cities to find the best evidence-based policies using a scientific approach. Thirdly, the new framework assessment developed can be used by urban planners and stakeholders to evaluate potential alternative land use and transport strategies, which are planned to be implemented in real life practice.

Moreover, all of the new aspects from this research can give new insights for preparing long term strategic planning for a city in the framework of sustainability, especially for Indonesian cities. In current practice, the Indonesian cities spatial planning has not been planned in an integrated way. It is expected that the concept plan approach developed in this research can transform the way of designing policies from prejudice-based to evidence-based using a scientific approach for all cities in Indonesian.

1.8 Outline of the thesis

The thesis contents in this study have been structured into five main parts. The five main parts of this thesis consist of ten chapters as illustrated in the Figure 1.3 below :

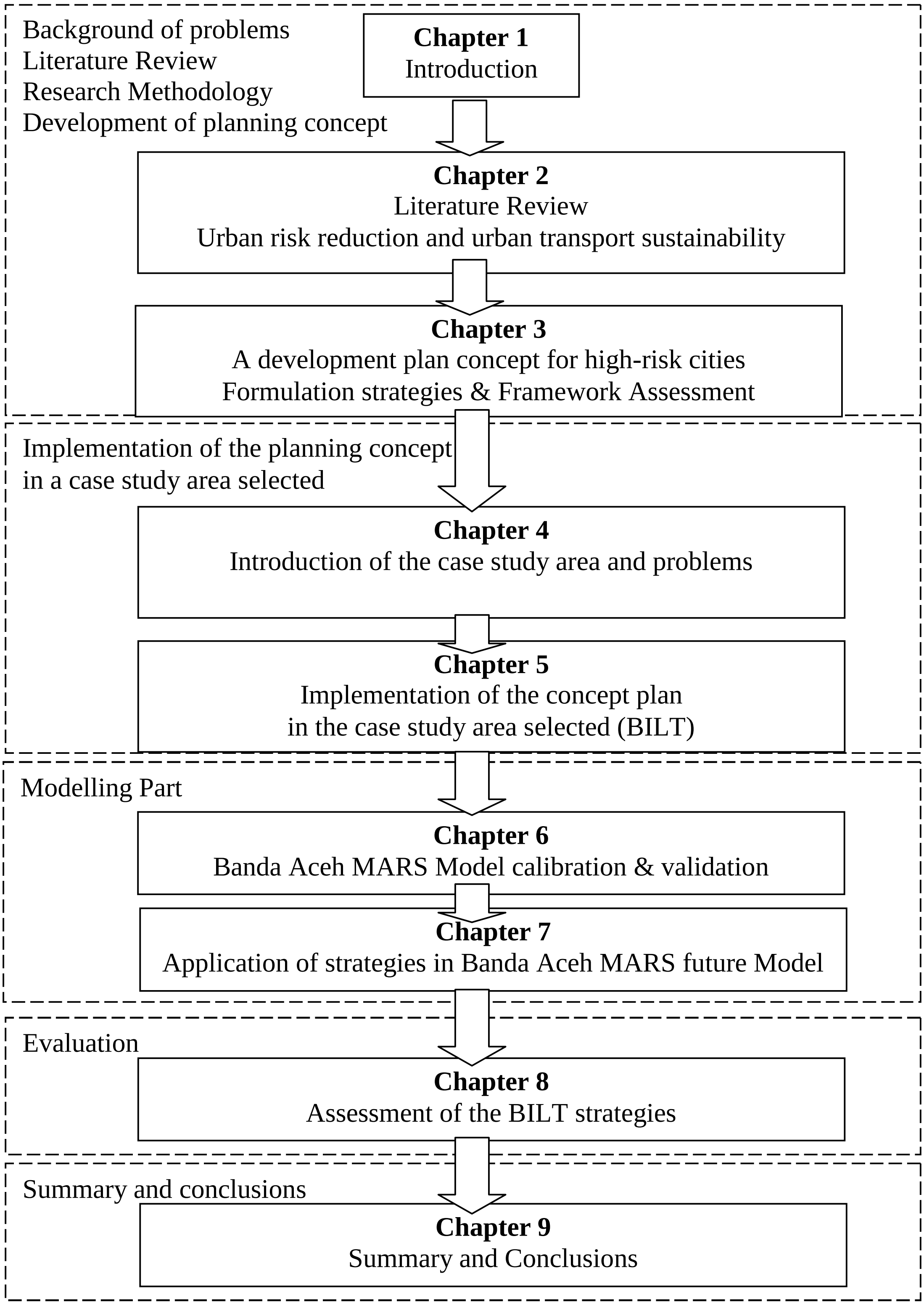

Figure 1.3: The outline structure of the thesis

As can be seen in the previous Figure 1.3, generally, the five main parts of this research consist of (1) descriptive background of problems until development concept plan, (2) implementation of plan concept, including strategies proposed in the case study area selected, (3) the modelling part, (4) evaluating the results of the strategies tested in a LUTI model, (5) recommendations for further studies.

The first part of this thesis consist of chapter 1, chapter 2 and chapter 3. The first chapter is the introduction chapter which generally describes the content of the thesis. This chapter consist of several sections, namely background and rationale (1.1), context of study (1.2), motivation of study (1.3), research questions (1.4), objectives of study (1.5), originality of the research (1.6), contribution of the research (0) and the structure of the thesis (1.8).

Then, the chapter 2 discusses about the first objective of this research that want to be achieved as mentioned in the objective of study in the first chapter regarding the concept of urban development plan related to land use and transport plan in the framework of urban risk reduction and urban transport sustainability to be applied in the context of high-risk city. The literature reviews in this chapter then was used to support the development concept of urban planning in the framework of urban risk reduction and urban transport sustainability, which then was developed in chapter 3.

The chapter 3 discusses the second objective of this research regarding development of a city long term strategic plan concept through a combination of planning for disaster mitigation with conventional land use-transport strategies, including a framework assessment to be applied in the context of a high-risk city, which refers to the concept of urban risk reduction with urban transport sustainability.

The second part of this thesis consists of chapter 4 and 5. The chapter 4 has a description of the case study area selected, while chapter 5 discusses the implementation of a concept plan for the case study area. In this context, the implementation of the concept plan in the case study area, refers to the generic concept plan, which was developed in the chapter 3. The development of the concept plan through several alternative land use and transport strategies, which fit with the characteristics of the case study area, are discussed in this chapter.

The third part of this thesis discusses the modelling for this research. This part consists of chapters 6 and 7. Chapter 6 discusses the calibration of the Banda Aceh MARS Model. The Banda Aceh MARS model represents the behaviour of Banda

Aceh residents in the context of land use and transport interactions, which are divided into pre (1985-2000) and post-tsunami conditions (2006-2011). After the Banda Aceh MARS model was calibrated, the strategies proposed (e.g. the BILT discussed in chapter 5) were applied in the calibrated model. The implementation of BILT strategies in the Banda Aceh MARS Model are discussed in chapter 7.

The fourth part of this research consists only of chapter 8. This chapter discusses evaluation of the performance of the alternative policy measures in the BILT, which were already tested in the Banda Aceh MARS model, referring to several indicators selected. The application of framework assessment in chapter 8 has the objective to evaluate the alternative land use and transport policy measures, which can be implemented in the case study area selected to reach the sustainable city objectives in the framework of urban risk reduction and urban transport sustainability. However, it should be noted that, the evaluation process for the alternative policy measures selected in chapter 8 refer to the general framework assessment, which was developed in chapter 3. The evaluation process in the framework assessment applied in chapter 8 uses the non-weighted approach. Moreover, the application of the MCA (multi-criteria analysis) using a weighted approach based on analytical hierarchy process is recommended to be applied in a further study considering the limitation of this research.

Last but not least, the fifth part of this thesis is a general summary plus conclusion from this research. The steps selected in this research, including the outputs from each steps selected, were discussed in the general summary section. In the conclusions section, the discussion of this research was classified into discussions about the two aspects of policy and of modelling. The conclusions from these two aspects give new insights about how to prepare long term strategic planning for a city in the framework of urban risk reduction and urban transport sustainability. Moreover, this chapter also discussed recommendations for further studies. The discussion of recommendations and suggestions from this research were split between recommendations for making policy and those for modelling, including recommendations for policy makers in the context of Indonesia, which can be also used as lessons learned by others developing cities in other developing countries worldwide.

Chapter 2
Literature Review of Urban Risk Reduction and Urban Transport Sustainability

2.1 Overview

As discussed in chapter 1, the first objective of this research was to understand the concept of urban development planning related to land use and transport plan in the framework of urban risk reduction and urban transport sustainability. This chapter was intended to discuss literature reviews about the concept of urban development plan related to land use and transport plan in the framework of urban risk reduction and urban transport sustainability for high-risk city. It is important to discuss and understand these two different dimension issue in order to provide better insight about the concept of urban planning in the context of land use and transport interaction in order to achieve the sustainable city agenda.

Therefore, generally, the discussion issues in this chapter were distinguished into two main parts. First part was related to the issue of urban development planning in the framework of urban risk reduction. Second part was related to the urban development planning in the framework of urban transport sustainability. The review of the literatures covered the issue such as concept of urban sustainable development, including concept of urban risk reduction and urban transport sustainability, possible strategies in the framework of sustainability, framework assessment for evaluating the possible strategies selected, and land use-transport model that possible to be used. Last but not least, the summary of this chapter about the gaps between urban risk reduction and urban transport sustainability was discussed in the last section of this chapter.

For that reason, systematically, the structure of this chapter consists of several main sections as follow. (1) The concept of urban sustainable development that consist of the concept of urban risk reduction (2.2.1) and urban transport sustainability (2.2.2). (3) City objectives in the framework of urban sustainable development (2.3), including the indicators used (2.4). (4) Possible strategies in urban sustainable development, which were distinguished into strategies in urban risk reduction and urban transport sustainability. (5) A Framework assessment to evaluate the strategies in urban sustainable development (0 and 2.7). (6) An approach of land use and transport model in the framework of urban transport sustainability (2.8). (7) The gap issue between urban risk reduction and urban transport sustainability (2.9). In more detail, the systematic of literature review discussion is shown in

Figure 2.1 below.

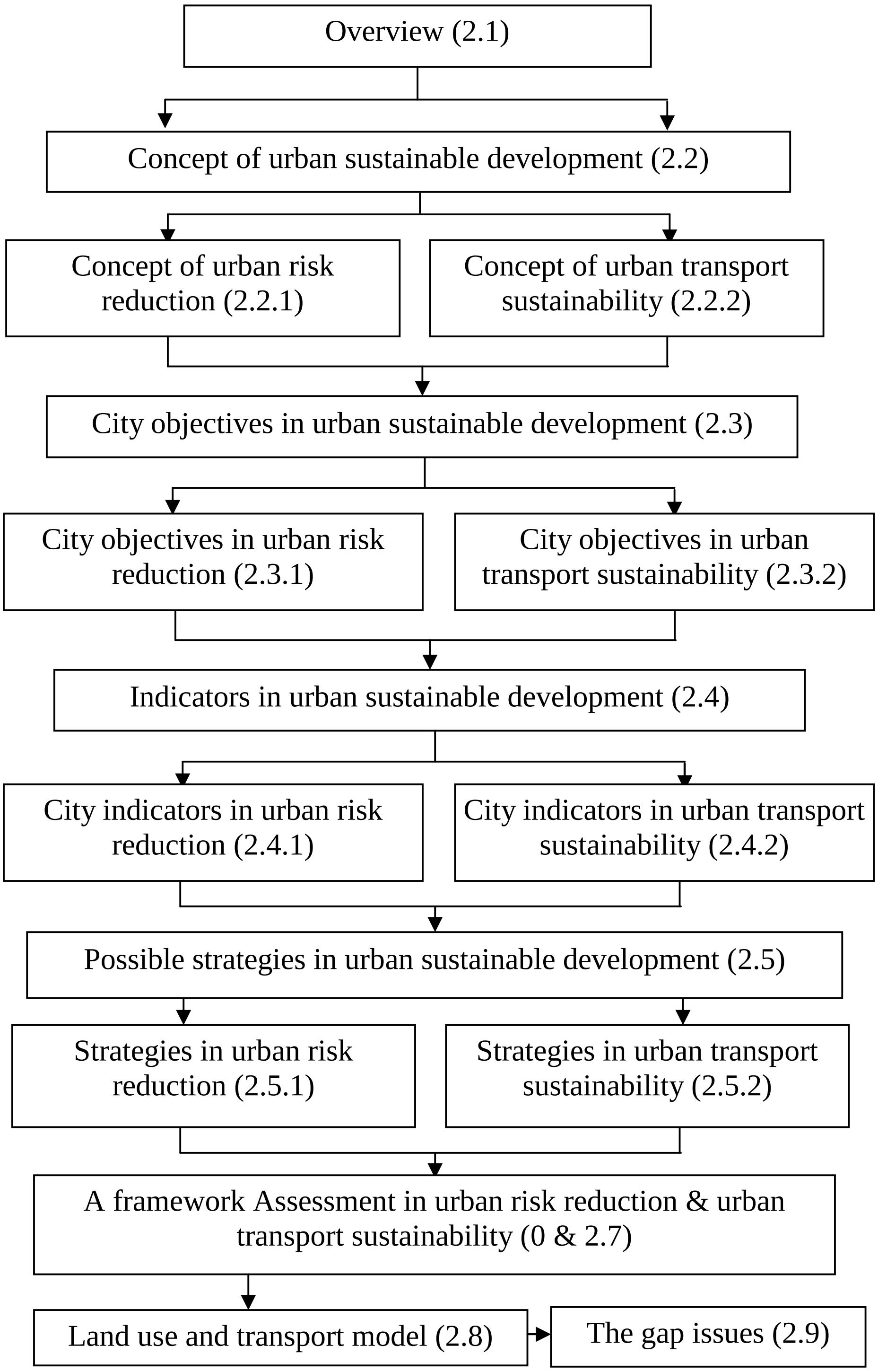

Figure 2.1: Structure of literature review

2.2 Concept of urban sustainable development

Nowadays, the discussion of sustainability issue has become the major concern of the government stakeholders around the world through meeting such as Kyoto or UNFCC meeting in Bali (United Nations Framework Convention on Climate Change) that resulting the agreement such as Kyoto protocol or Bali roadmap to reduce the level of carbon emission (UNFCC, 2013). This issue has been starting to be discussed around the world since the publication of report of the World Commission on Environment and Development, which was also known as the Brundtland report in almost the last three decades (WCED, 1987). In the section of sustainable development, the report mentioned the principle about the development plan that should "fulfil the needs of present generation without compromising the opportunity of the next future generations to meet their needs" (WCED, 1987).

In the latest update of United Nation version, the concept of sustainable development were emphasized in three aspects as follows :

1) "A commitment to equity and fairness, in that priority should be given to the improving the conditions of the world's poorest and decisions should account for the rights of future generations.
2) Long-term view that emphasizes the precautionary principle, i.e., "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".
3) Sustainable development embodies integration, and understanding and acting on the complex interconnections that exist between the environment, economy, and society" (Drexhage and Murphy, 2010) pp. 6".

In addition, the World Bank defined the sustainable development as the development concept that balancing the objectives of economic, environment, and social aspect in the present process of decision making in order to meet the needs in the future (World-Bank, 2013c). Moreover, the sustainable definition of the Brundlandt report version then have used and adopted in the most academic discussion issues or in policy making issues related to many areas that concern in environment and sustainability issue (Holland, 2000).

In areas of urban planning, this issue also become as the most popular issue that discussed by many scholars, which is known as the urban sustainable development. Rapid urban growth and motorization phenomena in urban areas were one of the reasons why the city long term strategic planning should be also encouraged to adopt the concept of sustainable development (SDSN, 2013).

According to United Nations future agenda in 21st century (SD21), disaster risk reduction and urban transport issues were included as the two main important issues in order to achieve the objectives of city sustainable development (UN, 2012a). For instance, the integration of disaster risk reduction in policies and planning is one of strategic goals in sustainable development process. In the context of future urban agenda, land use planning in the framework of disaster risk reduction was one of the keywords in five action priorities plan in order to achieve the goals of urban sustainable development (UN-DESA, 2011b).

Similarly, urban transport sustainability is also one of the United Nations agendas to promote the concept of sustainable development. It was expected that all the cities throughout the world could adopt the concept of urban transport sustainability development by minimizing the energy use in an environmentally friendly way as part of an integrated plan. For instance, the application concept of urban development by promoting public transport and non-motorised transport (e.g. walking and cycling) was one of priority city future agenda that should be implemented rather than encourage people to use private vehicles that potentially increase the carbon emission from transport sector (UN-DESA, 2011a).

Furthermore, the urban transport problem in developing cities of developing countries is also one of the main concerns of United Nations regarding sustainable cities agenda. The rapid urbanization phenomenon in emerging economy countries e.g. see (Hoskisson et al., 2000, World-Bank, 2013b), which was followed by the rapid increase of private vehicle ownership, were included as the main issues that should be placed in the list of priority (UN-DESA, 2012). It was estimated that the financial loss of urban transport problem such as congestion, pollution and road accidents was quite significant in the next future years. The cost of such problems could reach about ten percent of the developing country’s GDP (Dalkmann et al., 2011).

2.2.1 Concept of urban disaster risk reduction and city resilience

Urban disaster risk reduction is one of the important issues in the context of promoting city long term strategic planning in the framework of sustainable development. In this research, the concept of risk discussed was related to the disaster risk to natural hazard. In general term, according to the United Nations definition (International Strategy for Disaster Risk Reduction), the disaster risk reduction was defined as follows :

"*a 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*" (UN/ISDR, 2009a) pp 10-11.

The level of disaster risk could also change over time in dynamic process of urban development. According to the Hyogo framework for action plan (HFA), the level of disaster risk potentially increases in the condition where the vulnerability level also increases. In other words, the level of disaster risk was then influenced by two main factors, namely hazard and vulnerability. Moreover, exposure factor may be also included as another factor, which refer to the physical aspects of vulnerability (UN/ISDR, 2004, UN/ISDR, 2009a, Dickson et al., 2012).

The hazard was defined as a harmful or dangerous phenomenon of natural or manmade that might cause the negative impact such as fatalities, property and environmental damage and other losses (UN/ISDR, 2009c). For instance, As mentioned earlier in the background problem of chapter 1, many coastal cities have increasingly exposed with potential natural hazards such as earthquake, tsunami, flood, and volcanic events. Furthermore, the vulnerability was defined as susceptible to damage or injury. According to United Nation definition, the vulnerability was defined as "the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard" (UN/ISDR, 2009c). In the context of urban planning issue, vulnerability was defined as the degree to which exposed people, properties, asset, and other economic value that are located in high-risk areas of the city, which has the potential damage (Dickson et al., 2012).

In the context of urban planning, the vulnerability factor might be influenced by various factors such as changes of demographic, urbanization in unplanned city, or the increase of new development in high-risk areas of the city. For instance, as the cities evolve and develop, the urbanization may attract more people to reside in high-risk areas of the city in the lack of planning process condition (e.g. lack information and data in planning process). This situation may increase the degree of people and urban infrastructure that exposed to potential natural hazard (e.g. tsunami) for those who are living in coastal areas. In this situation, the city authority may strengthen the coping capacities such as building and providing tsunami early warning system in order to reduce the level of vulnerability for people that live in high-risk areas of the city to tsunami disaster. In this case, the level of vulnerability may decrease because the people in high-risk areas of the city can run away from tsunami prone areas as soon as they hear the tsunami warning alert from tsunami early warning system. However, the degree of urban infrastructure, which exposed to tsunami natural hazard still does not change. Furthermore, if the government ban the new development in high-risk areas, the number of city residents and infrastructures in the future that exposed to tsunami could be reduced simultaneously (UN/ISDR, 2009a, Dickson et al., 2012).

Based on two definitions mentioned earlier, in the context of urban planning, the urban disaster risk reduction can be defined as a systematic effort to reduce the city vulnerability level from various potential hazards in order to reduce the level of disaster risk. This concept is important to be discussed in order to understand regarding how to reach the city objectives, which refer to the concept of sustainable development as discussed in the section 2.2. From the explanation earlier, it is clear that the happening of hazard event in certain city cannot be prevented, but it can be prevented for becoming the disaster. In other words, the occurrence of potential disaster may be prevented by evaluating and reviewing the policies implemented in our communities. In this context, the policies selected plays the main role in making our cities more resilient or more vulnerable to resist the effect and impact of potential natural hazard in the future (UN/ISDR, 2012c).

Therefore, the objective in planning a city to be more resilient is a keyword in promoting the concept of sustainable development. However, it should be noted that there are various conceptions of resilience that could be found in several past studies e.g. (Manyena, 2006, Klein et al., 2003, Wisner et al., 2003, Mileti, 1999). For instance, Mileti (1999) explained that *"in the context of disaster management, resilience is used to describe the ability to resist or adapt to stress from hazards,* *and the ability to recover quickly"* (Mileti, 1999) or Wiesner et. al. (2003) defined resilience as *"the ability of an actor to cope with or adapt to hazard stress, which is a product of the degree of planned preparation undertaken in the light of potential hazard'* (Wisner et al., 2003). Moreover, according to UNISDR, the word resilience was defined as "*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and function*" (UN/ISDR, 2009c) pp 24.

Based on the several previous definitions given above, the city resilience can be seen as the city capacity and ability to resist from the effects of potential hazards in effective and efficient way through the implementation of certain policies before the disaster to protect the city or rebuild again the city to its essential basic structures and function as it was or better after the natural hazard happened.

In other words, the city residents should be "well prepared" and "less vulnerable" when the potential disaster hit the city in order to achieve "high level of resilience" (Cimellaro et al., 2010). In the level of strategies application, the implementation concept of city resilience in urban disaster risk reduction may also refer to the term of "adaptation strategies" in order to make the community more well prepared and to reduce the vulnerable level. The adaptation strategies may include several strategies such as land use and zoning plan in urban planning, protection of environmental resources, implementation of building code regulation, providing early warning system, improving public awareness and education about disaster risk, or government commitment and policies to support the risk reduction program (Carlsson et al., 2008).

From several strategies mentioned earlier, the possible strategies selected could be classified into the engineering and social resilience. The approach of engineering resilience more focus to the impact to people and city infrastructures (Vale and Campanella, 2005), while the social resilience more focus to improve the ability of city residents to cope with external shock or stresses, which may come from various aspects such as social, political and environmental changes (Adger, 2000). However, this research more focus on the aspect of engineering resilience approach in the aspect of land use planning because it is related to the application of land use and transport strategies in the framework of sustainability. In this context, the application of land use strategies are directed to reduce the distribution people and housing in the high-risk areas of the city by undertaking disaster risk assessment into land use planning in order to reduce the losses from fatalities and properties by planning city to be more less vulnerable to the potential hazard.

Moreover, according to the latest press release of the United Nations, the urban planners recommended that the concept of urban risk reduction will become very important issue in the future, which should be placed in the priority list of urban planning process as the result of rapid urbanization in many high-risk cities to natural hazard worldwide. The new building development in high-risk areas of the city should be avoided. On the other hand, for the existing building, the safety of city residents should be given special attention with other alternative safe strategies without necessarily forcing them to move to other areas. In addition, the building code regulation should be implemented in high-risk areas (UN, 2013).

It was also suggested that urban planning is a tool that play the main role in promoting the concept of urban risk reduction. Moreover, the aspect of disaster risk reduction should be incorporated in urban planning for reducing urban vulnerabilities in order to increase the quality of live city residents and reducing potential damage in the post disaster (Wamsler, 2006). Similarly, the World Bank through some case studies in developing cities such as Dar Es Salam, Jakarta, Mexico, Sao Paulo also recommended that the concept of urban risk assessment should be integrated in a city planning refer to the framework of urban risk reduction (Dickson et al., 2012). In addition, There were also some case studies, which could be seen regarding the implementation concept of urban risk reduction program in some Asian cities (Shaw et al., 2009).

In the framework of urban risk reduction (see Figure 2.2), the assessment of hazard and vulnerability play the main role in reducing the disaster risk in urban areas. However, the level of hazard and vulnerability could be different in each city, which depend on the various aspects. In this context, risk assessment is the main component that play the main role in urban risk reduction. The objective of risk assessment is to identify the risk of potential hazards (frequency and severity) and analyse the potential exposure of hazard to the urban areas, including vulnerability levels of city residents to the hazard. After that, the result of risk assessment is evaluated in order to find the possible strategies, which could be proposed in the context disaster risk reduction (Dickson et al., 2012). In more structure way, the main process in a framework risk analysis were namely hazard research, risk assessment and risk management can be seen in the Figure 2.2 below.

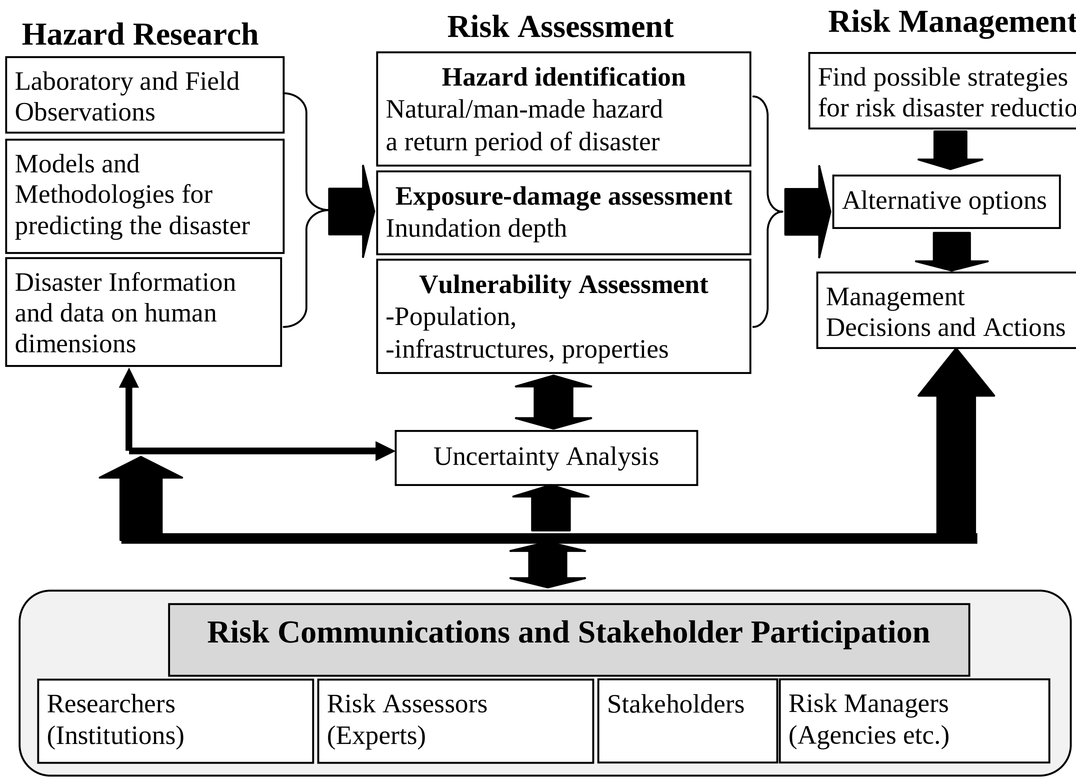

Figure 2.2: Framework of risk analysis assessment in disaster risk reduction (Ikeda, 2006) modified from (NRC, 1983)

The general framework of risk analysis in urban risk reduction consists of three main process, namely hazard research, risk assessment and risk management. Hazard research was a process to collect information about the hazard in the context disaster event from various scientific discipline such as seismology, climatology, environment etc. The result from previous analysis was used in the risk assessment process, which consist of hazard identification, exposure damage assessment and vulnerability assessment. After that the possible strategies were proposed in the risk management step that refer to the previous risk assessment analysis.

2.2.1.1 Disaster risk assessment

The process of disaster risk assessment play the main role in the framework of disaster risk analysis assessment before the possible strategies are selected to be applied. There were three factors considered in the disaster risk assessment process, namely hazard, exposure and vulnerability. These factors were interrelated each other's in the context of calculating the disaster risk. In other words, the disaster risk are the results of the interaction between hazard and vulnerability. There would not be a disaster if the hazard happen in empty areas, where there were not population that living there (without vulnerability) or there would not be a disaster without hazard event for the vulnerable city residents that living in disaster prone areas of the city (Wisner et al., 2003). Moreover, in the context of disaster risk, the risk refer to the possibility of loss based on the probability and magnitude of hazard that produce the loss, while the vulnerability refers to potential of damage or casualties in a particular element (Alexander, 1993). Therefore, the formulation of disaster risk calculation in mathematical equation is as follows :

Disaster risk = Hazard x Vulnerability…………………………...Equation 2.1

Furthermore, another past studies defined disaster risk as a factor that influenced by the product of hazard, the value element at risk and vulnerability. In this study, the concept of vulnerability was distinguished into the element at risk and vulnerability. In this context, the element at risk was defined as the people, building or infrastructures, including any other of city elements that exposed to the hazard. Vulnerability was defined as the degree of loss (fatalities) or the level of damage city element at risk (e.g. building damage) as a result of natural hazard event, which was related to the magnitude of hazard. In this context, the formulation of risk calculation was written as follows (Taylor, 2006) :

Disaster Risk = Hazard x Element at Risk x Vulnerability……….Equation 2.2

- Disaster risk .... Disaster risk in certain zone (index risk) (No unit)
- Hazard .... Assumption of probability of disaster risk in certain zone within certain period of time (e.g. 1 time in 30 years) (No unit)
- Element at risk ..... the potential of city element at risk (percentage of areas) that may be exposed to the tsunami risk in zone j. It is called the level of exposure (0%-100%) (Unit in Percentage).
- Vulnerability .... The degree of damage level (e.g. fatalities and building damage) as a result of tsunami inundated in a zone j of the city. It is called as level of vulnerability (0%-100%) (Unit in Percentage).

In the current practice, the National Economic and Development Authority (NEDA) under United Nations Development Programme used this concept to estimate the risk in land use planning in the framework of urban sustainable development (NEDA, 2008).

2.2.2 Concept of urban transport sustainability

As mentioned earlier, the Brundlant report about sustainable issue has been attracting various discipline of scientific knowledge to implement the concept of sustainable development. The key message in the Brundlant report was related to the concept of development that meet the needs of the present of today generation without sacrificing the needs of the future generations (WCED, 1987b). In the context of urban transportation, the sustainable development definition mentioned earlier also adopted in the context of urban transportation planning issues. In 1996, since the Bruntland report was released, and the OECD (Organization for Economic Co-operation and Development) started to put the issue of urban transport sustainability through a sustainable transport project in more clear context to be implemented in the reality. This project was called as the ‘Environmentally Sustainable Transport’ (EST) project. Moreover, this project also defined what the meaning of environmental urban transport in the context achieving the objective of sustainable development. In this project, the sustainable transport is defined as “where transport does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources below their rates of regeneration, and (b) use of non-renewable resources below the rates of development of renewable substitutes” (OECD, 1996). In other words, the sustainable transport system should promote the movement people or goods in a sustainable way by balancing the aspect of environment, economic and social.

Furthermore, based on the project report, it was also noted that the sustainable transport system should fulfil some criteria such as (1) providing the movement process of people, places, goods, and services in efficient way and safe, (2) fulfil the standard requirement of health and environment (air pollutant limits), (3) ensure to protect the ecosystem, (4) minimizing the negative impact to global phenomena such as climate change (Wiederkehr et al., 2004). In other research study in sustainable development in Europe through PROSPECTS project (Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems) defined the concept of urban transport sustainability in the context of land use and transport plan interaction. There were several criteria that should be fulfilled by a city in the framework of urban transport sustainability as follows: "*Provides access to goods and services in an efficient way for all inhabitants of the urban area, protects the environment, cultural heritage and ecosystems for the present generation, and does not jeopardize the opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage*" (May et al., 2003) pp. 12.

However, from both of these two projects, it can be seen that the objectives of urban transport sustainability are directed to achieve the city objectives that balancing the aspect of economic, environment and social. In a more structure way, the environmentally sustainable transport (EST) distinguish the proposed future urban transport compared to conventional plan approach in three differences as shown in Figure 2.3.

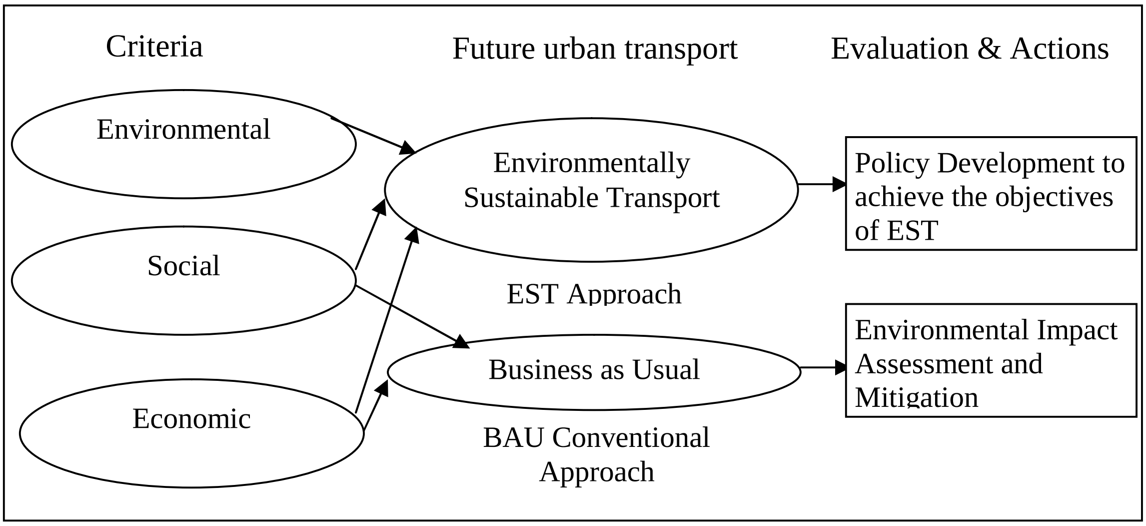

Figure 2.3: Comparison concept of urban transport sustainability EST version with conventional approach

Source : (OECD, 1996) and (OECD, 1998b) in (OECD, 2002)

As can be seen in the Figure 2.3, the first difference was related to the objective of EST approach that consistent with the objective of sustainable development by balancing the aspect of environment, social and economic, while the conventional approach does not fulfil the specific requirement of sustainable development. The second difference is that the EST approach totally concern on the environment impact of transport in dynamic process, while the conventional approach only focus on the impact of certain transport activity at present time without consider the growth of transport activity in the future for instance. Last but not least, the EST approach also proposed the development of the future strategy of urban transport in order to achieve the objective of sustainability such as policy to reduce the growth of environmental negative impact from transport activity as can be seen in the Figure 2.4 (OECD, 2002).

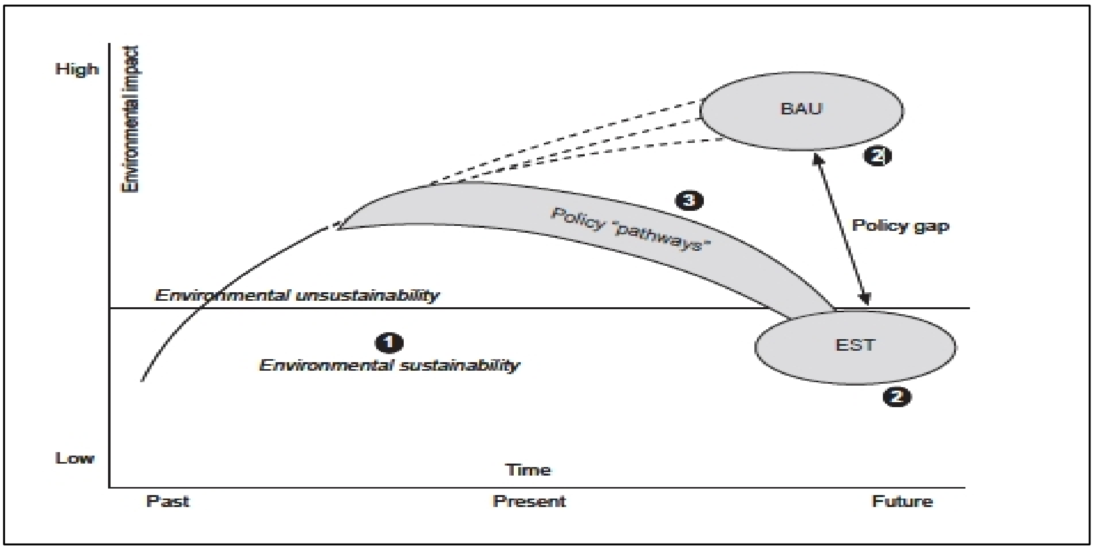

Figure 2.4: The policy gap between urban transport sustainability strategy with conventional strategy

Source : (OECD, 1998b) in (OECD, 2002)

From the Figure 2.4, it can be seen that the policy proposed in the concept of EST urban transport sustainability approach refer to current situation and future projection condition. The policy pathways was directed to sustainable condition in the future from unsustainable condition at present time. In other words, it was expected that the EST policy can reduce the environmental impact between do nothing scenario and do something scenario in the next future situation based on projection refer to the current situation and in the past. However, it can also be seen that the more many innovative strategies in do something scenario (EST) increased the policy gap that result in lowering the negative environmental impact. Therefore, the possible policies proposed in do something scenario was not limited to the current policies, but also they could broaden in order to cope the problems based on future scenario projections in the future (OECD, 2002).

For instance, a good example of PROSPECTS conceptual framework about city guidelines in the framework of urban transport sustainability could be used to find the land use and transport strategies that meet sustainability requirement. the conceptual approach of sustainable city was started with defining the city objectives. The city objectives were directed to achieve the sustainable city agenda through land use and transport strategies. In this context, the sustainable city agenda was defined based on sustainability definition, which was then interpreted into several sub-objectives. After that, the list of performance indicators in each sub-objectives were developed. The conceptual approach for finding land use and transport strategies can be seen in the Figure 2.5 below.

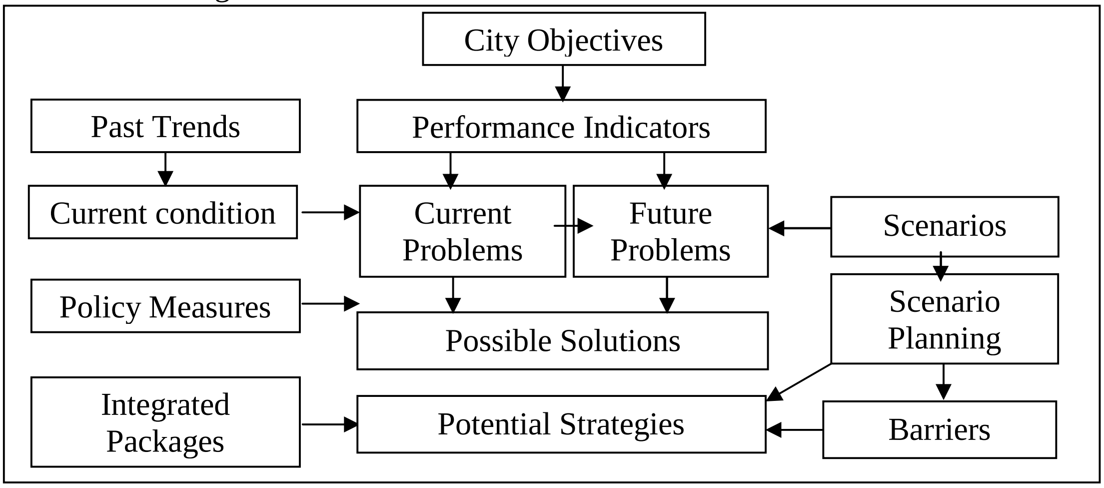

Figure 2.5: Conceptual structure for finding strategies in the framework of urban transport sustainability (May et al., 2001)

The city objectives developed (including with performance indicators) selected then were used as a basis to identify the problem at present time and in the next future years projection. It was assumed that the problem identification refer to the unsustainable condition where the city objectives was not achieved yet. In this context, the unsustainable condition was identified using list or performance indicators in each objective that was already developed. The city problems at present time were explained based on current condition, which refer to the trend in the past. Equally, the future problems were projected based on current problems that also refer to the trend in the past. However, it should be noted that the future problems projection also influenced by several assumptions in the future scenario condition.

After the current problems and future projection problems was identified, it becomes possible to consider several possible alternative solutions. The possible solutions could be obtained from a wide range of land use and transport measures in the framework of urban transport sustainability. After that, the potential strategies from several possible solutions could be selected, which refer to the scenario planning by addressing some barriers in the context of strategies implementation. In addition, the integrated packages of combined land use and transport strategies could be also proposed to be used as potential strategies, which could be possible to be implemented in the reality (May et al., 2001). In this context, identification of land use and transport problem in a case study area selected plays a main role in finding the possible strategies selected in order to achieve the city objectives, which are planned to be achieved.

The data related land use and transport interaction should be collected to describe the land use and transport condition in the case study area selected. The data collected could be such as GDP of country and city, city residents in each zone, household income, vehicle ownership and modal split. All of these data might interrelate each others. For instance, there is strong relationship between income growth and vehicle ownership. Economic growth is likely to increase, which could increase the demand in transportation (Dargay and Gately, 1999). In 2002, the number of vehicles, which owned by non-OECD countries, were only 24% of total vehicles ownership in the world. In fact, the faster economic growth in some developing countries increased the percentage of vehicles ownership more than two-fold to 56% in 2007 (Dargay et al., 2007). However, the increase of economic growth is a positive thing, which is expected. Therefore, the economic development should be increased, while the increase of transport demand as a result of positive economic growth should be well managed. If the transport demand is no well managed, the sustainability city objectives in the aspect of urban-transport issue are difficult to be achieved.

For instance, the number of people that used private vehicles in the cities of developing countries such as in Riyadh, Jakarta, Hanoi and Kuala Lumpur was much higher compared to other Asian cities such as Hong- Kong, Shanghai and Singapore (Senbil et al., 2007, Haghshenas et al., 2013). This condition could be used as one of indicators to measure the level of sustainability in the framework of urban-transport issue (Haghshenas and Vaziri, 2012).

2.3 City objectives in the framework of urban sustainable development

This section discussed about the city objectives in the framework of urban sustainable development. In this sub section, the discussion of city objectives in the framework of sustainable development was classified into the city objectives in the framework of urban risk reduction (2.3.1) and urban transport sustainability (2.3.2)

2.3.1 City objectives in the framework of urban risk reduction

All the city objectives in the framework of urban risk reduction refer to the concept of urban risk reduction that has been discussed in section 2.2.1. As mentioned earlier, most of the concept of urban risk reduction refer to the Hyogo framework action plan (the Five HFA priorities action plan), which were then interpreted into several strategies disaster risk reduction by the United Nation (UN/ISDR, 2005). In the Hyogo framework plan, it was expected that the city action plan should consider disaster losses through disaster risk reduction program such as live, the asset of economic and environment, including social aspect of city communities (UN/ISDR, 2012b).

Therefore, the main city objectives selected in the framework of urban risk reduction should has an objective to reduce the increasing of disaster and it is also expected that the city will become more resilient to disaster in the future (UN/ISDR, 2009b). According to the UNISDR terminology, the resilient city is defined as a city that has a capacity to withstand against the potential effect and impact of hazard that exposed the areas of the city trough adaptation, preservation or restoration in efficient and effective way, which has the ability to recover after the event of hazard (UN/ISDR, 2009c). In other words, the objectives of resilient city can be achieved through combination the urban planning process in the pre disaster response and the specific actions of disaster mitigation aspect in the post disaster response. The response in pre and post disaster program can be done through several activities such as (a) integrating the aspect of disaster risk reduction in urban planning process, (b) building the disaster management board that can be used to facilitate the consultation process between multi stakeholders, (c) developing and providing the infrastructure for hazard mitigation, (d) Improving the awareness about disaster risk reduction through education such as training programmes (UN/ISDR, 2012c).

Furthermore, there were several aspects that should be considered in order to achieve the city objectives in the framework of disaster risk reduction, which consist of “1) institutional and administrative framework for risk reduction, 2) financing and resources for risk reduction, 3) multi-hazard risk assessment know your risk, 4) infrastructure protection, upgrading, and resilience, 5) protect vital facilities : education and health, 6) Urban planning and building regulations, 7) Training, education and public awareness, 8) Environmental protection, including protecting ecosystems, 9) Effective preparedness, Early warning and response, 10) Recovery and rebuilding communities (UN/ISDR, 2012c)”.

In the context of prevention and mitigation aspect, the city plan can have the objectives in the framework of urban risk reduction such as reduce exposure and vulnerability of population that live in hazard prone areas and increase the capacity and ability of the population to deal with the negative impact of hazard in order to reduce the disaster risk. These are two city objectives can be applied in the national or local city plan in the framework of urban risk reduction (DILG, 2011, BAPPENAS and BNPB, 2006). In the context of huge potential disaster, a big disaster can be triggered by the natural hazards such as tsunami. In this case, the authority should give more attention in two aspects. The aspects considered were related to (1) strengthen the concept of disaster risk reduction in urban planning and (2) the preparedness for emergency response (IOC, 2008).

2.3.2 City objectives in the framework of urban transport sustainability

According to the PROSPECTS project (Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems), the objectives of urban transport sustainability consisted of seven specific objectives as follows : (1) achieving economic efficiency, (2) protection of the environment, (3) creating liveable street and environment, (4) Improving safety, (5) Equity and social inclusion, (6) supporting the economic growth, (7) and intergenerational equity (May et al., 2003).

In the first sub objective, the economic efficiency was related to maximizing the benefit of urban-transport system for people after considering the resources cost for provision and operation of transport system (May et al., 2003). In the context of transport planning and policy, reducing unit cost for travel was one of the examples regarding how the transport planning was directed to achieve the sub objective of economic efficiency of urban-transport system (Litman, 2010). The second sub objective was related to the protection of the environment, which has an objective to reduce the environmental degradation. In this context, the negative impact of human interaction and urban development process in the context of land use and transport system interaction should be reduced (May et al., 2003). For instance, urban sprawl development that create the automobile dependency should be avoided because this situation produced more air pollution from transport sector, which potentially increased the greenhouse gases that contribute to climate change (Petersen, 2004).

The third sub objective was creating liveable street and environment. This sub objective was related to the effort for creating the urban environment that more friendly to walking and cycling modes. In this context, the city residents feel free to do the outdoor activities such as social, cultural or recreational without using motorization modes (May et al., 2003). The fourth sub objective was related to safety issue. This objective include the effort to reduce number of accidents for all modes of transport (May et al., 2003). For instance, road accidents were significantly rising in developing countries due to the number of motorcycles was growing rapidly (Morris, 2006). Consequently, more motorcyclist potentially increased the potential road accident since the physical vulnerability of driver and passenger compared to four wheel vehicles. The safety level might be improved if the motorcyclist can be encouraged to use public transport system. Improving level service of bus (e.g. reduction travel time) was one of alternatives to promote modal shift from motorcycles to public transport system (A. K et al., 2006).

The fifth sub objective was related to the issue of equity and social inclusion. In this context, the equity was related to the principle concerns about giving the same opportunities to make a journey, cost of travel and environment, including safety aspect. Social inclusion was related to giving access for poor people that does not have private vehicles, including disable people, which have limited mobility (May et al., 2003). The sixth sub objectives was related to contribution to economic growth issue. In this context, the land use and transport strategies proposed should give contribution to the economic growth. Last but not least, intergenerational equity was the last important objective that should be considered in the context of achieving sustainability city agenda. In this context, the implication of land use and transport impact was not only consider at present time, but also the potential impact in the future should take into account. For instance, carbon emission from transport sector as a result of human interaction in urban areas at present time impacted to the climate change. This condition potentially created adverse impact for future generations (May et al., 2003).

In another project of urban transport sustainability, which was called sustainability mobility plan for long term strategic city plan, the urban transport system should consider several objectives such as (1) the accessibility that offered by urban transport system can be accessed by all city residents, (2) the urban transport plan should improve the safety and the security aspect, (3) the city plan should consider the energy consumption in urban transport activity and the negative impacts produced from the urban mobility activities such as air and noise pollution, (4) the city plan selected should also consider the aspect of cost efficiency in the urban transportation system for city residents and goods, (5) the city plan should also improve the quality of city environment through integrated urban design in the framework of urban transport sustainability (Bührmann et al., 2011). However, the city objectives selected should refer to the city characteristics and the priority city program that want to be achieved. The city stakeholders played the main role in determining the city objectives that were planned to be listed in the city priority program (May et al., 2001).

2.4 Indicators in the framework of urban sustainable development

The indicators discussed in the framework of urban sustainable development were distinguished into the indicators used in the framework of urban risk reduction (2.4.1) and urban transport sustainability (2.4.2).

2.4.1 Indicators in the framework of urban risk reduction

As mentioned earlier in the sub section 2.3.1, according to Hyogo Framework plan, it was expected that the city objectives was to reduce the disaster losses and residents that are affected (UN/ISDR, 2005). Based on these objectives, there were three main indicators that proposed by Hyogo Framework plan as follows (UN/ISDR, 2008) such as (1) number of fatalities as a result of the natural hazard event, (2) total of loses from economic aspect because of natural hazard event, (3) Number of city residents that affected by natural hazard events.

The similar indicators were also used by a study under the overseas development institute (ODI). In this study the indicators selected were classified based on the goal and targets that are planned to be achieved. For instance, the number of people that exposed to potential hazard are also used as an indicator to measure the performance strategies selected in disaster risk management program (Mitchell et al., 2013). The other similar concept of indicator used also could be seen in several other past studies (UNDP, 2004, Dilley et al., 2005)

Furthermore, social vulnerability index can be also used in order to predict the negative impact of disaster event based on social perspectives. This indicator can be used to support the physical vulnerability indicator mentioned earlier in the first two paragraphs for developing multi-hazard assessment. Therefore, the vulnerability indicator can be seen as the factor that influenced by the interaction of physical and social indicators (Cutter et al., 2003). In other words, the level of people vulnerable to the potential hazards not only depends on how far they were from the source of the hazard, but is also influenced by the social aspect. In this context, the integration of physical hazard and social vulnerability in measuring the risk could be used in disaster reduction plan (Collins et al., 2009).

2.4.2 Indicators in the framework of urban transport sustainability

According to PROSPECTS project for making city requirements in the framework of urban transport sustainability, there were several indicators that can be used to measure the successful strategies selected that are directed to achieve the city objectives. (May et al., 2001). Table 2.1 below shows the possible indicators that can be used to measure the objectives of urban transport sustainability.

Objective	Indicators level 1	Indicator level 2
Economic efficiency	Net present value	Time, money
Environment	Environmental cost	Emission, Noise
Liveable street	-	Vulnerable city residents to accidents
Safety	Cost of accidents	Number of accidents
Equity	Accessibility of poor and disabled people	-
Economic Growth	Increase in GDP	-
Intergenerational Equity	CO2 costs	Fuel consumption

Table 2.1: Possible indicators to measures the objective of urban transport sustainability (May et al., 2003)

As can be seen in Table 2.1, there were two level indicators proposed in the PROSPECT project that were used to measure the city strategies selected in the framework of urban transport sustainability. Indicators used in the level 1 were general indicators that obtained based on the city objectives that were already defined. All of these indicators were quantitatively used to comprehensively measure the city objectives. Indicators proposed in the level 2 were also the indicators that used to measure the city objective achievement quantitatively. These indicators depend on the data availability. In other words, in this level all of the city objectives selected can be quantitatively measured in order to check whether the strategies selected meet the city objective or not. However, there were another indicators that was not show in the Table 2.1, which was classified as indicators in the level 3. In this level, the indicators proposed were used to measure qualitatively the achievement of city objectives. All in all, the indicators should cover the whole range of city objectives selected to provide enough information for stakeholders (May et al., 2003).

2.5 Strategies in urban sustainable development

This chapter discussed about the possible strategies in the framework of urban sustainable development. The concept of urban sustainable development as a response to address the background problems of high-risk cities was already discussed in section 2.2. Therefore, the possible strategies discussed in this section referred to the concept of urban risk reduction and urban transport sustainability as discussed in the previous sections (2.2.1 and 2.2.2), which were directed to overcome city problems related disaster risk to natural hazard and carbon emission from transport sector that mentioned in previous Chapter 1 section1.2.1 and 1.2.2.

For that reason, there were two dimension strategies that were discussed in this section regarding the city concept plan in the framework of urban sustainable development. Firstly, it was related to several disaster risk reduction strategies in the framework of urban risk reduction. Second, it was related to several land use and transport strategies in the framework of urban transport sustainability. In a more structured way,

Furthermore, it was also needed to explain what the meaning of strategy is in the context of this research. Generally, the strategy was defined as what need to be done in achieving the goal (Porter, 1996). In the context of this section, the strategy was defined as what we need to be done in achieving the city objectives. In the context of the research, the city objectives referred to the objectives of urban sustainable development, which was limited in the context of urban risk reduction to natural hazard (e.g. tsunami) and urban transport sustainability (e.g. carbon emission from transport sector).

However, the strategy need policy instruments and policy measures to achieve the city objectives. In general, policy was defined as law systems, measures in regulation, courses of action, and funding priorities that made by a governmental institution or its representatives in order to address public issue (Kilpatrick, 2000). The policy brought government vision to achieve the objective in the plan that made in institutional environment with supported by political power (Considene, 2005). Therefore, in the context of the issue discussed, the policy instrument was defined as a tool that can be used by policy makers (government institution) to overcome the urban problems related disaster risk or transport in order to achieve the city objectives (May et al., 2001, Lim et al., 2004). In more specific level, the policy measures was defined as an instrument that can be applied by policy makers to achieve the policy objective, both in the context of urban risk reduction or urban transport sustainability (May et al., 2001, Lim et al., 2004). For that reason, the possible strategies discussed in this section also covered the discussion about policy instruments and measures to support the strategies discussed in the context achieving city objectives in the framework of urban risk reduction and urban transport sustainability.

2.5.1 Possible strategies in urban risk reduction

The strategies proposed in disaster risk reduction regarding natural hazard can be found in the organizations data base such as UN (Isoard et al., 2008) International Decade for Natural Disaster Reduction (IDNDR), Yokohama Strategy and Plan of Action for a Safer World, UN International Strategy for Disaster Reduction (ISDR), Hyogo Framework for Action 2005–15. Moreover, the possible strategies in climate change adaptation (e.g. sea level rise) can be also seen in several organization reports such as National communications to the UNFCCC or National Adaptation Plans of Action (NAPA) for Least Developed Countries (Thomalla et al., 2006).

However, there were relevance and similarity between the concept of strategy adaptation in the context of disaster risk reduction to natural hazard (e.g. Earthquake, tsunami, flood) and climate change (e.g. sea level rise). For instance, coastal city residents, who survived in the tsunami tragedy, were also likely to consider the long-term impact of climate change (e.g. sea level rise that may trigger flood in low lying coastal areas of the city) e.g. see report (Hallegatte et al., 2013), if the awareness of people about the such hazards consequences was improved through disaster risk reduction strategy as part of government program for instance (Baker, 2010).

In general, there were three type of strategies that could be implemented in the context disaster risk reduction to natural hazard (e.g. tsunami), including climate change adaptation strategy (sea level rise context), namely planned-retreat, accommodation and protection strategies (Dronkers et al., 1990, IOC, 2008, Ishiwatari and Onishi, 2012).

The planned retreat strategy was defined as the strategy that do not allow the development in vulnerable coastal areas. In this strategy, there is no protection in the land from potential hazard from the sea. This strategy was influenced by the effort to reduce the excessive economic and environmental impact in urban development process that expand into green protected areas (Dronkers et al., 1990). For instance, mangrove forest in the wetlands near to the coastal zones should be protected, which potentially reduced the impact of tsunami disaster or sea level rise (Nicholls et al., 1999, EJFCT, 2006).

The accommodation strategy was defined as the strategy that continue development process in high risk areas of the city, which does not followed by the effort to prevent the land from the potential flood. This strategy concern on conservation of ecosystem with include some adaptation options as a response to potential disaster risk such as building emergency flood shelters, elevating buildings, converting the function of land use (agriculture to fishery in the coastal zones). In similar land use plan, the protection strategy was defined as the strategy that related to mitigation effort by providing hard structural options (e.g. sea wall) or soft structural options (dune restoration or wetland creation) in order to reduce the impact of hazard that comes from the sea. The existing land use development in high-risk areas of the city can be continued in this strategy (Dronkers et al., 1990).

In the context of land use planning, the strategies mentioned earlier also discussed regarding whether the high-risk areas of the city can be used as a new promoted development or not, and what were the recommended adaptation strategies that should be selected (Abel et al., 2011, Niven and Bardsley, 2013, Ingram et al., 2006). Table below shows the description of strategies mentioned earlier in the context of land use strategy in the context of urban planning issue.

No	Disaster Risk Reduction Strategy	Description of strategy (Land use Planning)
1	Planned-retreat	Banning development in high-risk areas
2	Accommodation	Allowing development in high-risk areas
3	Protection	Allowing development in high-risk areas

Table 2.2: Description of disaster risk reduction strategy in the context of land use planning (Dronkers et al., 1990, Baker, 2010)

2.5.1.1 Policy instruments and measures in planned-retreat strategy

In the context of planned retreat adaptation strategy, the type of the policies selected were in the form of very strict regulation (extreme case) by abandon the whole of high-risk areas (strict zoning plan) or it can be also to apply through the government intervention in the marker through subsidies, incentives or insurance to reduce risk in the context limiting the development in high-risk areas of the city (Bagstad et al., 2007, Boateng, 2008). However, it should be note that the implementation of strong regulation and legislation played the main role in directing the policy instruments to achieve the planned-retreat strategy objectives (Boateng, 2008).

In most cases, these policy measures were applied as a response to people behaviour that tend to avoid the implementation of disaster mitigation concept. A past study about risk management related flood hazard indicated that a new development in flood-prone area continuously increased if the city authority did not apply the strict regulation to force people for moving to low risk areas or without any government incentive policy (Cigler, 1996). The city residents tended to underestimate the probability of future disaster (Kunreuther, 2006). Table 2.3 below shows the types of policy instruments that can be possible to apply in planned-retreat strategy to achieve the sustainable city agenda in the context of urban risk reduction.

No	**Policies in Planned-retreat**	**Description of Policies (Land use Planning)**
1	Very strict zoning plan	Totally banning development in high-risk areas through forcing land use regulation policy.
2	Pricing policy	Reducing the potential of new development in high-risk areas through financial incentives subsidies and insurance policies.

Table 2.3: General type of policies instruments in planned-retreat strategy (UN/ISDR, 2012c, UN/ISDR, 2012a)

From Table 2.3, it can be seen that, generally there were two types of policy instruments that could be applied in the planned retreat strategy. The first policy instrument was related to applying very strict zoning plan through implementation of strict regulation to prevent people to reside in high-risk areas of the city. On the other hand, the second policy instrument applied pricing policy to reduce number of potential people in future development that reside in disaster prone areas of the city Table 2.4 below shows the policy measures of strict zoning plan policy instrument through land use regulation policy by not re-issue the new permit development for business and housing in disaster prone areas of the city.

No	Policies in Planned-retreat	Description of Policies (Land use Planning)
1	Strict Zoning plan	Totally banning development in high-risk areas through forcing land use regulation policy.
	Policy Measures	**Description of Measures**
A	Land use regulation policy measures	Banning business and residential development in disaster prone areas through government legislation and regulation (Stop new permit for new development). For general concept land use plan see the guidelines from International Decade for Natural Disaster Reduction (IDNDR) (IDNDR, 2000). For the real practice see some case study in some city. (Beacon, 2013, Huffpost-Alberta, 2013)

Table 2.4: Policy measures in strict zoning plan policy of planned-retreat strategy (IDNDR, 2000)

As can be seen in Table 2.4, the possible land use measure selected was related to apply a new permit regulation for building development in high-risk areas of the city. In this context, the city authority should have a good data and information about the potential disaster risk in all of areas of the city. After that, the policy makers should also make the analysis about the risk assessment of potential hazards in all areas/districts/zones of the city. The objective of risk assessment was to direct urban development to low risk areas in order to reduce the vulnerability of communities or assets to the potential hazard (ADPC, 2013).

For instance, the Alberta city in Canada introduced a new policy to ban new business and housing development in disaster prone area of the city. The city government stopped to issue permit for new business and housing development in southern areas of the city, which have been identified as high-risk areas to flood.

Furthermore, the government also gave two options policy for city residents. The first policy, the city authority helped the existing city residents for those that would rebuild and repair their damaged house. However, the government also announced that they would not allocate any more the budget for future disaster recovery fund assistance. In other words, the existing city residents that decided to stay in high-risk areas would take the future risk. On the other hand, the city government encouraged the existing city residents to avoid the potential flood risk in the future by providing financial support for those who prefer to move to low risk areas of the city (Huffpost-Alberta, 2013).

The pricing policy instruments can be also applied to achieve the objective of planned-retreat strategy. Table 2.5 below shows the policy measures that possible to be applied in pricing policy instruments in order to achieve the city objective in the planned-retreat strategy.

No	**Policies in Planned-retreat**	**Description of Policies (Land use Planning)**
1	Pricing Policy	Reducing the potential new development in high-risk areas of the city
	Policy Measures	**Description of Measures**
A	Incentives (e.g. tax)	Increasing land and property tax in high-risk areas and reducing the taxes in low risk areas of the city
B	Subsidies	Providing financial support for city residents that want to move to low-risk areas of the city

Table 2.5: Policy measures in pricing policy instrument of planned-retreat strategy (Bagstad et al., 2007, Myers, 2013, ADPC, 2013)

In this policy measure, the government objectives was to reduce the potential new development in high-risk areas by intervening market price (e.g. building or land price) to reduce the attractiveness of high-risk areas of the city. As known that, in most cases, the housing and land price or rent in disaster prone areas of the city can reduce significantly after these areas have been identified as high-risk areas. For instance, in a case study of a city in Japan, the rent of housing in the area of earthquake disaster was relatively lower compared to the other areas, which are relatively safe to the hazard of disaster. In fact, the housing average rent reduced 16% of average rent and the housing value decreased 13% after the disaster tragedy (Naoi et al., 2009). Similarly in Indonesia, the impact of earthquake and tsunami in 2004 and earthquake in 2007 also influenced the property values in high-risk areas of the city (Syahid, 2011).

As can be seen in Table 2.5 earlier, the policy measures that are possible to be applied in pricing policy instruments consist of incentives (e.g. fiscal incentive through tax), subsidies and insurance. It is also needed to understand what is the definition of these measures in the context of urban risk reduction issue.

According to United Nations International Strategy for Disaster Risk Reduction (UN/ISDR), the financial incentive played the main role in directing the urban development in the context of reduction the disaster of risk. In this context, financial incentive was defined as a financial tool to encourage or motivate communities or business to develop or invest in condition and situation that related to the risk reduction effort (UN/ISDR, 2012a). In reality, tax policy as an incentive was a measure that can be implemented to encourage the urban development in the right path based on urban spatial planning (Papke, 1994). For instance, the land and property tax was used to reduce the density population in the certain zone of urban areas if the land or property tax was increased (Song and Zenou, 2006, Banzhaf and Lavery, 2010). Moreover, the incentives (e.g. concession through tax breaks) or disincentives policy measures was also influenced the development process in sustainable way (Daly and Farley, 2004). In other words, the financial incentive measure was an alternative measure to limit the urban development in high-risk areas of the city and at the same time, it was used to encourage the direction of development to low risk areas of the city (ADPC, 2013).

On the other hand, subsidy was a government payment that allocate in budget expenditure, which had opposite function compared to tax (Daly and Farley, 2004). it was defined as "a form of government support to an economic sector (or institution, business, individual), generally with the aim of promoting an activity that the government considers beneficial to the economy overall and to society at large (Myers and Kent, 1998) pp.5". In the context of disaster risk reduction program, the subsidy as a financial tool can be also used to improve the urban facilities that related to disaster mitigation program. For instance, the government could allocate the financial support for city residents to adopt and implement the building code regulation (ADPC, 2013). However, in the context planned-retreat strategy, the scheme subsidy for possibility of housing damage in high-risk areas should be reduced or eliminated in order to attract people for moving to low risk areas.

2.5.1.2 Policy instruments and measures in accommodation strategy

As mentioned earlier, in the accommodation strategy, the high-risk areas of the city are allowed to be used as a new promoted development areas. The objective of this strategy was to reduce the disaster risk by encouraging people or business to develop building based on adaptation strategy (ADPC, 2013). Therefore, all the policy measures in this strategy were related to building adaptation to potential hazard such as providing emergency flood shelters or escape building, implementing building code regulation for building development, elevating buildings on piles to avoid damage impact of floods and etc. (Dronkers et al., 1990, Johnson, 2011). For instance, the regulation for new building (e.g. housing) such as implementation of building code regulation could reduce the disaster risk such as earthquake (Burby et al., 1998, Spence, 2004).

Similar with planned-retreat strategy, the policy measures in this strategy could also use the concept of pricing policy to attract people to reduce the disaster risk by strengthening the housing in mitigation measures for instance. Table 2.6 shows the possible measures in accommodation strategy.

No	Policies in Accommodation	Description of Policies (Land use Planning)
1	Pricing Policy	Providing financial support for people that reside in high-risk areas
	Policy Measures	**Description of Measures**
A	Tax Incentive	Giving tax incentive for city residents that adopt/implement mitigation measures
B	Subsidies	Allocating subsidy for communities in high-risk areas to implement adaptation measures (subsidy for adapted housing)

Table 2.6 : Policy measures in pricing policy instrument of accommodation strategy (Kunreuther, 2006, Bagstad et al., 2007)

All of the policy measures in accommodation strategy are directed to assist the communities that reside in high-risk areas of the city. For instance, the tax incentive could be applied to encourage people to apply the measures of disaster risk reduction. In this case, the city resident, who implemented the building code regulation, could get the discount for their land and property tax (Kunreuther, 2006). Moreover, the subsidy as a financial tool could be also used to improve the urban facilities that related to disaster mitigation program. In this context, the government could allocate the financial support for city residents to adopt and implement the building code regulation for instance (ADPC, 2013).

2.5.1.3 Policy instruments and measures in protection strategy

Similar with accommodation strategy, the protection strategy allowed the new promoted development in high-risk areas of the city. However, in this strategy, the hard structures or soft structure should be built to reduce the potential disaster risk (Dronkers et al., 1990). Therefore, all policies measures in this strategy were related to the effort to build protective structures and infrastructures such as engineering structures in order to reduce the risk (SDC, 2008). Table 2.7 below shows the possible policy measures in protection strategy.

No	Policies instruments	Description of Policies (Land use Planning)
1	Budget allocation for hard structures	Building hard structure/soft structure in high-risk areas of the city
2	Pricing Policy	Providing financial support for housing development in high-risk areas of the city
	Policy Measures	**Description of Measures**
A	Building hard protection structures	Reducing the impact of disaster risk e.g. tsunami, sea level rise, storm surges.
B	Subsidies	Allocating subsidy for communities in high-risk areas of the city

Table 2.7: Policy measures in protection strategy (Ishiwatari and Sagara, 2012, Bagstad et al., 2007)

The policy measures in this strategy involved the measures such as development of hard protective structures such as sea walls for tsunami or sea level rise and dikes for hazard reduction that come from the sea. In addition, the soft alternative solutions such as dunes and vegetation (e.g. mangrove) also could be used as the protections to reduce the disaster risk (Dronkers et al., 1990). For instance, the Japan government built a huge tsunami walls in Miyako City, Iwate Prefecture, Tohoku region in Japan. The development of this huge wall took more than thirty years long period to be finished. Moreover, the development of this protective structures was not only has an objective to withstand the tsunami but also other natural hazard such as storm surges (Ishiwatari and Sagara, 2012).

As can be seen in the Table 2.7, the possible policy instruments, which could be selected, consisted of government budget allocation for hard structure and pricing policy. The government budget allocation was used to support the policy measures of building hard protection structures. In this policy measures, the city authority spent more budget to develop the protection infrastructure to protect the disaster risk. On the other hand, the government should also allocate other budget for disaster fund assistance in the case, when the protection structure fail to reduce the disaster risk as expected. In this case, subsidies and insurance could also be used to help the communities in high-risk areas of the city (ADPC, 2013, Burby, 2006).

However, it should be noted that the cost for protection structure building was quite expensive. On the other hand, it should be also noted that many protective hard structures such as dikes and breakwaters were destroyed by the huge and destructive natural hazard such as tsunami (Fraser et al., 2013, Yeh et al., 2013). Therefore, the structure protection developed should be designed for only one events to prevent the fatalities, including damages on housing and infrastructure and two event for objective to reduce damage in lower scale compared to the first event (Ishiwatari and Sagara, 2012). Moreover, it should be also noted that the protection structures could also fail. For that reason, another instruments, which also played the main role in reducing disaster risk, was related to providing early warning system for detecting the potential hazard in advance (Waidyanatha, 2010). The objective of installing early warning system was to strengthen and improve the communities in high-risk areas of the city that threatened by hazard to response quickly in order to reduce the potential loss such as loss of life, injuries, property damage and other loss (UN, 2006).

The advance information from early warning system about oncoming hazard such as tsunami, hurricane, storm surges could give time for city residents to leave high-risk areas of the city immediately. In this context, the fast information that spread to the communities and including the accurateness of time warning played the main role in reducing the potential fatalities or injuries. For instance, in the case storm surge or flood hazard, people in coastal areas could also reduce the potential damage of their valuable things. The advance warning from early warning system could give enough time for the householders or business owner to move their expensive or beneficial stuff to higher floors to avoid potential damage from flood (Kunreuther and Michel-Kerjan, 2012).

2.5.2 Possible strategies in urban transport sustainability

There are many possible strategies that can be selected in the context of urban transport sustainability. In general, according to guideline book of developing land use and transport strategies in PROSPECTS project, there were four important key element in urban transport strategy that could be proposed in order to reach the sustainable city agenda. The key important element mentioned were as follows :

1) Reducing the need to travel at present time and in the future.
2) Reducing the need to travel by motorised vehicles and promoting the travel by non-motorised.
3) Reducing the individual travel using motorised private vehicles by improving the public transport system.
4) Improving the performance of road network (Minken et al., 2003).

From the four key element of urban transport strategy, there were some possible urban transport strategies that can be selected in order to reach the sustainability objective. In other words, it could be understood that the alternative solutions for urban transport problems do not consist of single strategy. All of the possible strategies interrelated to each other to achieve the city sustainability objectives. For instance, if the need to travel could not be reduced at present time, which potentially increase the travel by car, therefore, the new road development should be limited to attract people to use public transport system (Minken et al., 2003).

Furthermore, the key element of urban transport strategies mentioned earlier also need the policy instruments to direct the strategy on the right path to achieve the objectives of urban transport sustainability. For instance, the lack of land use planning create the dispersed development (urban sprawl). This condition increased the demand for using motorised vehicles that increase the transport problems such as traffic congestion and air pollution (Petersen, 2004). Therefore, the land use policy could be used as an alternative solution to promote compact city in order to reduce the need to travel by motorised vehicles. On the other hand, the pricing policy was an alternative that could be applied to reduce the travel by private vehicles and promoting modal shift from private vehicles to public transport system (Minken et al., 2003). However, the policy measures selected also could be combined in order to achieve the similar objectives of urban transport strategies (May et al., 2006).

In similar project, the PROSPECT project classified the land use and transport policy instruments into six types, namely : land use measures, infrastructure provision, infrastructure management, information, attitudes and pricing. All of these policy instruments were directed to reach the city sustainability that has mentioned earlier. Moreover, in this project, the objectives priority of city sustainability were distinguished into four areas, namely core area (city centre), inner sub-urban areas, outer sub-urban areas, and smaller urban areas. For instance, Table 2.8 below shows how the urban transport policy instruments are directed to reach the objectives of sustainability for city centre areas.

City Centre	Sustainability objectives						
Policy	Efficiency	Environment	Liveability	Safety	Equity	Economy	Future generations
Land use	●	●	●●			●●●	●●●
Infrastructure	●●	●●●	●●	●●		●●●	●
Management	●●●	●●●	●●●	●●●	●●●	●	●●
Information	●●●			●	●		●
Attitudes	●	●●	●	●			●
Pricing	●●●●	●●●	●	●●	●●	●●	●●●●●
● Minor Contribution ●●●●● Mayor Contribution							

Table 2.8: Land use and Transport policy Instruments to achieve sustainability city objectives in city centre area (May et al., 2003).

As can be seen in Table 2.8, pricing policy gave dominant contribution to achieve the sub objectives of economic efficiency and intergenerational equity. For instance, Reduction of public transport fares could increase the economic efficiency to travel in urban areas. Moreover, the pricing policy could also attract people to use public transport rather than private vehicles that may contribute to the reduction of carbon emission from transport sector. This condition potentially reduces the negative impact related to climate change issue that has the benefit for the future generations.

Management is also one of the policies that play the main role to achieve the sustainability objectives. Road management policy is potential tool to reduce the congestion in urban areas of the city that contributes to reduction of environmental cost. In addition, management policy is also effective to be implemented for achieving the others sub objectives such as efficiency, safety and equity.

2.5.2.1 Policy instruments and measures in land use planning

As known that the urban structure plays an important role in affecting the transport performance indicators in urban area. The change of urban form affected the travel pattern in urban networks, which were influenced by location of centre activities and residential area (Zhao et al., 2010). In the context of urban structure pattern, there were two main land use planning concepts that could be applied to achieve the sustainability objectives in the framework of urban transport sustainability. The first concept was related to the application concept of centralization and the second concept was related to the application concept of decentralization (Anas et al., 1998). One of the indicators used to measure the performance of urban structure pattern was commuting, which was reliant on where jobs and residential areas location (Sohn, 2005).

Furthermore, the question is that what type of urban structure pattern that should be promoted for promoting the concept of urban transport sustainability ? There were many past studies that concerned in this issue. However, In the context what type of urban structure should be promoted in terms of lower urban transport energy consumption, there was still debate among the supporter of compact city (Breheny, 1994, Owen, 1995) and proponents of urban planner that promoting the concept of decentralised concentration (Dutton, 2001, Talen, 2005). In other words, there was no consensus regarding what type of urban form should be promoted in order to achieve urban transport sustainability.

In the real practice, there were also several studies that concerned on this issue. there were two different results found in associated with the types of urban form that have less commuting trip, which might be associated with less carbon emission. One of the past study in some cities in the United States concluded that asserted that the re-adjustment of urban form in decentralised jobs resulted in less commuting trip length (Gordon et al., 1989). Similar results also found by a further research that conducted in the city of San Fransisco. This study concluded that the application of concept decentralization by evolving city into polycentric (more than one core area) model city led to shorter commuting time by 30% (Cervero and Wu, 1997).

On the other hand, there were also several studies that had the different results with the several past studies mentioned earlier. For instance, a past study that conducted in Paris found that the application of decentralized concentration by moving employment to sub urban areas in in this city increased the commuting distance (Baccaini, 1997) . The similar results also found in several other case studies in the similar context (Giuliano and Small, 1993, Cervero and Wu, 1998). Their results showed that the implementation concept of decentralized concentration increased the average commuting time and distance. They also argued that the rapid regional growth in the case study area contributed to the lengthen of commuting time as a result of the increase of vehicles miles travelled.

The relationship between urban form and trip impact in a conceptual figure was described as shown in Figure 2.6 below for understanding the best and the worst scenario in reducing commuting distance or time.

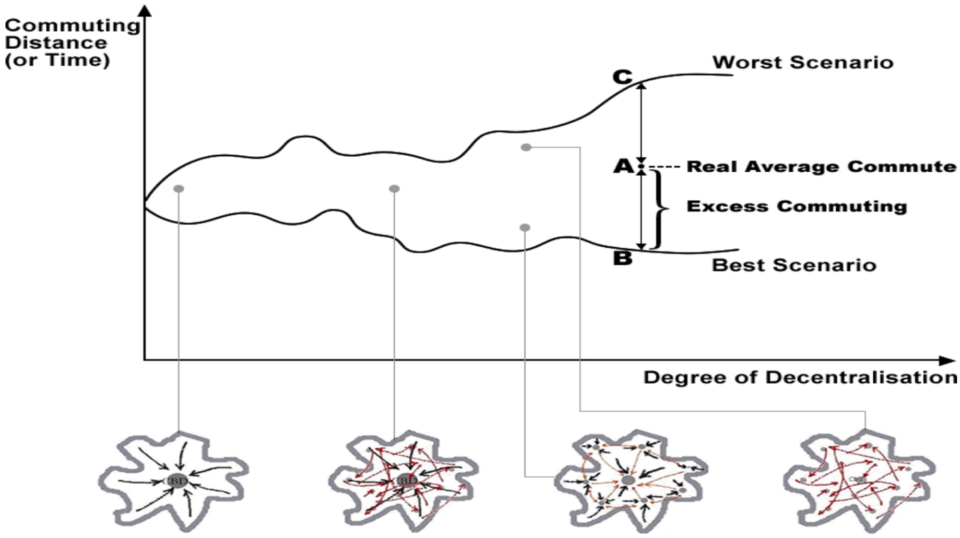

Figure 2.6 : Maximum and minimum commutes in different type of urban structure pattern (Ma and Banister, 2006)

This study compared the transport impact of application concept of centralization and decentralization concept that direct the urban structure pattern into monocentric and polycentric model city. It was found that the application of decentralized concentration concept contributed more commuting distance or time compared to centralize concentration because this city model has a greater commuting range (Ma, 2002).

There were several possible land use strategies in the context of urban planning that could be applied in order to promote the application of centralization and decentralization concentration. Generally, the main policy instruments could be classified into several general approaches such as land acquisition, regulation and incentive approach (Bengston et al., 2004). In the real practice, taxation policy such as land or housing tax, which is combined by urban growth boundary, might be possible to be applied for shaping the urban structure pattern in the framework of sustainable development (BRUECKNER, 2000, EEA, 2010). However, the application of such these policies should be put in the right context of planning, whether the city is directed in monocentric or polycentric model. For instance, in the context of monocentric model city, the application of property tax could increase the new development in urban fringe areas that encourages more urban sprawl (Brueckner and Kim, 2003). Moreover, the increase of property tax might reduce the size of city. If the property tax was increased by 1%, there was a possibility that the city size would reduce 0.4% (Song and Zenou, 2006).

Moreover, the phenomenon urban sprawl also might lead to the increase of public service cost. Low density of population in the urban sprawl phenomenon also increased the allocation of government expenditure in public services (Carruthers and Ulfarsson, 2003). In this case, the reduction of negative impact of urban sprawl phenomenon in monocentric model could be reduced by directing the urban expansion to adopt the concept of polycentric urban structure. The city evolution from single monocentric to a single polycentric cities was quite similar with the urban evolution from single monocentric cities to a system monocentric cities (Anas and Pines, 2007). In the context of two asymmetric cities, the expansion of urban development should be directed to the smaller cities rather than the bigger one in the context of a system two monocentric cities. In this case the land use policies selected in the bigger city should be more restrictive, while in the smaller city the land use policies applied could be more soft because there were still more land availability for new development to accommodate excess new development in the bigger city (Anas and Pines, 2008).

In the aspect of transport perspectives, incentive or pricing could be also used to be implemented for combating sprawl that result in more commuting distance and travel time. For instance, the application of congestion cost that combined with urban growth boundary could be selected as an alternative to reduce the urban sprawl (Anas and Pines, 2008). The impact of congestion cost implementation could increase the living cost for those who live in the urban fringe areas that need to pay this cost. Therefore, people considered to find their housing location near to centre of activities to reduce the commuting cost (Nechyba and Walsh, 2004).

2.5.2.2 Policy instruments and measures in road transport infrastructure

The development of a new road transport structure in urban areas is also one of the alternative solution to accommodate the increase of transport demand. For instance, this policy was the implementation of the strategy to increase the supply aspect in transport planning as a response to the growth of transport demand (Broaddus et al., 2009). In general, the policy instruments in the strategy of road transport infrastructure development can be in the form of the development of the new road or adding more lanes as a response to accommodate the increase of vehicle numbers in order to reduce the problem such as congestion etc.

The development of road infrastructure increase the accessibility in the area, where the development of infrastructure is developed. As known that, the increase of accessibility as a result of new road development influence the preferences of people to select their housing location. In this context, the development of the new road infrastructure should be directed to reach the sustainability city objectives, which consider the interdependence of land use and transport interaction. In this case, travel time is one the factor that influence the accessibility by car and public transport. The increase of accessibility in certain area increased the attractiveness of that area. (Bertolini et al., 2005). In other words, the policy measures of road infrastructure development should be directed based on land use planning as explained in sub section 2.5.2.1, whether the urban development prefer to adopt the concept of decentralization or centralization concentration.

However, it is important to not only consider the road development as the only way to accommodate the increase of transport demand. It should be noted that the development of more the new road infrastructure also attracted more private vehicles on the road by neglecting the importance of public transport system and non-motorized mode of transport (Breithaupt et al., 2010). Several developing cities in developing countries adopted this strategy rather than selecting the strategy to promote public transport system and non-motorized transport such as promoting walking and cycling concept as sustainable transport modes in urban areas (UNEP, 2010). The other problem is that this strategy needed a huge cost to be allocated in its development process, including the maintenance cost (Broaddus et al., 2009). The more explanation regarding the possible policy instruments and measures in urban public transport system was discussed in the next sub section 2.5.2.3.

2.5.2.3 Policy instruments and measures in improvement of public transport system

Improving public transport system was a main strategy that could be applied to promote the concept of urban transport sustainability (Litman, 2004). Some cities in Europe, North America and Australia has been starting to promote the public transport system a long time ago in order to influence the modal choice by subsidizing transport fares. However, there have not been many developing cities in developing countries that improve the quality of public transport. For instance, in Asia and Latin America, the quality of public transport services is very low, which are generally not subsidized by the government (Meakin, 2002).

Generally, it is accepted that mass of public transport is one of the alternatives that can be used as an alternative solution to reduce the urban transport problems. In the current application, there were two types of mass public transport that have been implemented in developing cities of developing countries, which generally classified into rail and bus based system. In the context of mass rapid transit, the rail based system could be classified into a heavy rail transit and light rail transit, while the bus based system could applied in the form of Bus Rapid Transit (Wright and Fjellstrom, 2003). However, it should be noted that the investment in rail infrastructure had higher risk rather than for bus rapid transit, which uses road infrastructure as its dedicated track in terms of cost overruns using the comparison data between actual and forecast cost (Flyvbjerg et al., 2004). Moreover, the development of rail infrastructure, whether it is light or heavy rail, also needed higher cost to be allocated in the development process compared to the investment for bus rapid transit infrastructure. In addition, Bus rapid transit was not only cheaper, but also it had better quality of service rather than rail based system because the services provided by bus rapid transit, which use road infrastructure, could have more one service in a specific corridor compared to the rail based system that use rail track system (Kain, 1988). In the reality, the capital cost for building rail based system such as Metro could reach US$ 55-207 million, while for the BRT, the investment cost was only $US1-10 million per kilometre (Wright and Fjellstrom, 2003). Moreover, the operational cost for rail based system such as LRT was also far more expensive compared to the BRT system. The operational cost per hour for LRT could be almost eight times more expensive compared to the BRT system (GAO, 2001).

The other advantages of BRT implementation was that the BRT infrastructure could be developed faster compared to the rail based system and it was also more adaptable to changing of travel pattern in urban areas because the BRT use road infrastructure (Hensher, 2007). In other words, BRT is one of the best options for developing countries because of its low-cost and it can be developed faster compared to Metro or LRT (Hook et al., 2015). There were several major advantages of the BRT implementation compared to other public transport modes such as follows :

- Speed and reliability. In this context, the implementation of BRT services using busways or bus lanes with reliable and consistent travel times make this mode of transport more attractive compared to other conventional public transport with unreliable travel time because of the congestion problems (CUTA, 2007). However, in the case of developing city in a developing country such as Jakarta the reliability factors has still become the main issue that should be tackled. The main problems faced by Transjakarta BRT are (1) long waiting time, (2) long queue at the bus stop station, and (3) unclear departing/arrival time (DISHUB-JAKARTA, 2006).
- Greater passenger. The premium service that offered by the BRT related faster speed and higher reliability might has high possibility to attract more new passenger to use this mode as a convenient alternative (CUTA, 2007).
- Lower cost. The investment for BRT infrastructure is much lower compared to the investment cost for the transport mode rail based system. The BRT infrastructure system does not need track and specialized electricity such as the rail based system (CUTA, 2007). In the context of best practices in developing countries, Colombia (Bogota) and Indonesia (Jakarta) have tried to provide at the lowest cost (Hook et al., 2015).
- High capacity. The BRT is also a high capacity vehicles that can accommodate many passengers. In this context, the frequent service of the BRT and its

flexibility in routing structure in the transport network of the city that allow this mode of transport can service more passengers compared to the rail based system (CUTA, 2007).

- Operational flexibility. The operational of the BRT is more flexible compared to the rail based system. This flexibility allow the BRT to give express service, to local areas and skip-stop services, which are difficult to be applied in the rail based system environment (CUTA, 2007).
- Incremental implementation. The implementation of BRT can be applied in a stages process. In Jakarta, the first BRT corridor was implemented in 2004, while the others two additional corridors were launched in 2006. In 2012, there were 12 BRT corridor, which have been developed and become fully operational (Akbar, 2012). Moreover, the BRT facility also can be used by other buses to travel to congested areas, then switch onto the roadway to serve other uncongested line (CUTA, 2007).

In the context, of developing cities in developing countries the limitation of financial issue is the main issue that should be raised in finding the best option for mass rapid transit to be implemented in their urban areas (Broaddus et al., 2009). The investment of rail based system is more far expensive compared to the BRT. The investment for rail based system was more risky compared to the BRT because of its high uncertainty. Moreover, expanding the rail track was more difficult and expensive compared to the development of dedicated track for bus (Wright and Fjellstrom, 2003). Therefore, it must be planned carefully. Moreover, the overall cost effectiveness for BRT is better compared to rail based system and the BRT system could also be used to attract many passengers as other mass rapid transit option such as light rail or heavy rail (Currie, 2005). In other words, the BRT option was a better alternative to be implemented in developing cities of developing countries rather than rail based system by considering the BRT performance and value of money (Fouracre et al., 2003).

In economic aspect, the implementation of BRT system in the Bogota city attracted many offices building along the BRT line corridor. In this city, the rent of property that near to the bus station increased more than 6%, which gave the benefits for the property owners (RodrÍGuez and Targa, 2004). This policy scheme attracted more landowners and business to support the development of BRT stations near to their local areas. In these case, it can be seen that the BRT implementation also showed the positive aspect to stimulate the economic development by performing as the nodes development through several construction of BRT station (Wright and Fjellstrom, 2003). In addition, the implementation of the BRT development should be also supported by the land use policies and other transport policies, such as parking management in order to attract more people to use public transport rather than private vehicles (Levinson et al., 2003).

2.5.2.4 Policy instruments and measures in parking management

The parking policy instrument was one of the policy in transport demand management strategy (Meyer, 1999). The transport demand strategy is a strategy that has an objective to improve the effectiveness of urban transportation system by encouraging city residents to use public transport and non-motorized transport (walking and cycling) rather than private vehicles. The possible measures in the transport demand management strategy were distinguished into the concept “push” and “pull”. The possible measures in the push concept has an objective to reduce the attractiveness of the use of private vehicles (progressive parking fees). On the other hand, the possible measures in the pull concept aims to increase the attractiveness of other modes of transport, which is more effective and environment friendly such as public transport and non-motorized transport (Broaddus et al., 2009) .

The parking management was one of the measures that classified into the pull concept. In this context, the parking policy instruments could act as positive and negative pull concept. In the negative aspect, the application of parking policies can be implemented in the form of progressive parking measures. In this context, the expensive charge of parking was applied that has an objective to make the use of private vehicles less attractive. In the positive aspect, the addition of more parking space near or in public transport station could increase the attractiveness of public transport as an alternative mode of transport in making a trip to core area of the city (Levinson et al., 2003). For instance, The development of more parking space around the public transport station through park and ride policy was one of alternative policy that can be used attract more people to use public transport system. In other words, parking management was an alternative that could be implemented to support the transit oriented development and the implementation of urban public transport system (Litman, 2013).

According to a sourcebook about implementation concept of urban transport sustainability for stakeholders in developing cities of developing countries, there were four type of parking that commonly applied in several countries in the world (Rye, 2010).

- On-street parking. This type of parking allows the vehicles to be parked in the space of the public road. The on street parking take places on the space of the side on the road. It can be legal under the regulation or it also can be illegal under the lack of regulation. If the space parking is priced under city regulation, the charge for this type of this parking is usually cheaper compared to off-street parking. In the case of lack of planning and no regulation, the space for parking in on street parking use the space reserved for pedestrian.
- Public off-street parking. In this type of this parking, the spaces provided for parking do not use the side of public road, which can be used by the public to park their car such as in on-street parking. The park area of off-street parking might be owned and operated by city authority or private sector.
- Private non-residential (PNR) off street. This type of this parking is related to the parking where the spaces parking used are provided by an institution or organization such as government building, commercial building, hospital or shopping centre, whether it is indoor parking in the building or parking in outside building in the particular land provided for parking lot. The spaces of parking provided are only can be used by the people that related to the such institution or organization.
- Private residential parking. This is the type of off-street parking that privately owned by city residents. The spaces provided in this type of this parking may only be used by the owners of houses or flats that have the parking spaces.

However, in the context of developing countries, on-street parking in the most type of parking that can be seen in their urban areas. Poor management and lack of parking regulation contributed to more urban transport problems such as congestion and air pollution (Rye, 2010). At this time, this policy instrument is also included as the main important part of transport demand management strategy to be applied in the context of developing cities of developing countries. Several guide book of promoting the concept of urban transport sustainability discussed this a part as an important parking policy that should be integrated in the policies package application in managing transport demand (Litman, 2004, Ríos et al., 2013).

In fact, there were not many developing cities in developing countries that adopt the parking instruments as mobility management tool in achieving the city objectives in the framework of urban transport sustainability. For instance, there was a lack attention of city authority in several cities in Southeast Asian that consider to constraint the parking spaces in congested areas of the city. The issue of parking discussed generally focused on the issue how to increase the parking spaces to accommodate more private vehicles rather than to restrain the capacity parking in the context to attract more people to use public transport system (Barter, 2011).

Table 2.9 below shows the various parking prices that have been implemented in several countries in Asia.

City	Zoning Fares	Parking fare($PPP) PPP=Purchasing power parity	Time limits
Dhaka	More expensive charge in CBD	0.78 (Tk20/day)	No
Ahmedabad	Single price	0.16 (Rs2.5/hour)	No
Jakarta	Two zone with different prices	0.37(Rp.2000)	No
Kuala Lumpur	Uniform price	0.41 (RM0.80)	Yes (3hours)
Bangkok	Uniform priced	0.60(B10)	No
Hanoi	Two zones	0.81 (D5000)	No
Guangzhou	Different prices in each zone	1.05 (CNY4)	No
Beijing	Different prices in three zones	1.32 (CNY5)	No
Hong Kong	Uniform price	1.46 (HK$8)	Yes (2 hours)
Manila	Different prices	1.71 (P40 1st & P35 2nd hours)	Yes (3 hours)
Singapore	Prices in the CBD two times higher than elsewhere	1.90 (S$2)	No
Taipei	Different prices	3.45(NT$60>6th hours)	No

Table 2.9 : The application of parking fares and time limits in several Asian Cities (Barter, 2011).

As can be seen in the Table 2.9, various of parking charge were applied in several cities in Asia. The parking fare in several cities such as Dhaka, Ahmedabad, Jakarta, Kuala Lumpur, Bangkok, and Hanoi were cheaper compared to other cities such as Beijing, Singapore Taipei and Seoul. For instance, the price of parking charge in Seoul was about 20 times more expensive compared to the city such as Jakarta

(Barter, 2011). The cheaper parking prices increases the attractiveness of automobile to be used as the main mode of transport in the city, which may lead to the increase of congestion and air pollution from transport sector. Moreover, it also increased the oil subsidy for the oil import country as a result of the increase of motorized vehicles demand (Shoup, 1997).

2.5.2.5 Policy instruments and measures in fuel pricing

Regulation and fiscal instruments (e.g. fuel tax) were one of alternative policies that could be selected to promote the implementation concept of urban transport sustainability. These policies could be implemented as a policy measure, which has objectives to increase government revenue as well as to reduce the carbon emission from urban transport sector. In this case, fuel tax is the most popular policy instruments applied to achieve these objectives (Timilsina and Dulal, 2008).

In the real practice, the fiscal instruments such as fuel tax became a popular policy that implemented in several developed countries as an positive effort to reduce the air pollution from urban transportation sector (Crawford and Smith, 1995). This policy helps several developed countries to reduce the increase of fuel demand. In other words, the selection of high tax policy measures might be used as an alternative reduce the level of carbon emission. According to a past study, the absence of fuel tax increased the carbon emission more that 40%, while the implementation of high fuel taxation as applied in several developed countries significantly reduced the emission about more than 30% (Sterner et al., 1992). Moreover, the implementation of lower fuel tax in the U.S compared to in Europe countries, which implemented high-fuel tax, increased the total fuel demand in low fuel tax country as two times larger compared to the country that implemented high fuel taxation (Sterner, 2007).

On the other hand, there were also several countries that subsidized the fuel price. There were two subsidy definitions that used widely in the energy subsidies issue. The first definition refer to the definition that made by the OECD (Organisation For Economic Co-Operation And Development). The OECD defined the subsidy as "*any government measure that keeps prices for consumers below market levels, or for producers above market levels, or that reduce costs for consumers and producers*" (OECD, 1998a). Similarly, the international energy agency (IEA) defined subsidy as "*any government action that concerns primarily the energy* *sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers* (IEA, 1999). Moreover, in the context of fossil fuel subsidy, the subsidy concept were distinguished into two concept, namely consumer and producer subsidies. The consumer subsidies refer to the concept of reducing the cost of fossil fuel consumption, while the producer subsidies refer to the concept of supporting the production of fossil fuel domestically (Beaton et al., 2013).

In this sub section, the discussion of subsidy more focussed in the aspect of consumer subsidy since this concept was widely implemented, especially in several developing countries compared to implementation of producer subsidies that applied limitedly in global market oil (Koplow, 2009, IEA, 2013). Figure 2.7 below shows several developing countries that domestically subsidize the fossil fuel price.

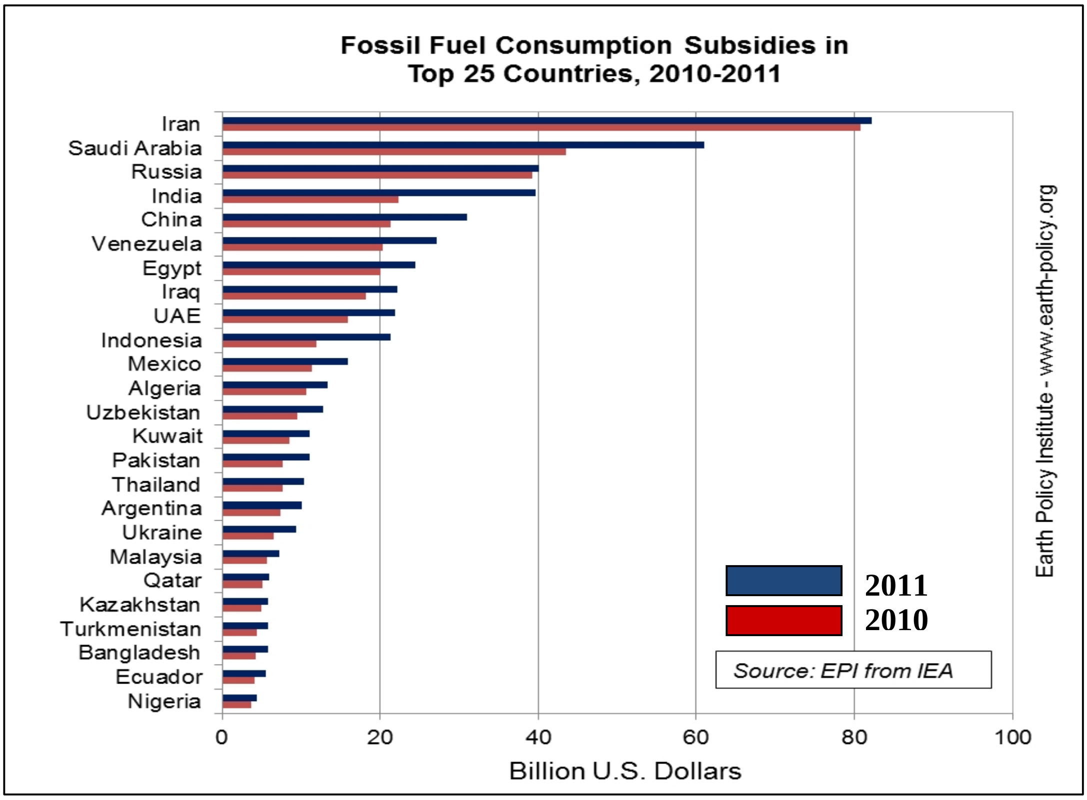

Figure 2.7 : Fossil Fuel Subsidies in developing countries 2010-2011 (IEA, 2010, IEA, 2011)

As can be seen in the Figure 2.7, all of the countries, which adopted the fuel energy subsidies policy were developing countries. The domestic fossil fuel price in these countries was set below market prices because the government implemented the energy subsidy policy. In the context of consumer subsidies, there were various subsidies concept that possible to be applied in the reality as follows (Beaton et al., 2013).

(1) Government allocated subsidy expenditure in order to reduce the fuel price below the market prices.

(2) The energy produced in the country was sold below the market price.

(3) Implementation of regulation to sell the fuel price at below market price.

(4) Stipulation of price that does not include the full cost of energy production, maintenance cost or cost for future energy investment.

(5) Lowering fuel price at below market price through giving incentives in fiscal instruments such as tax exemptions or reductions, giving rebates or credits to energy consumers (Beaton et al., 2013).

The question is that why the developing countries still adopt the fossil fuel subsidy, where the fuel that sell in the market prices is below market prices ? In fact, some past studies have shown that there was strong relationship between cheap price of fossil fuel and the increase of carbon emission from transport sector (Sterner et al., 1992, Whitley, 2013).

In this case, there were several possible answers regarding the obstacles faced to promote the implementation of fiscal instruments to reduce the carbon emission in transport sector. One of the possible answer was related to the lack of government attention in several developing countries against the issue of climate change as a result of the more fossil fuel burned. Another aspect was related to the domestic political situation in the countries.

In the political aspect, it was difficult to increase the domestic fuel price by cutting the fuel subsidy because the top stakeholders in the countries was the election winner that should consider the interest of their electorate population regarding cheap fuel price issue (Hammar et al., 2004, Sterner, 2007). In this context, the objectives of government fossil fuel policy subsidies was to provide cheap energy for the population as a popular policy for the public. It was also assumed that subsidy implementation policy accelerated the economic growth (automobile industry) and help the lower income people such as in the case of China, Indonesia and Malaysia (Gan, 2003, Oh et al., 2010, ESDM, 2012a).

Furthermore, the budget allocation for fossil fuel subsidy also reduced the government expenditure and decrease the fiscal space (Beaton et al., 2013). Table

2.10 shows the budget allocation for fuel subsidies in several developing countries selected in Southeast Asian.

ASEAN Countries	Budget for Fuel Subsidies	Percentage share of GDP
Indonesia	US$21.3 billion	2.5%
Malaysia	US$7.2 billion	2.6%
Philippines	US$1.5 billion	0.7%
Thailand	US$10.3 billion	3.0%
Vietnam	US$4.1 billion	3.4%

Table 2.10 : Fossil Fuel Subsidies in Southeast Asian countries (IEA, 2012, IISD, 2013)

As can be seen in Table 2.10, the budget allocation for fuel subsidies was quite high, ranging from US$4.1 to US$21.3. It can be also seen that the amount of subsidy has depleted the government expenditure that reached 0.7% to 3.4% of the countries selected GDP (Gross domestic product). In fact, the elimination of the gap price between the worldwide market price and the domestic subsidized fuel price could significantly save the government budget (Koplow, 2009).

As mentioned earlier, the fiscal instruments can be selected as an alternatives to promote the concept of urban transport sustainability such as through fuel tax implementation rather than the implementation of fossil fuel subsidy. The fuel tax could be implemented to increase the government revenue, which could be used to fund other infrastructure project or it could also be applied to solve the transport problems such as congestion and carbon emission from transport sector by encouraging people to use public transport system rather than private vehicles (Gupta and Mahler, 1995, Acutt and Dodgson, 1997, Parry et al., 2007). In the current practice of several countries such as South Korea, Nigeria and Nicaragua, the implementation of fuel tax policy measures contributed to 20% of their total government revenue (Timilsina and Dulal, 2008).

2.6 Framework of assessment in urban risk reduction

There were several framework assessment that could be applied to evaluate the strategies selected in the framework of urban risk reduction. The framework of assessment applied is directed to reach the city objective in the framework of disaster risk reduction (UN/ISDR, 2004, Bogardi and Birkmann, 2004, Wisner et al., 2003, Birkmann, 2006, OECD, 2012).

In general concept, the Organisation for Economic Co-operation and Development (OECD) stated that there were several steps that should be followed in developing the framework of disaster risk reduction in order to finding more effective disaster risk management strategies such as follows (OECD, 2012).

1) Analyse the level of potential disaster risk that refer to hazard identification regarding their probability or return period in order to identify the potential impact of disaster event. In this step, the relevant and good data played the main role in the process of analysing disaster risk.
2) The output from step 1 was then communicated to the decision makers or stakeholders. The information about the potential disaster risk should be updated regularly to be used as a basis information in evaluating the possible risk management strategies available.
3) Improve the concept of disaster risk assessment and its output that was directed to develop the alternative method for financing the risk. It was conducted to allocate the disaster risk budget in effective way to finance the cost of disaster event. The risk distribution and the city or country financial capacities should be considered in this step.
4) Evaluate the availability and sufficient of budget for financing the potential disaster risk. In this context, the budget limitation should be considered as the problems that might be faced by city residents, business or city authority. For that reasons, the incentives policy could be applied to manage the risk.
5) Evaluate the strategies or policies selected as a corrective actions in the process of financing and transferring risk by including the problems related the financial capacities and problems in order to find the better policy instruments.

Based on the five steps mentioned above it was also noted that the framework proposed should be planned in flexible way that involving the key issues from various aspects, which could be easily understood and implemented in the reality in order to guide the decision makers in the right path of sustainable development (OECD, 2012).

Moreover, the five steps mentioned earlier were formulated in a framework assessment to evaluate the strategies selected in the framework of disaster risk reduction by considering the economic aspect in the context financing the risk. Figure 2.8 shows the framework of assessment in disaster risk management that could be used in evaluation of strategies selected in general perspectives.

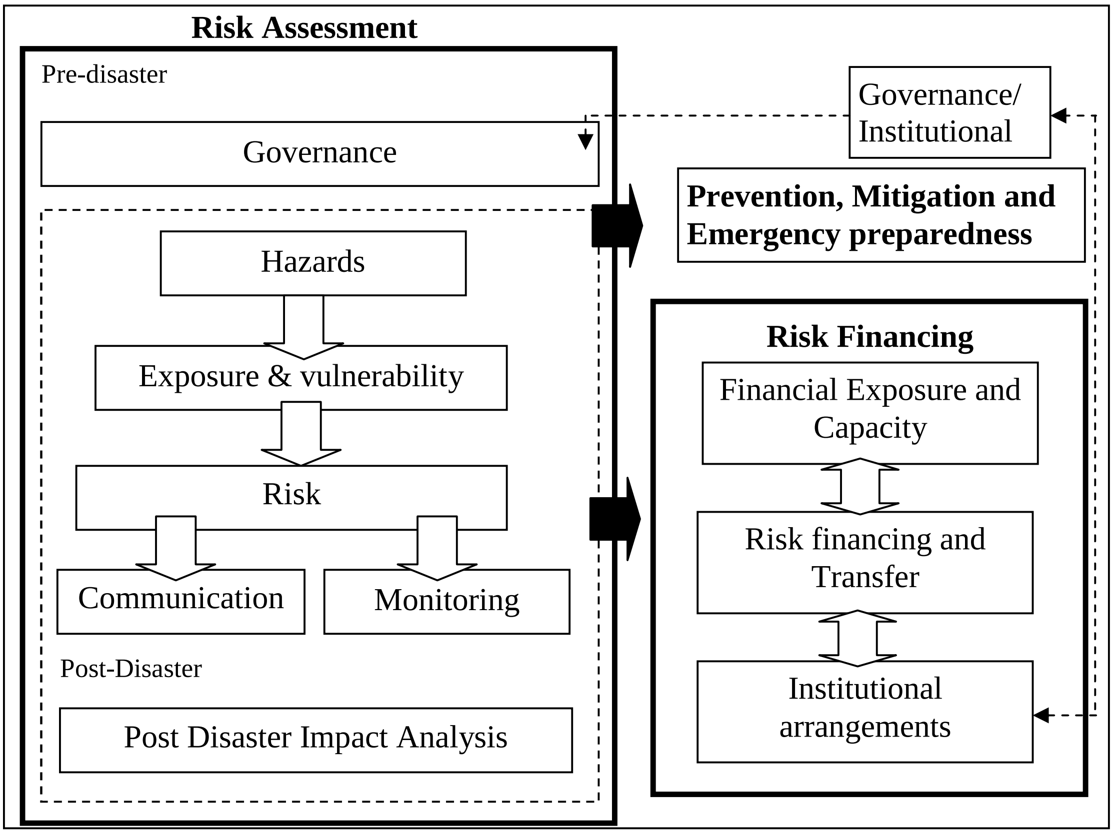

Figure 2.8 : Framework of assessment in disaster risk management (OECD, 2012)

As can be seen in the Figure 2.8, the part of risk assessment plays the main role in giving the guidance to the plan of budget allocation in disaster risk management process. According to the global assessment report on disaster risk reduction, the number of countries, which improved their database regarding risk to disaster, increased in order to having better approach in estimating the direct loss of disaster events. This condition help these countries to understand how to finance the risk in disaster risk management process. Moreover, the evaluation in the part of risk financing process could be also used to review the policies instruments selected in disaster risk reduction program for finding the new scheme plan or strategies to be implemented (UN/ISDR, 2013).

Similarly, the UN/ISDR conceptual framework also placed the hazard and vulnerability factor as the main part in the process of assessing disaster risk. This factor was placed together with the strategies in disaster risk reduction within a framework. In this framework, the implementation of strategies selected were directed to reach the sustainability objectives in framework of disaster risk reduction (UN/ISDR, 2004).

Furthermore, Figure 2.9 shows the vulnerability framework in disaster risk reduction that can be used to promote the sustainability objectives in the framework of urban risk reduction. In the framework below, it can be seen what indicators that could be used in evaluating the strategies selected, such as number of fatalities, housing and transport infrastructure damaged.

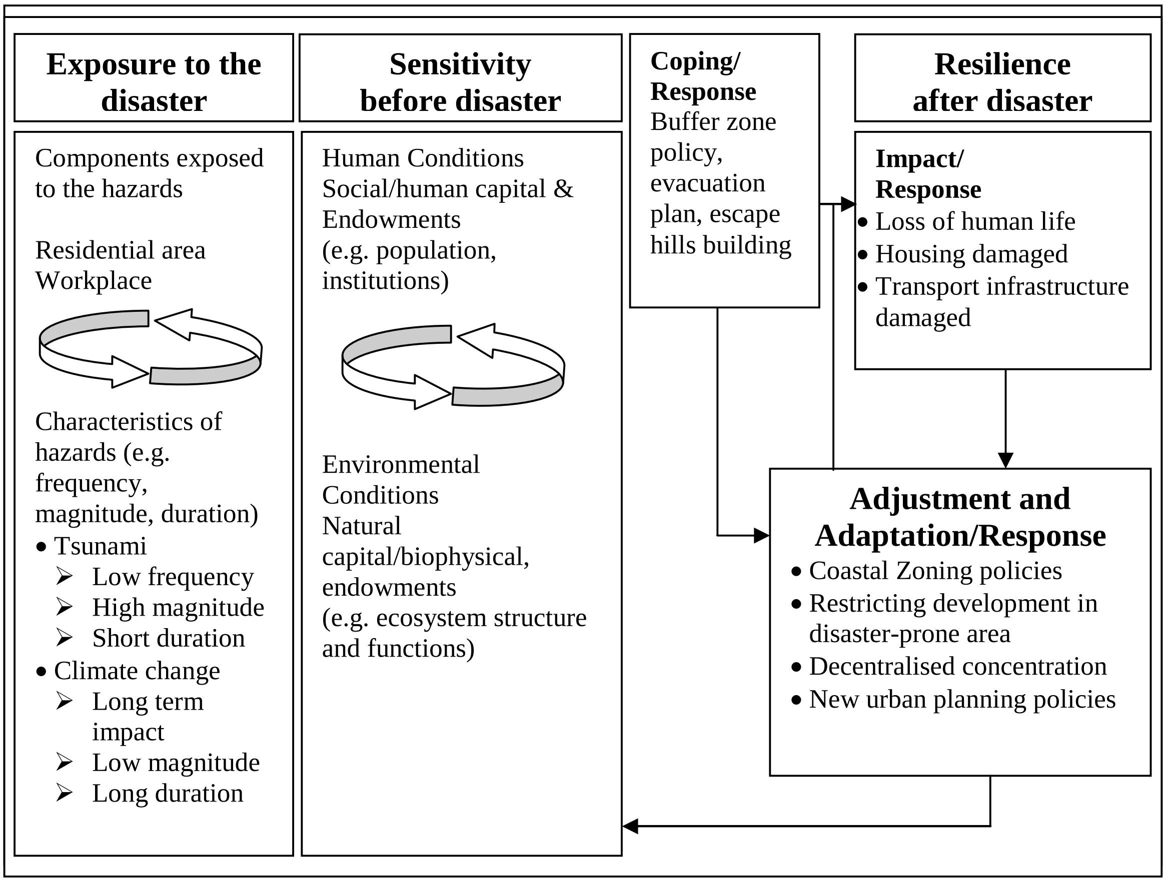

Figure 2.9 : Framework of vulnerability in disaster risk reduction in the context of high-risk city (Turner et al., 2003)

2.7 Framework assessment in urban transport sustainability

There are also several framework assessment that could be applied to evaluate the strategies selected in the framework of urban transport sustainability. In several literatures, it can be seen that the framework of assessment implemented was directed to reach the city objective in the framework of urban transport sustainability (Ambrosino et al., 1999, May et al., 2001, May et al., 2003, Mihyeon Jeon and Amekudzi, 2005, Huang et al., 1998, Zellner et al., 2008, Xing et al., 2009). According to the PROSPECT project, there were several steps that should be conducted in planning the long term strategic of a city in the framework of urban transport sustainability. Figure 2.10 below shows how the logical structure in developing strategies, including the evaluation process in the framework of urban transport sustainability (Minken et al., 2003).

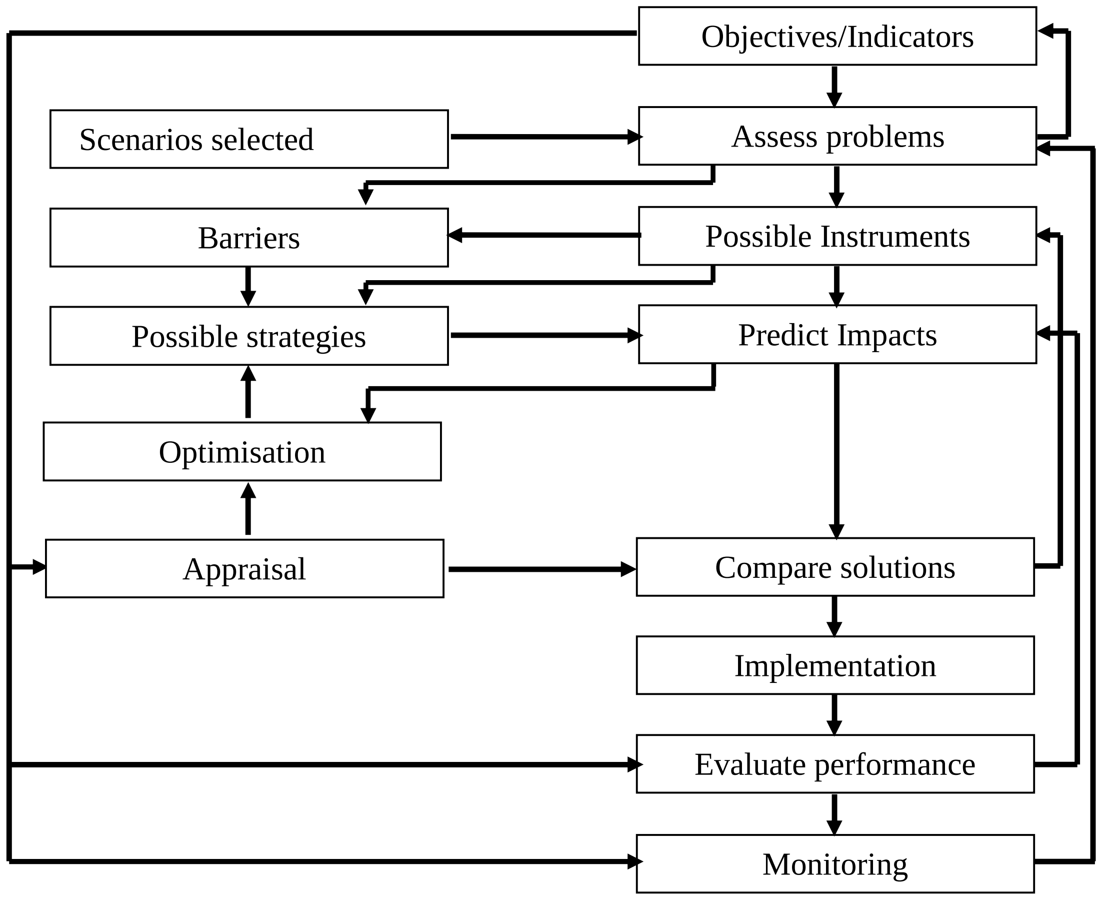

Figure 2.10 : Logical structure in developing and land use and transport strategies in urban transport sustainability (Minken et al., 2003)

As can be seen the Figure 2.10, the process of strategies development was ended with evaluation and monitoring steps in order to assess the performance of strategies selected. The assessment of the performance strategies selected conducted after the quantitative outputs, which were obtained from the result of model simulation. The indicators in the framework of urban transport sustainability, which was explained in sub section 2.4.2, were used to measure the successful performance of policy measures selected.

The similar concept of framework could be also seen in Urban Development Sustainable Assessment Model (UD-SAM). However, in this framework proposed, the indicators used for strategies evaluation were generally classified into environment, social and economic aspect. In the environmental aspect, the indicators selected were distinguished into depletion of natural resources, emissions and waste. In the social aspect, the indicators selected to measure the sustainability objectives were categorized into direct impact and indirect impact. The example indicators selected in direct impact such as community participation, housing provisions, health and education, while for indirect impact, the indicators selected consist of such as crime/security, health, and social capital. Lastly, the indicator in economic aspect was directed to measure the impact of multipliers effect of employments (Xing et al., 2009). However, there was also another study that develop the framework assessment based on economic and environment factor in order to evaluate the sustainability city objectives (Huang et al., 1998). Besides that, there was also the framework assessment that only focus on the environmental aspect which use indicator emissions and energy consumptions (Ambrosino et al., 1999). From several concept of framework assessment as mentioned earlier, it can be seen that there were various version of the framework that can be used to evaluate the strategies selected in order to reach the sustainability city objectives.

Furthermore, there were also two different approach that could be used to evaluate the indicators mentioned earlier in the framework assessment of city sustainability objectives, which are known as Multi-Criteria Analysis (MCA) and Cost Benefit Analysis (CBA) (Saaty, 1977, Beria et al., 2012). The MCA was an alternative method to select alternative strategies that is commonly used in various projects, including transport project related to sustainability issues based on several evaluation criteria that refer to indicators selected such as in the aspect of environment, social and economic (Tzeng et al., 2005, Munda, 2006, Brucker et al., 2011). In MCA method, the alternatives selected were ranked based on the weight system, which could be applied to identify best preferred strategies selected or it also could be used to categorize the sustainable issue, whether they were accepted or considered as unsustainable options (DCLG, 2009). Moreover, the implementation of MCA could be also used as an important factor in evaluating the transport project investment in the context of institutional approach (Brucker et al., 2011). In the level of application, It should be noted that the weight setup in various criteria should be considered carefully in order to make the MCA as flexible alternative in evaluating transport investment project (Sayers et al., 2003). In this approach, the analytical hierarchy process was used to arrange the factors considered in a hierarchic structure (Saaty, 1990). Moreover, this method was quite effective to be implemented in various urban transport project in order to achieve the sustainability objectives (Tsamboulas et al., 1999, Yedla and Shrestha, 2003).

On the other hand, the cost benefit analysis was also a method that used mostly to assess the investment in infrastructure project, which used money as the main measure unit to investigate the performance of strategies selected related the cost and benefits of alternatives selected (DCLG, 2009, Beria et al., 2012). For instance, it could be used to evaluate the impact of transport strategies selected that implemented to improve the performance of urban transport system (Venables, 2007). This method was widely used in several transport project investment such as in Europe and Asia (World-bank, 1996, World-Bank, 2010a, Odgaard et al., 2005, ECMT, 2005).

Moreover, this approach could be also used together with the MCA approach to evaluate the alternative options in the context of economic evaluation. In this context, the application of the CBA could be applied to avoid unbalanced knowledge between the planners with stakeholders. The CBA results could provide several alternative options based on economic indicators. In this case, the effects of the several CBA options could be widely discussed among the economic expert and stakeholders. On the other hand, the MCA could be used to accommodate the different perspectives regarding the discussion between the expert and stakeholders in evaluating the outputs of CBA. In this part, the MCA supported the perspective expression of stakeholders to be actively participated in evaluating the selection of options using a measures approach selected (Damart and Roy, 2009).

2.8 Land use and transport model

At this time, There were around 20 integrated land use and transport models that could be used and applied to test long term strategic of urban planning in the context of land use and transport interaction. Table 2.11 below reviews 20 land use and transport models that were applied in several different cities in the world based on urban sub-systems used in the model. The 20 land use and transport models selected were evaluated based on the urban changes process. In this context, the urban transport systems were classified based on speed of changes in its dynamic process, which consist of very slow (networks and land use), slow (workplaces and housing), fast (employment and population) and very fast changes (goods and travel) (Wegener, 2003).

Models	Speed of Change								Remarks
	Very slow		Slow		Fast		Very fast		
	Net-works	Land-use	Work-places	Hous-ing	Employment	Population	goods	Travel	
BOYCE	+				+	+		+	Chicago (US)
CUFM		+	+	+	+	+			California (US)
DELTA		+	+	+	+	+			UK
HUDS				+	+	+			Harvard (US
ILUTE	+	+	+	+	+	+	+	+	Dortmund
IMREL	+	+	+	+	+	+		+	Philadelphia
IRPUD	+	+	+	+	+	+		+	Dortmund
ITLUP	+	+			+	+		+	Philadelphia (US)
KIM	+				+	+	+	+	Illinois (US)
LILT	+	+	+	+	+	+		+	Leeds (UK)
MEPLAN	+	+	+	+	+	+	+	+	Reading (UK)
METROSIM	+	+	+	+	+	+		+	New York (US)
MUSSA					+	+			Santiago (Chile)
POLIS		+			+	+			California
RURBAN		+			+	+			Japan
STASA	+	+	+	+	+	+	+	+	Oregon (US)
TLUMIP	+	+	+	+	+	+	+	+	
TRANUS	+	+	+	+	+	+	+	+	Caracas
TRESIS	+	+	+	+	+	+		+	
URBANSIM		+	+	+	+	+			Oregon (US)
MARS	+	+	+	+	+	+		+	Vienna (Austria)

Table 2.11 : Land use and transport model (LUTM) (Wegener, 2003, Pfaffenbichler, 2003)

2.8.1 LUTI model selection

As mentioned earlier in Table 2.11, there were several urban land use-transport interaction model that have been developed, which were applied in various countries across the world such as ITLUP, URBANSIM and MUSSA (Wegener, 2003). The ITLUP, URBANSIM and MARS are the land use and transport interaction model that originally were developed for the US cities and European cities (Putman, 1996, Waddell, 1998, Pfaffenbichler, 2003), while the MUSSA urban land use and transport model is a model that was developed for the city of Santiago in Chile (Martínez, 1996). The review about the operational of urban land use and transport model can be seen in several studies e.g. (Hunt et al., 2005, Pfaffenbichler, 2008).

Furthermore, the application of land use and transport model could be also seen in several studies that applied in several cities across the world. For instance, the URBANSIM was implemented at the first time in the city of Eugene-Springfield, Oregon in the US, which was funded by the department of transportation Oregon (Waddell, 2002). In general, the URBANSIM application for Eugene-Springfield performed quite well. The correlation between the model outputs and data observed was quite good (Waddell, 2002). This urban land use and transport model was also applied in other several cities such as in Texas and San Francisco (Kakaraparthi and Kockelman, 2011, Waddell, 2013).

The MARS model, which was selected in this study, was originally developed for the city of Vienna. This LUTI model has been applied in several European cities such as Edinburgh and Leeds. Moreover, this model has been also applied in several Asian cities such as Hanoi and Ho Chi Minh cities in Vietnam. In the case of Asian cities, the motorcycle mode was added in the sub transport model of MARS LUTI model (Pfaffenbichler, 2008, Emberger et al., 2005). The additional of motorcycle mode it its sub transport model is a plus factor for the MARS model compared to other models when a LUTI model is applied in the context of Asian cities.

2.9 The gap between urban risk reduction and urban transport sustainability issues

There are two issues that can be raised regarding the gap between the discussion of urban risk reduction and urban transport sustainability in the context of long term strategic city planning in line with the lack of literature and the tools. Firstly, There is such an isolation between the discussion of the concept of urban disaster risk reduction and urban transport sustainability. In fact, in the context of urban planning, these two issues should be considered in an integrated way since there are several cities that located in disaster prone area (e.g. high-risk to natural hazard) and at the same time also face the urban transport problems. Moreover, the interaction of land use and transport plan contribute to increase the city vulnerability to disaster. In certain case, people prefer to reside in high-risk areas of the city because of better accessibility to transport in these areas (Matsumaru et al., 2012). In this case, the number of people that reside in hazard prone areas will potentially increase in the next future years if the city authority ignore the importance aspect of land use and transport planning. Failing to understand this issue in an integrated way will increase the potential of the wrong strategies selected in order to achieve the sustainability city objectives in the framework of urban risk reduction.

Secondly, based on the literature review that was discussed earlier, all of the land use and transport interaction model (LUTI) available only focus in the aspect of promoting the concept of urban transport sustainability. In fact, in the current practice, several cities need to define and select their objectives not only in the context of urban transport sustainability, but also in the context of urban risk reduction. In this case, it can be seen that clearly the application of LUTI model as shown in previous Table 2.11 ignore the importance aspect of the concept of urban risk reduction since the sub land use in the model do not consider the variable of disaster risk. Consequently, the alternative policy measures tested in the LUTI model can be only directed to achieve the sustainability city objectives in the framework of urban transport sustainability and ignoring the important aspect of urban risk reduction. This condition increases the city vulnerability to disaster (e.g. residents distribution in high-risk areas) in the dynamics process of model simulation. For that reason, it is important to consider the aspect of disaster risk in the sub land use of the LUTI model.

Chapter 3

A Development Plan Concept : An Innovative direction in urban risk reduction and urban transport sustainability

3.1 Introduction

This chapter is intended to introduce a development plan concept regarding the land use and transport plan for certain group of high-risk cities, which are located in natural disaster prone areas. As discussed in the last section of literature review, there is a gap between urban risk reduction and urban transport sustainability in the context of land use and transport planning. For that reason, a development plan concept is introduced as an innovative direction in land use and transport planning in order to reach the objectives of urban sustainable development in the framework urban risk reduction and urban transport sustainability.

There were three main important part in developing the development concept plan, which consist of concept formulation (1), strategies formulation (2), and strategies selected evaluation (3). In the first part, the formulation of development concept plan was the first step that should be clearly defined. In this step, the concept of urban risk reduction was combined with the concept of urban transport sustainability in the context of land use and transport planning (3.2) in the second step of the first part, the main problems city concerned related to the disaster risk and transport problems were identified in order to select the main city priority objectives (3.3 & 3.4). After that, the indicators selected to measure the city objectives were classified into indicators in the framework of urban risk reduction (3.5.1) and urban transport sustainability (3.5.2).

In the second part of developing the concept plan, the possible strategies were formulated after the clear problems were already identified and city objectives were already selected (3.6). The possible strategies were classified into the land use strategies in the framework of urban risk reduction (3.6.1) and the land use-transport strategies in the framework of urban transport sustainability (3.6.2). After that, these possible strategies were combined in order to reach the city objectives in the framework of urban risk reduction and urban transport sustainability (3.7). In the next step, an alternative LUTI model was selected to be used for testing strategies selected. In the third part, a framework assessment was developed to evaluate the impact of strategies selected (3.8). Moreover, the example of indicators selected in the case study area can be seen in the last sub-section of this chapter (3.9). Figure 3.1 below shows each step in developing the concept plan of land use and transport interaction for urban planning in the framework of urban risk reduction and urban transport sustainability.

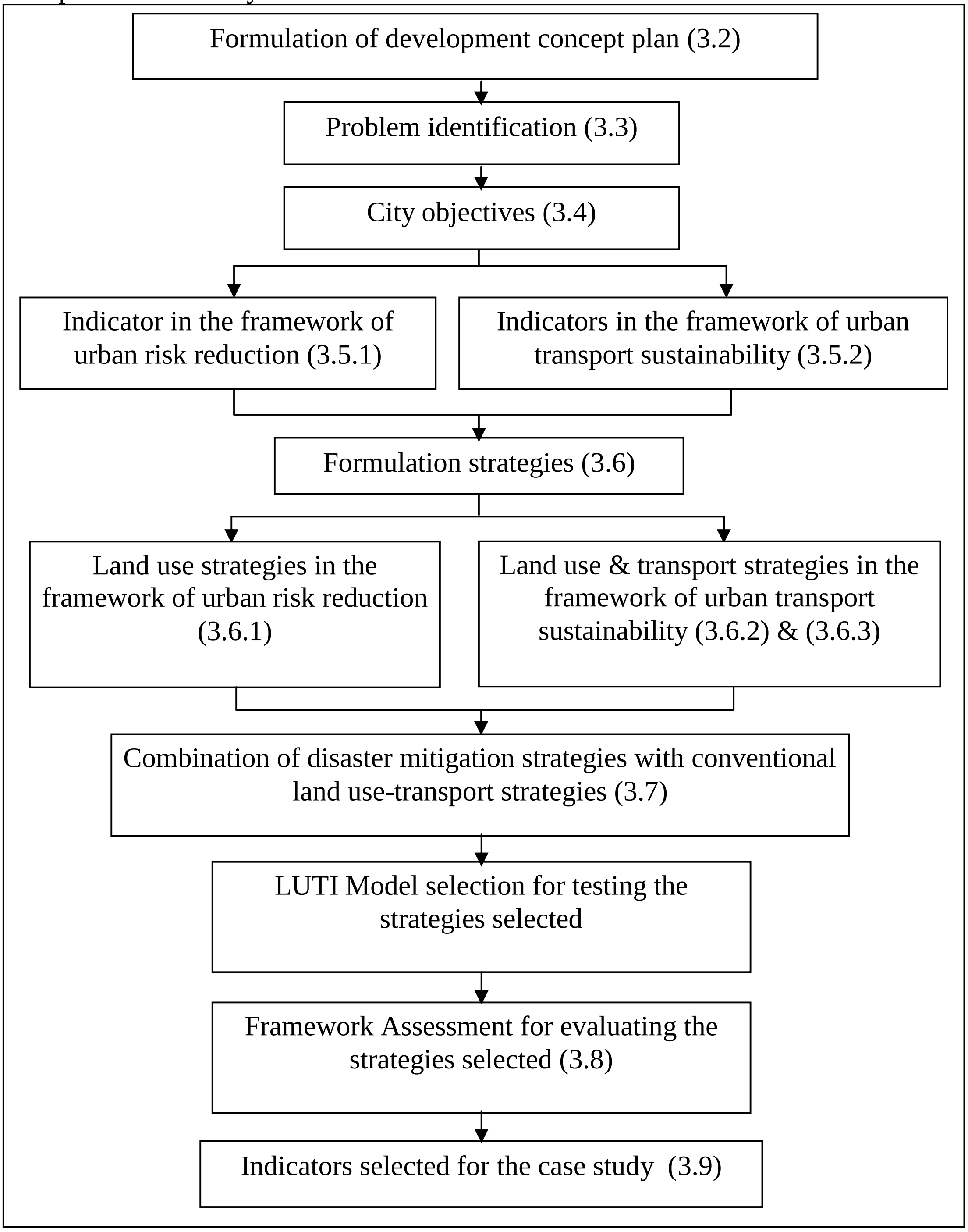

Figure 3.1 : Logical structure in development plan concept in the framework of urban risk reduction and urban transport sustainability

3.2 A concept plan for urban risk reduction and urban transport sustainability

As explained in the chapter 2 of literature review, a sustainable development was a concept of development that meet the needs of the present of today generation without sacrificing the needs of the future generations (WCED, 1987b). Urban planning in the context of land use and transport plan play the main role in order to promote the concept of sustainability. Nowadays, there are two main priority issue that might be considered to promote the concept of sustainability into development process. The first issue was related to urban risk reduction issue through disaster mitigation program (Shaw et al., 2009, ADPC, 2013). The second issue is related to the to the urban transport sustainability through reduction of carbon emission program from transport sector (May et al., 2001, May et al., 2003). These two issues were important to be put in the priority list of many cities in the world to response the rapid process of growing cities as a result of rapid urbanization according to the latest report of the World Bank (Lall, 2013).

In the context of urban risk reduction issue, the urban planning should be directed to reduce the potential of disaster risk in the next future years (UN/ISDR, 2005). On the other hand, in the context of urban transport sustainability, the urban transport system should be directed to promote the movement people or goods in a sustainable way by balancing the aspect of environment, economic and social (OECD, 2002). In other words, it was suggested that the plan of urban transport in the framework of urban transport sustainability should provide a good mobility in an efficient way with consider adverse impact to the environment in order to ensure that the plan does not jeopardize the opportunities of future generations to having similar or better quality of live as today (May et al., 2003).

For that reasons, this section introduced a concept plan in the framework of urban risk reduction and urban transport sustainability. In this context, it is expected that a sustainable urban development plan should consider the aspect of disaster risk in land use planning and at the same time it should also consider the aspect carbon emission from transport sector in the context of land use and transport plan interaction. In other words, *it is defined that the concept plan should provide a good mobility in an efficient way with trying to keep minimum adverse impact to the environment and at the same time the plan should also not attract people to reside in* *high-risk areas of the city in order to reduce the level of vulnerability to potential disaster risk*. Moreover, Figure 3.2 shows a logical structure of how a concept plan for high-risk city was developed in the framework of urban risk reduction and urban transport sustainability.

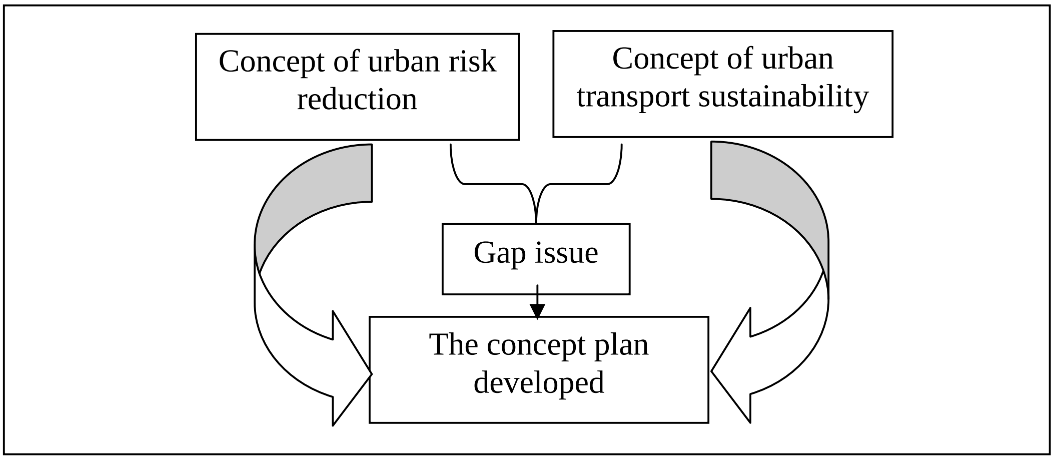

Figure 3.2 : A concept plan for high-risk city in the framework of urban risk reduction and urban transport sustainability

As can be seen in the Figure 3.2, the concept plan was developed to bridge the gap issue between the concept of urban risk reduction and urban transport sustainability. There is a big gap in the context of planning if the concept of disaster mitigation is isolated from the concept of urban transport sustainability. For instance, residents distribution in dynamic urban growth would increase the level of vulnerability to disaster risk if the risk information is excluded in land use planning. On the other hand, the lack of government attention to urban transport system can also increase the potential of carbon emission from transport sector. Improving the transport accessibility or implementation land use plan that allow new development in high-risk areas of the city might increase the attractiveness of those areas. For instance, the unrestricted land use plan in disaster prone areas and giving subsidy to the city residents that reside in high-risk areas attracted many people to build their house in risky areas (Burby, 2006). In other words, there would be more people that reside in high-risk areas of the city in the future years with poor land use planning (World-Bank, 2013a). Therefore, it is needed a new concept to integrate the aspect of disaster mitigation into urban planning (Berke et al., 2009).

In this context, the concept developed provide the new insight about how the concept sustainability for high-risk city should be defined in the framework of urban risk reduction and urban transport sustainability. This concept is important to be understood and implemented by stakeholders or decision makers because of two main reasons. The first reason is related to ensure that the land use planning does not distribute more people in high-risk area of the city. The second reason is related to the effort to reduce the carbon emission from urban transport sector in the next future years development.

3.3 Problem identification

After the new concept plan was formulated, the next step, which should be conducted, is to identify the problems and select the objectives that plan to be achieved. The objectives refer to the concept plan that has been formulated as a response to problems that has been identified.

Therefore in this sub section, there were two main issues that are discussed. The first issue was related to the identification problems in a case study area selected, which consist of the disaster risk assessment in the context of land use plan (3.3.1) and transport problems in the context of transport plan (3.3.2). The second issue was related to how the city objectives were selected after the problems have been identified for setting the target, which want to be achieved (3.4).

3.3.1 Disaster risk assessment to the potential of natural hazards in the context land use plan

Disaster risk assessment is an effort to identify and assess the potential of disaster risk that likely occur in a case study area selected. The risk itself has two distinctive meaning, which could be defined as chance, possibility or probability of hazard events or it can be also has the meaning as potential loose refer to certain cause, period and place (Dickson et al., 2010). This assessment is important to be conducted before the main city objectives are selected. In certain case, the most destructive hazard could be considered to be put in main list of priority as the main city objective (TDMRC, 2011, RTRW, 2009). The more detail explanations about this indicator are explained in the Figure 3.3.

There are three main steps in this process, which were referred to the three factors that influence the risk, namely hazard, element at risk (exposure) and vulnerability (Taylor, 2006). The first process is related to the collection of historical analysis of hazard events (1). This data can be used to analyse the hazard event recorded that can be used to predict the return period of hazard event in the future. The second process is related to identification of exposure and vulnerability level (2). Level of exposure can be defined as the potential of city element that potentially exposed to the disaster risk. Level of vulnerability can be defined as the degree of loss such as level of fatalities or property damage, which is influenced by level of exposure. The third step is related to the process of developing the disaster risk map (3). This map can be used to spread the information about disaster risk to the city residents and it can also be used as the information input in the land use planning. For instance, the Aceh government already produced Aceh disaster risk map, including contingency plan for Banda Aceh city (TDMRC, 2008, Government-of-Aceh, 2011). The detail about the concept of disaster risk assessment could be referred to several past studies as mentioned in chapter 2 literature review (Ikeda, 2006, Dickson et al., 2010). Figure 3.3 below shows the steps disaster risk assessment as part of the concept plan developed in the framework of urban risk reduction.

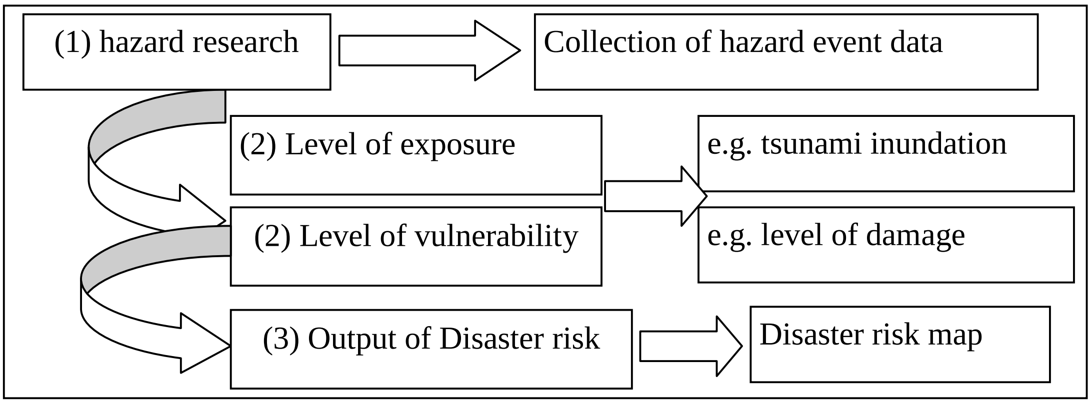

Figure 3.3 : Steps in disaster risk assessment of the concept plan developed

As can be seen in the Figure 3.3, the process of disaster risk assessment is started by the process of hazard research. In this part, all the data of potential disaster risk in a case study area are collected. The previous hazard events recorded can be used to identify and analysis the frequency and magnitude of the hazard occurred (Taylor, 2006). For instance, after the tragedy, the Indonesia government provide this information through Indonesian National Board for Disaster Management (BNPB, 2014), which was used in Aceh disaster risk map (Government-of-Aceh, 2011). Another example, the series of tsunami events could be also obtained from global tsunami historical database (NOAA, 2014).

After that the level of exposure and vulnerability were investigated based on the data hazard events, which were already collected. In the context of tsunami event, the data observed and modelling of tsunami waves using detail bathymetry and topography data in a case study area selected could be used to calculate the level of exposure and level of vulnerability (Taylor, 2006). For instance, the calculation example of exposure and vulnerability level could be also seen in several past studies that conducted in Banda Aceh city after the tsunami tragedy (SDC, 2009, Marchand et al., 2009).

After steps 1 and 2 were done, disaster risk could be calculated refer to the data and results obtained outputs in step 1 and 2. The disaster risk map could be produced to summarized the relative of disaster risk in all zones in a case study area selected. The example of disaster risk map could be seen in Aceh disaster risk map (Government-of-Aceh, 2011). The formula used to calculate the disaster risk could be referred to the application of concept of disaster risk reduction into land use planning (NEDA, 2008) which was adopted from "*hazard-risk model*" in calculating risk in the context of natural hazard management (Taylor, 2006). The disaster risk from the potential hazard can be calculated using the formula below.

Disaster Risk = Probability Of Hazard x Exposure x Vulnerability..................3.1

Where :

- Prob. of disaster risk...... the probability of natural disaster risk in certain period of time in a case study area selected (No unit).
- Exposure........................ The potential of city element at risk (e.g. people and property that exposed to the natural disaster risk, which can be expressed by percentage of inundation in all zones of a case study area selected (%).
- Vulnerability.................. The degree of loss (fatalities) or the level of damage (building damage) as a result of natural hazard impact in a case study area selected (%).

The disaster risk calculated then can be inputted into the map of a case study area selected. The output of disaster risk in a map can be used to give the detail information about the relative level disaster risk in all zones of the case study area selected. Visualization of the disaster risk output through a map is also an alternative that can be done for easier to be understood by the stakeholders or decision makers.

Moreover, the most likely disaster occurred or the most destructive hazard can be considered to be put in the main list priority of “preventive program”. The policy measures application through preventive program should be focused for the areas, which are located in high-risk areas to the natural hazard. The preventive program is important to be considered because the budget allocation in investment program can save more money loss rather than only focus on the post disaster program. The cost in post disaster program would be more seven times expensive rather that total allocation budget before the disaster (WEF, 2011). According to the latest study, the impact damage of natural disaster would spend 2-15% of annual GDP based on world bank estimation (World-Bank, 2004).

3.3.2 Land use and transport problems identification in the context of urban-transport plan

The identification of land use and transport problem is a process to analyse the land use and transport condition in a case study area selected. This process is important to be conducted in order to understand the existing urban transport condition in a case study area selected.

All the data related land use and transport interaction, including its existing plan should be collected to describe the land use and transport condition in the case study area selected before the possible strategies are formulated. The various data collected could be such as GDP of country and city, city residents in each zone, household income, vehicle ownership, and modal split. All of these data might interrelate each other in the context of land use and transport plan interaction issue. For instance, the increase of economic growth could increase the transport demand as a result of the economic development, which is planned to be achieved. In this case, it is expected that the urban transport planner could manage the transport demand to be placed in the right track in order to achieve the city objectives in the framework of sustainable development.

All in all, the land use and transport problem identification in this research were used to describe the picture of land use and transport condition in the case study area selected. Moreover, the picture of land use and transport condition at present time was used to forecast the future image of the case study area selected in the future. After that, the best possible strategies are formulated to achieve the city objectives.

3.4 City objectives for response the problems

The main high-risk city objectives in this study are related to the city objectives in the context of local and global issues. The city objective in the framework of urban risk reduction is a part of city strategy to response the problems in the local context. For instance, the problems faced related disaster risk is not similar between a city and the others cities across world. Therefore, the issue of city objective selected in the framework of urban risk reduction should be raised based on city characteristics in the local context. (e.g. its location that vulnerable to specific natural hazard). On the other hand, the reduction of carbon emission strategy can be applied globally by many cities across the world to promote the concept of urban transport sustainability.

For that reason, the long term city strategic planning should be directed the city sustainability objectives in the framework of urban risk reduction and urban transport sustainability. In this context, the direction of city planning in the framework of urban risk reduction and urban transport sustainability should be placed in the context of international, national, and local context. In the context of international and national, the city sustainability city objectives can be directed to reach the target of carbon emission from urban transport sector. On the other hand, the sustainability city objectives in the framework of urban risk reduction can be applied in the local context refer to the specific natural hazard.

For instance, in the current practice, Indonesia has two main national action plan in the framework of urban risk reduction and urban transport sustainability. The first action plan is a part in the effort to reduce the potential disaster risk since most of Indonesian cities are located in disaster-prone area to natural hazard (BNPB, 2013). This action plan was implemented in the national government disaster risk reduction (BAPPENAS and BNPB, 2006). The second action plan is related to the national government strategy to response the global issue related to the carbon emission, especially from urban transport sector. The second action plan was implemented a national action plan to reduce the carbon emission from various sectors, including urban-transport sector (PP-Republik-Indonesia-No.61, 2011). This national action plan was implemented to follow–up the Bali Action Plan (UNFCC, 2007a). This action plan also has an objective to fulfil the Indonesian government commitment to reduce greenhouse gases about 26%-41% in 2020 as mentioned by the President of Republic Indonesia at the G20 leaders' summit in Pittsburgh (Yudhoyono, 2009).

Furthermore, there were several other examples regarding how city objectives should be defined in the framework of urban risk reduction and urban transport sustainability, which can be seen in other several past studies worldwide that conducted by the World Bank (Dickson et al., 2012, World-Bank, 2011b).

3.5 The indicators selected in the framework of sustainability

Several indicators were selected to be used for measuring the sustainability performance in the case study area selected. The indicators selected were categorized into the indicators in the framework of (1) urban risk reduction and (2) urban sustainable development. As discussed earlier in chapter 2 e.g. sub section 2.5.1 and 2.5.2 about possible strategies in the aspect of urban risk reduction and urban sustainable development, there were several possible indicators, which could be used to measure the performance of city sustainability. The indicators selected in this research were based on the current local indicators, which fit with long term strategic objectives of Banda Aceh city as explained earlier in the previous sub section 3.4. In this case, it should be aware that all of the possible indicators in the framework of sustainability cannot be accommodated. Therefore, in this research. the indicators selected focused on the condition in the case study area selected.

For instance, in the aspect of urban risk reduction, by learning from tsunami tragedy in Banda Aceh, loss of life and loss of infrastructure destroyed (e.g. road, building, etc) are the indicators, which could be used to measure the performance of strategies selected. In the aspect of urban transport sustainability, most of the urban transport sustainability project focus on the strategy to implement the concept of pull and push transport strategies by improving the efficiency factor (e.g. travel time) as one options to make public transport more attractive compared to the private vehicles. In the political aspect, the fuel subsidy in the area of urban transport system is also another important aspect, which could be considered, regarding how much the government spending should be allocated in the government budget subsidy items. Last but not least, reduction of carbon emission is the other factor, which should be considered regarding global consensus (e.g. Kyoto Protocol, UNFCC Bali) for promoting the concept of sustainable development for the Banda Aceh city.

All of the indicators mentioned earlier were selected in order to represent the Banda Aceh city government action plan in the three different level of action plan implementation, namely (1) the local, (2) national and (3) global context. For instance, if these indicators are implemented in Banda Aceh city, there are three specified action plan that could be considered such as (1) reduction of disaster risk to potential tsunami hazard, which become as the main city objective in the framework of urban risk reduction in the local context. (2) Reduction of fuel consumption for helping national government to reduce the national fuel subsidy budget. (3) Reduction of carbon emission from urban transport sector as part of national and global long term government strategic program.

What are implications of missing other indicators out for Banda Aceh? The other missing indicators can be put in complementary priority list of city long term strategic plan objectives. However, in the reality, the decision to put what are the list of indicators that can be considered as essentials (first top list of priority) or complementary (second top list of priority) might be influenced by the political factors in deciding where the government vision is directed.

3.5.1 Indicators for framework of urban risk reduction

Table 3.1 below shows several possible indicators, which can used to evaluate the policies measures selected in the framework of urban risk reduction. The indicators selected refer to the local context of the local and national action plan of Banda Aceh city in the framework of urban risk reduction (RTRW, 2009, BNPB, 2010).

	Urban risk reduction objectives			
Objectives	**Fatalities (1)**	**Economy (2)**	**Environment (3)**	**Future generations (4)**
Indicators	People in high-risk areas of the city (Potential fatalities) (A)	Property in high-risk areas of the city (B)	Space size for conservation areas in high-risk areas of the city (C)	Number of people reside in high-risk areas of the city (D)

Table 3.1 :Selection of indicator evaluation in the framework of urban risk reduction

As can be seen in Table 3.1, the sustainability objectives in the framework of urban risk reduction covers four main aspects, namely fatalities, economy, environment and future generations, which refer to the city objectives. All of these aspects are derived from the concept of urban risk reduction as explained in chapter 2 literature review (UN/ISDR, 2005) and using sustainability objectives criteria selected in the PROSPECT project (May et al., 2003). The fatalities is the main indicator, which is selected to evaluate the strategies performance in this research. The projection of residents distribution in the long run of urban development process in the model is one important output that can be used to evaluate the city sustainability objectives for fatalities aspect.

In the economy aspect, the projection of housing distribution in urban dynamic urban development process is used to evaluate the city sustainability objectives in the context of financial loss (housing damage) if disaster occur. In the environment aspect, the decrease of people number in high-risk areas of the city can save more land to be used as conservation areas or green buffer areas without force all the land available in coastal areas to be used as residential areas or business areas. Last but not least, the future generation is also one of the main aspect that should be considered to evaluate the city sustainability objective. In this part, the number of people that attracted to reside in high-risk areas is indicator selected in this aspect.

3.5.2 Indicators in the framework of urban transport sustainability

Table 3.2 below shows the possible indicators that can be used to evaluate the policies measures selected in the framework of urban transport sustainability. The indicators selected refer to the local context of the national action plan (reduction of GHG) of Banda Aceh city in the framework of urban transport sustainability (PP-Republik-Indonesia-No.61, 2011).

	Urban transport sustainability objectives			
Objectives	**Efficiency (5)**	**Environment (6)**	**Economy (7)**	**Future generation (8)**
Indicators	Travel time (E)	Carbon emission (F)	Government revenue (G)	Fuel cons(H).

Table 3.2 : Selection of indicator evaluation in the framework of urban transport sustainability

As can be seen in Table 3.2, the sustainability objectives in the framework of urban transport sustainability also covers four main aspects, namely efficiency, environment, economy and future generations. All of these sustainability indicators selected also refer to the interpretation concept of urban transport sustainability in the guidebook of PROSPECT project (May et al., 2003). In the aspect of efficiency, travel time is one factor that can be considered to evaluate the performance of the strategies selected in this research. For instance, the travel time using public transport system is one of the option, which could be selected.

Moreover, the increase of public transport performance might attract more people to use public transport rather than private vehicles. Consequently, the reduction of city residents number that use private vehicles might also impact on the reduction of carbon emission level from urban transport sector. This indicator is used in the environment aspect of sustainability as shown in Table 3.2 above. In the aspect of economy, the government revenue from strategies selected such as implementation of progressive parking or fuel tax scheme also can be used to evaluate the city objectives sustainability. Last but not least, the fuel consumption and lower carbon emission are also one factor that can considered in the aspect of future generation. The lower fuel consumption today can result in lower carbon emission that make the earth today better to be inherited to our future generations.

3.6 Formulation strategies in the framework of urban risk reduction and urban transport sustainability

After the problems were already identified and the city objectives were already selected, the city strategy through implementation of some policy instruments could be started to be formulated. The city strategies selected consist of strategy in disaster mitigation in the framework of urban risk reduction and land use-transport strategy in the framework of urban transport sustainability.

In the context of disaster mitigation strategies, there are various strategies that can be selected in order to reach the city objective in the framework of urban risk reduction. However, the detail strategies discussed in this research was focused only in the context of land use strategies in the framework of urban risk reduction. As mentioned in chapter 2, the land use strategies discussed refer to some guidelines that were discussed in the level of academic and practice in the context of integration of aspect disaster mitigation into land use planning in the framework of urban risk reduction (Dronkers et al., 1990, ADPC, 2013).

In the context of land use and transport strategies, there also some various strategies that can be selected to reach the city objectives in the framework of urban transport sustainability. The possible of land use and transport strategies discussed refer to the several strategies that were explained in chapter 2 literature review. As mentioned in the chapter 2, the possible land use and transport strategies discussed refer to several guidelines or past studies regarding the issue of urban transport sustainability (May et al., 2003, Broaddus et al., 2009).

However, this section focused only in the discussion of transport strategies in the context of developing countries since there was a different significance issue that should be raised regarding urban-transport problems between developing and developed countries (Dimitriou and Gakenheimer, 2011). For that reason, this section consist of two main sub-sections. The first sub section discussed about the land use strategies in the framework of urban risk reduction (3.6.1). The second sub section discussed about the land use and transport strategies in the framework of urban transport sustainability (3.6.2).

3.6.1 Land use strategies in the framework of urban risk reduction

Table 3.3 below shows the three land use strategies in the framework of urban risk reduction that possible to be selected in the context of urban planning.

Land use strategies in the framework of urban risk reduction		Description of strategies
A	Accommodation (Land use plan A)	Allowing new housing development in high-risk area.
B	Planned-retreat (land use plan B)	Not allowing new housing development in high-risk area.
C	Planned-retreat (Land use plan C)	Allowing new housing development in high-risk area, but in very strict and limited areas.

Table 3.3 : Description of land use strategies in the framework of urban risk reduction

As can be seen in Table 3.3, there are three type of possible land use strategies that can be selected to be applied in a city, which is located in disaster prone areas to natural hazard, which consist of land use plan A, B and C. Firstly, in the accommodation strategy (land use plan B), the high-risk areas of the city are allowed to be used as new residential area redevelopment. In other words, the high risk zones, which were identified as high-risk areas as explained in section 3.3.1, are allowed to be planned as a new promoted development in the next future years. Ideally, in this strategy, all of the building in this area should fulfil the minimum building construction standards in associated with disaster mitigation strategy such as building code and the residents who reside in high-risk areas are encourage to have financial protection such as natural disaster risk insurance. Moreover, in this strategy, the authority should also provide the escape building or escape routes in the case of emergency in associated with the return period of disaster occurrence for the very destructive natural hazard such as tsunami. For instance, the local government of Banda Aceh already built some escape building as an alternative evacuation in tsunami emergency response (Pemkot-Banda-Aceh, 2012b).

Moreover, if the government has much budget, the protection strategy could be applied to support the strategy land use plan A. The high-risk zones identified are provided with the hard structural building (e.g. sea walls) to reduce the potential impact of natural hazards that coming from the sea such as tsunami. In the reality, the application of this strategy was applied in several coastal cities in Japan that vulnerable to tsunami disaster (UDO et al., 2012). Furthermore, it also should be noted that the cost for building such sea walls was quite expensive and it took a long time to be built. For that reason, this strategy was not recommended for a city in developing countries in respect to the consideration of budget limitation (Ishiwatari and Sagara, 2012). Moreover, the hard structural protection does not guarantee the safety of the people or the property in high-risk areas of the city. According to several of the past studies, the structural defences such as breakwaters or dikes were destroyed by huge tsunami that hit coastal cities in Japan on 2011 (UDO et al., 2012, Fraser et al., 2013).

Secondly, in the planned-retreat strategy (land use plan B), new housing development in the high-risk area is strictly prohibited. The most of the high-risk area are planned as green belt area by moving people that have been living there. In this strategy, the new promoted development areas are directed to the low-risk zones of the city. For instance, in the case of Banda Aceh city, this strategy has been tried to be applied in Banda Aceh city immediately after the tsunami tragedy. The authority planned to apply restricted development areas in the high-risk areas of the city based on tsunami inundation limit in 2004. However, there were some problems at that time that cannot to be solved in the emergency response by the authority such as land availability, property rights, compensation cost and land acquisition issue in the new promoted development area (BRR, 2005, Nazara and Resosudarmo, 2007). Moreover, there was no incentive policy that offered by the authority to attract the people to reside in low risk areas of the cities. Consequently, most of the tsunami victims decided to go back to build their houses in tsunami prone areas (YAPPIKA, 2005).

Thirdly, the land use plan C an alternative option, which is proposed as a moderate solution between land use plan A and B. This land use strategy allows the new housing development in high-risk areas of the city, but in very strict and limited areas. This strategy is proposed as a win-win alternative solution if the concept land use plan A and B cannot be fully implemented. The concept of pricing e.g. through increasing the land or property tax could in the high-risk areas of the city be applied in order to reduce the attractiveness of the high-risk zones.

3.6.2 Land use strategies in the framework of urban transport sustainability and urban risk reduction

In the context of urban structure pattern, there were two general strategies that possible to be selected for promoting the concept of urban transport sustainability as explained in the previous chapter 2. The possible strategies that could be selected consist of centralization and decentralization strategy. The centralization strategy has an objective to promote the compact city model, while the decentralization strategy has an objective to create more than one city centre, which is also known in the form of polycentric model city (Anas et al., 1998). Both of these strategies could be applied for promoting the concept of urban transport sustainability. However, there was no consensus between the supporter of compact city (Breheny, 1994, Owen, 1995) and the proponent of polycentric model city (Dutton, 2001, Talen, 2005) regarding what kind of urban structure that should be promoted in the framework of urban transport sustainability. Table 3.4 shows the possible of land use strategies that can be applied in the framework of urban transport sustainability.

No	Land use strategy	Objectives	Description of strategies
1	Decentralized concentration	Reduction of carbon emission	Planning second new promoted development areas for reducing length of commuting and travel time
2	Centralized Concentration	Reduction of carbon emission	Planning old city centre more compact to reduce length of commuting and travel time

Table 3.4 : Land use strategy in the framework of urban transport sustainability

As can be seen in the Table 3.4, the application of these two land use strategies have a similar objective to reduce the carbon emission from urban-transportation sector. in this concept plan developed, the concept of decentralized concentration strategy promote more than one core area of the city by planning a second new promoted development areas. On the other hand, the concept of centralization strategy direct the urban development process in one core area of the city in order to promote the compact city model. It is expected that this strategy could shorten the length of commuting and travel time.

Moreover, in this research, the land use strategies in the framework of urban risk reduction was combined with the land use strategies in the framework of urban transport sustainability. For that reason, the aspect of disaster mitigation, which has an objective to reduce the potential risk to natural hazard, was integrated into the land use strategy in the framework of urban transport sustainability, which can be seen in Table 3.5 below.

Land Use Strategy 1 / **Land Use Strategy 2**		**Urban Risk Reduction Plan**	
		Planned-retreat (reducing disaster risk)	**Accommodation and Protection (reducing disaster risk)**
Urban Transport sustainability	**Decentralized concentration** **(reducing carbon emission)**	1. Attracting more people to reside in low risk area of the city. 2. Planning new promoted development area in low risk areas of the city.	-
	Centralized Concentration **(reducing carbon emission)**	-	1. Attracting more people to reside in the high-risk core area of the city. 2. Planning old city centre in high-risk areas more compact.

Table 3.5 : Integration of disaster mitigation aspect in land use strategies in the framework of urban transport sustainability.

As can be seen in Table 3.5, after the aspect of disaster mitigation was integrated into the concept of land use strategy as shown in Table 3.4 above, the concept of decentralization strategy direct the urban development process to having a second new core area in low risk area that could be used as a new promoted development area because of the core area of the city is located in the disaster prone areas. On the other hand, in the concept of centralization strategy, the urban development process is directed to make the old core area of the city more compact. In this strategy, the disaster mitigation strategy refer to the concept of urban risk reduction as mentioned in section 3.6.1 such as providing escape building and escape routes.

3.6.3 Transport strategies in the framework of urban transport sustainability

There are various transport strategies that possible to be applied to reach the city objectives in the framework of urban transport sustainability. For that reason, in this sub section, the discussion of transport strategies focused only on the possible of transport strategies in the context of developing countries in the chapter 1 (Context of study). The reason lies behind this issue because of there is a different significance issue that should be raised regarding urban-transport problems in developing and developed countries as mentioned in the context of study and it was also explained in sub section 3.6. Table 3.6 below shows two possible of transport strategy that could be selected for promoting the concept of urban transport sustainability in the context of developing cities in developing countries. The possible transport strategies selected refer to several concept of urban-transport implementation for developing cities in countries (Litman, 2004, Petersen, 2004).

No	Transport strategy	City objectives	Description of strategies
1	Improvement of public transport	Reduction of carbon emission	Attracting people to use public transport system
2	Transport demand management (TDM)	Reduction of carbon emission	Attracting people to use public transport system

Table 3.6 : Transport strategy in the framework of urban transport sustainability

As can be seen in Table 3.6, there are two transport strategy that possible to be implemented in the concept developed in this research. The strategies consist of improving of public transport system and transport demand management. All of these strategies has an objective to reduce the carbon emission from transport sector by attracting people to use public transport system rather than private vehicles. The improvement of public transport system has an objective to increase the level performance of public transport system. The transport demand management strategy has an objective to discourage the city residents to use private vehicles. Therefore , it is expected that the transport demand management could encourage people to use public transport system rather than private vehicles.

Furthermore, The strategy of public transport improvement could be applied through promoting Bus Rapid Transit (BRT). This strategy has been implemented in several cities of developing countries (Ernst, 2005, Hidalgo and Graftieaux, 2008). The concept of BRT was quite potential to be applied in developing countries such as in Asia in the context low to middle income group countries (Hossain, 2006). On the other hand there were several policy measures that can be selected transport demand management (TDM) strategy as mentioned in the previous chapter 2 literature review (Sub section 2.5.2). However, in this research, the policy measures selected in transport management strategy consists of several possible policy measures that can be seen in Table 3.7 below. The detail explanation regarding the detail strategies selected in the case study area selected will be discussed in the next chapter 5.

No	Transport measures	Objectives	Description of measures
1	Improvement of public transport	Reduction of carbon emission	Bus rapid transit (BRT) with high level services
2	Progressive Parking scheme	Reduction of carbon emission	Increase significantly parking charge
3	Cut fuel subsidy	Reduction of carbon emission	Reducing or cut fuel subsidy

Table 3.7 : Transport policy measures of transport demand management strategy in the framework of urban transport sustainability

As can be seen Table 3.7, there are three policy measures that possibly selected to be applied in the concept developed of this research, refer to several alternative possible policy measures available that were discussed in chapter 2. The reasons lies behind the selection of parking and cut fuel subsidy because of these policies have been started to be implemented in some developing countries. For instance, the fuel subsidy was the most popular issues discussed in most developing countries in the context of the increase of the world oil price (IISD, 2013).

On the other hand, the progressive parking has been also initiated and applied in several cities in Indonesia through sustainable urban transport improvement project (SUTIP-Project, 2011, SUTP, 2013b). Moreover, the SUTP project also promoted this policy in various developing countries in the world (SUTP, 2013c). For that reason, it is expected that the policies measures selected as shown in Table 3.7 above are easier to be understood and implemented in the reality in the context of other developing cities of developing countries worldwide.

3.7 Combination of disaster mitigation with conventional land use and transport strategies

This part is the last part in the process of development land use and transport strategy in the framework of urban risk reduction and urban transport sustainability. In this part, the land use scenarios proposed in the framework of urban risk reduction and urban transport sustainability as explained in the section 3.6.1 and 3.6.2 were combined with transport strategies in the section 3.6.3.

Furthermore, Table 3.8 below shows the possible combination of land use and transport strategies selected in the framework of urban risk reduction and urban transport sustainability. However, it should be noted that there are others various transport strategies that still could be selected. Several strategies in Table 3.8 are only to be used as an example regarding how the strategies in disaster mitigation are combined with conventional land use and transport strategies in order to reach the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability.

Land-use plans in the framework urban risk reduction & urban transport sustainability	**Transport Plans**		
	BAU (1)	**Public Transport (2)**	**TDM (3)**
Accommodation (land use plan A)	A1	A2	A3
Planned-Retreat (land use plan B)	B1	B2	B3
Planned-retreat (land use plan C)	C1	C2	C3

Table 3.8 : The land use and transport policy measures in the framework of urban risk reduction and urban transport sustainability (1)

As can be seen in Table 3.8, there are 9 (nine) combinations of land use and transport strategies that could be selected to be applied in the case study area selected, which have range from A1 to C3. In the aspect of urban risk reduction, the application of disaster mitigation strategies refer the concept “allowing development” and “not allowing development” or “allowing development with very strict/limited areas” in high-risk areas of the city. As mentioned earlier sub section 3.6.1, in general, the new development in high-risk areas of the city are allowed in the accommodation and protection strategies (land use plan A). On the other hand, the new development in future is not allowed in the planned-retreat strategy (land use plan B) or if it is allowed, the future development is allowed in very strict/limited areas (land use plan C).

In the aspect of urban transport sustainability, the application of the transport strategies selected refer to the concept of “push” and “pull” concept that applied to reach the city objective in the framework of urban transport sustainability (Broaddus et al., 2009). In this context, the improvement of public transport system was defined as a pull strategy that has an objective to increase the attractiveness of public transport system. On the other hand, the transport demand management strategy was defined as a push strategy that has an objective to reduce the attractiveness of private vehicles to be used as main modes of transport in urban areas.

However, the urban-transport planner could combine two or three policies measures in transport demand management strategies in order to applied the concept of “push” and “pull” simultaneously. For instance, the measures of public transport improvement can be also combined with implementation of new parking progressive scheme in order to attract more people to use public transport rather than private vehicles. In this context, the application of pull concept strategy is directed to attract more public transport passenger, while the progressive parking scheme is applied to push people to use public transport system rather than private vehicles. Moreover, the strategy in transport demand management can be also combined with other measures such as reducing the fuel subsidy. The application of this measures after the progressive parking mentioned earlier could increase more the transport cost for private vehicles in order to discourage people to use private vehicles and promoting modal shift from private vehicles to public transport system.

Furthermore, the measure of strategy in transport plan should be started from the side of supply aspect (e.g. improving bus services) before the measures in transport demand management are applied (e.g. parking or fuel pricing). For instance, the measure of strategy application should be started by improving public transport system in the city. In the first place, this strategy is an option to give people choice (other mode alternative) for travel in urban areas using public transport rather than using private vehicles. In the second step, the progressive parking scheme can be introduced to increase the travel cost by private vehicles, especially in the core area of the city. Consequently, people consider using convenient public transport rather than private vehicles that cost them more expensive as a result of expensive parking charges. Lastly, the reduction of fuel subsidy or even fuel pricing can be implemented in the next step in order increase more the cost of travel by private vehicles.

Table 3.9 below shows the combination of transport policy measures in transport demand management strategy that can be possible to be applied in the generic level.

Land-use plans in the framework urban risk reduction & urban transport sustainability	**Transport Plans**
	Combination of Public Transport & Transport Demand Management
Accommodation (land use plan A)	A4
Planned-retreat (land use plan B)	B4
Planned-retreat (land use plan C)	C4

Table 3.9 : The land use and transport policy measures in the framework of urban risk reduction and urban transport sustainability (2)

As can be seen in Table 3.8 and Table 3.9, there are several possible strategies that are possible to be applied. All of combined policy measures selected are implemented in the same way to reach the city objectives in the framework of urban risk reduction and urban transport sustainability in order to reach the sustainability vision.

In the strategy land use Plan A, it is also possible to use transport strategies for supporting the concept of urban risk reduction. As mentioned earlier, the direction of urban development in the strategy land use plan selected should be directed to low risk areas of the city. In this case, the level of public transport service to the low risk areas should be higher rather than in high-risk areas of the city. It is expected that the support of transport strategies in the land use plan A could reduce more the number of people that reside in high-risk areas of the city in the next future years development.

Furthermore, in the land use plan B and C, it is also possible to apply the transport strategies in order to support the land use plan B and C., Therefore, the objectives in the aspect of urban risk reduction are not only support by policy measures in land use plan selected but also it could also be support by the transport strategies.

3.8 Framework assessment for evaluating the strategies implementation

After the land use and transport strategies were selected as discussed in sub section 3.7 and tested in a LUTI model, a framework assessment was developed to evaluate the outputs of the strategies selected. Figure 3.4 below shows the logical process in evaluation process of land use and transport strategies selected in this research.

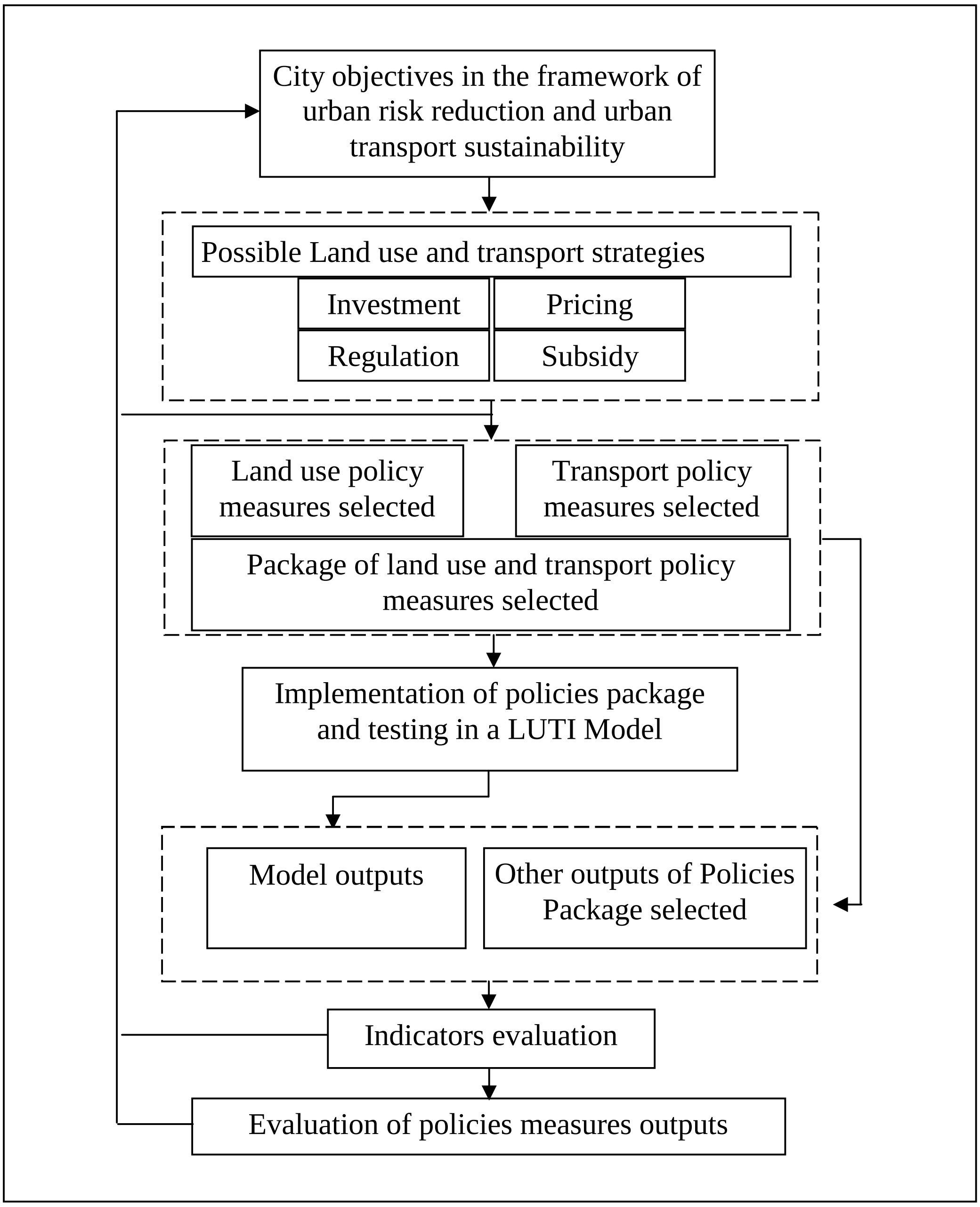

Figure 3.4 : Logical structure in evaluating land use and transport strategies selected

As can be seen in the Figure 3.4, there are some steps that should conducted before the outputs strategies are evaluated. The possible land use and transport strategies are derived based on the city objectives in the framework of urban risk reduction and urban transport sustainability. The possible strategies that consist of investment, regulation, pricing and subsidy policy instruments are used to formulate the possible land use and transport policy measures that fit with the characteristics of the case study area selected. After that, as discussed earlier in section 3.7, some possible land use and transport policy measures selected are combined in an integrated policy packages such as shown in Table 3.8 and Table 3.9. Furthermore, all of the policies measures selected are tested in a LUTI model. The results outputs are evaluated using several indicators in the framework of urban risk reduction and urban transport sustainability. The evaluation result of policies measures outputs then are used as a feedback to re-evaluate whether the target that stipulated in the city objectives have been met or not. For instance, the Indonesian government target in national action plan to reduce greenhouse gases about 26%-41% in 2020 (PP-Republik-Indonesia-No.61, 2011).

Furthermore, the indicators used to evaluate the policies measures selected consist of indicators in the framework of urban risk reduction and urban transport sustainability. In this context, the indicator selected in the framework of urban risk reduction is related to the number of people and housing in tsunami inundation areas of the city referring to the LUTI model projection. In other words, the residents and housing distribution in dynamic process of city development is used as an indicator to evaluate the impact of land use and transport policies measures, which are tested in the model, in the framework of urban risk reduction.

On the other hand, the indicators such as modal split, carbon emission and energy consumption are used to evaluate the impact of land use and transport policies measures selected in the framework of urban transport sustainability. For instance, it is expected that the implementation of policies measures in do something scenario can increase the number of people that use public transport rather than private vehicles. In this context, it is also expected that the increase of number of people that use public transport will reduce the level of carbon emission from urban transport sector. At the same time, the reduction of people that use private vehicles also can save more energy consumption in urban areas that will potentially reduce the government fuel subsidy in urban-transport sector.

Figure 3.5 below shows the framework assessment that is used to evaluate the outputs of land use and transport policies measures selected in this research.

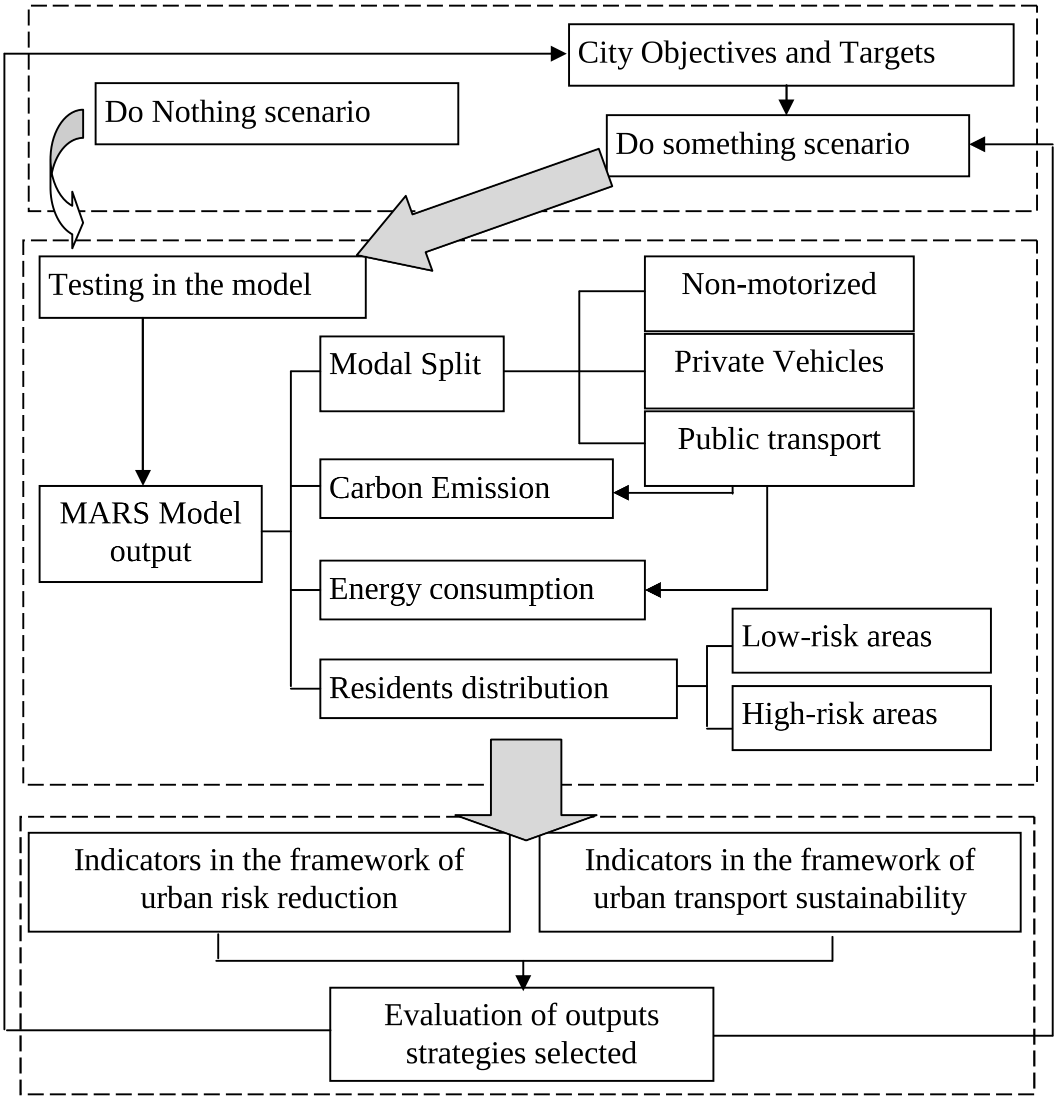

Figure 3.5 : The framework assessment used for evaluation the outputs of strategies selected

As can be seen in the Figure 3.5, the indicator outputs in MARS, which are consist of residents distribution, modal split, carbon emission and energy consumption model are used to evaluate all strategies selected that are tested in the model. The more detail explanation about indicator used in the framework of urban risk reduction refer to the previous sub section 3.5.1 (e.g. fatalities, economy, environment, future generations), while the indicator evaluation used in the framework of urban transport sustainability refer to the sub section 3.5.2 (e.g. efficiency, economy, environment, and future generations).

3.9 Indicators selected in the case study area selected

There were four indicators selected to evaluate the alternatives strategies selected in this research consist of vulnerability (3.9.1), environment (3.9.2), economic (3.9.3) and efficiency indicators (3.9.4), which were discussed in more detail below. These indicators will be used in the strategies evaluation process, which will be explained later in the chapter 4.

3.9.1 Vulnerability indicators

The argument lies behind the selection of this indicator, refer to Indonesian national action that has an objective to reduce the city vulnerability to potential disaster risk (BAPPENAS and BNPB, 2006). There were two indicators selected to represent the vulnerability indicators, which consist of potential number of fatalities and value of housing loss. The assumption used for calculating these two indicators refer to the tsunami tragedy in 2004 in the case study area selected (JICA, 2005).

The sub-district of Meuraxa (zone 1), which is located in very high-risk areas of the Banda Aceh city, was selected to be used for evaluating all of the alternative policy measures selected refer to the two indicators mentioned later in order to reach the sustainability objectives in the framework of urban risk reduction. As explained later in chapter 4, the number of fatalities after the tragedy in this sub-district had the highest number among the others sub-districts because the location of this sub-district is very near to the coastal areas. Furthermore, the level of building damage in this area was also the highest compared to the other zones, which reached 85% to 100%.

The vulnerability indicators for potential of number fatalities and value of housing were calculated using the formula below.

Formula for calculating the number of fatalities in zone 1.

$Fatalities_{zone\ 1} = \%\ fatalities_{zone\ 1} \times N_1^{in}(t=19)$…………………...…..…….**Equation 3.2**

Where :

- $Fatalities_{zone1}$ ...... Number of potential fatalities in zone 1 (Meuraxa)
- $\%fatalities_{zone1}$ .... % of fatalities in zone 1 refer to the tsunami tragedy in 2004 (see detail information in chapter 4 section 4.2.1 page 132).
- $N_1^{in}(t=19)$ .... Projection of residents number in zone 1 in the year 2030.

The residents number in zone 1 (N_1^{in}(t=19) was calculated using previous formulas that can be seen in the equation 6.1 chapter 6 page 190, which are repeated here for convenience as follows (Note : N_1in(t=19) in the equation 3.2. is calculated using the formula in the equation 3.3.).

$$N_1^{in}(t = 19) = N_i(t = 0) + SUM\ (N_i^{in}(t) - N_i^{out}(t))$$ **…………...Equation 3.3**

Where :

- P^{in}(t) .... Potential of moving population from other zones to zone 1 made up from exogenous population growth.
- a^{in}_j (t)............. Attraction to move into zone 1 in the year t.
- $^{WP}Acc^{PC,PT}_1$(t) Aggregated accessibility of workplace from zone 1 in the year t
- R^D_1(t)............ Monthly rent for domicile in zone 1 in the year t (Rp – Indonesia Rupiah).
- b, e................ Parameters for calibration, which are derived using the results observed data from time series statistics data.

Formula for calculating the potential loss of value of housing in zone 1.

Value of housing $loss_{zone1}$ = % damage $level_{zone1}$ × number of $houses_{zone\ 1}$ × House Price **……………………………………………………….............................Equation 3.4**

Where :

- Value of housing $loss_{zone\ 1}$.. total of cost for potential housing loss in zone 1 in the year 2030.
- % damage $level_{zone1}$............ the percentage of housing damage in zone 1 based on tsunami tragedy in 2004, which refer to the past study in the case study area selected (see chapter 4 sub section 4.2.1 Table 4.2 page 136 for details).
- Number of $houses_{zone1}$........ number of houses projected in zone 1 based on the model output of MARS model.
- House price .... the price per house in the case study area (see Appendix G for detail).

3.9.2 Environment indicators

The environment indicator in this study only focus on carbon emission indicator. The main reason that lies behind the selection of this indicator refer to Indonesian national action that has an objective to reduce the carbon emission from urban transport sector (PP-Republik-Indonesia-No.61, 2011).

There are several formulas that used to calculate the environment indicator, which only focus on carbon emission indicator. The formulas used to calculate the emission indicator is as follows :

$$Total\ CO_2\ Emission = CO_2\ Emission\ car + CO_2\ Emission\ moto + CO_2\ Emission\ PT$$
..Equation 3.5

CO_2 Emission car = Avg. CO_2 Emissions car × trips number car × car distance

..Equation 3.6

CO_2 Emission moto = Avg. CO_2 Emissions moto × trips number moto × moto distance**...Equation 3.7**

$$CO_2\ Emission\ PT = Avg.\ CO_2\ Emissions\ PT \times Veh.km\ PT$$
....
..Equation 3.8

Where :

- CO_2 Emission............ Total of all CO_2 Emissions produced by motorized of transport mode in the case study area selected (tonnes/year).
- CO_2 Emissions Car ... Total of all CO_2 Emissions produced by car (tonnes/year).
- CO_2 Emissions moto. Total of all CO_2 Emissions produced by motorcycles (tonnes/year).
- CO_2 Emissions PT .... Total of all CO_2 Emissions produced by public transport (tonnes/year).
- Avg. CO_2.................. Average level of CO_2 emissions assumption used in MARS model for car, moto and PT (bus) (grams/kilometre) (see carbon emission sub model in MARS).

3.9.3 Economic indicators

There are two economic indicators selected, which was classified into indicators cost and revenue. The cost indicators consist of BRT infrastructure cost (BRT initial investment, including BRT operating and maintenance cost per year) (see Appendix A.3) and fuel subsidy cost. The revenue indicators consist of fuel, parking, BRT fare and NPV revenue indicators). These indicators are important to be discussed in order to provide the general insight for stakeholders in decision making process.

Furthermore, in the real condition, the issue discussed subjected to where the subsidy items should be allocated in the budget planning, whether it should be used for subsidizing the fuel or public transport for instance. For that reason, it is expected that the application of these indicators could give the positive insight about where the government subsidy should be allocated in order to promote the concept of urban transport sustainability. Several formulas below show how all of the economic indicators were calculated, which can be seen as follows.

The formula below shows how the cost for BRT infrastructure (E), including maintenance and operating BRT cost (F) were calculated.

$$BRT\ Infrastructure\ \text{cost} = \sum (items\ in\ bus\ \text{inf}.\ development \times \text{cost}\ \ per\ items)$$ **………………………………………………………………………………Equation 3.9**

$$BRT\ operating\ \text{cost} = pt\ bus\ vehicle\ km \times pt\ bus\ \text{cost}\ \ per\ \ km$$ **……………………………………………………………………………………………Equation 3.10**

Where :

- Items of BRT Inf. ....Several items in BRT infrastructures (e.g. number of bus stops, buses and other items which can be seen in detail in the Appendix A.3) page 311 (Rupiah).
- Cost per items ....The cost per units for all items of BRT infrastructures. The detail information about all of these costs can be seen in the Appendix A.3 page 311 (Rupiah).
- PT bus vehicle km...total bus vehicle km in a year (km).
- PT bus cost per km..bus operating and maintenance cost per km (in Rupiah) (see Appendix A for detail page 312).

The formula below shows how the fuel subsidy (G) cost was calculated.

$$Fuel\ \ subsidy = fuel\ consumption \times subsidy\ \ fuel\ \ price\ \ per\ liter$$ **..Equation 3.11**

Where :

- Fuel subsidy............Fuel subsidy calculation is obtained from the results of fuel consumption in the MARS model outputs. The units used for fuel subsidy calculation is Indonesian Rupiah.
- fuel consumption. ...City fuel consumption that refer to results calculation in the MARS model outputs (Unit in liter).
- Subsidy fuel price ...the calculation of subsidy fuel price per litre (see Appendix C.7) (Indonesian Rupiah).

It is important to present this indicator since the issue of fuel subsidy has been becoming an important issue for Indonesian stakeholders. It was projected that Indonesia will become as the biggest importing oil country in order the to meet oil domestic demand that mostly allocated in urban transport sector (Jefriando, 2014). In 2012, the BBM subsidy allocation reached 211.19 trillion rupiah (SETKAB, 2013).

The formula below shows how the potential fuel revenue (H) for government was calculated.

$$Fuel\ \mathrm{Re}venue = fuel\ \ saving \times subsidy\ \ fuel\ \ price\ \ per\ liter$$ **..Equation 3.12**

Where :

- Fuel revenue............the calculation about potential saving of government from the reduction of fuel subsidy as a result of transport measures implementation (Indonesian Rupiah).
- Fuel saving..............the fuel saving obtained after the implementation of transport policy measures (in kilo-litre).

Moreover, the next two formulas shows how the potential government revenue from parking sector (I) and BRT fare revenue (J) respectively were calculated according to the alternative policy measures implemented in the model as can be seen in the equation 8.16 and 8.17.

$$Parking\ \mathrm{Re}venue = number\ of\ \ trips\,[car, moto] \times parking\ fares\ [car, moto]$$ ………
………………………………………………………………………………**Equation 3.13**

Where :

- Parking revenue ....Potential parking revenue from the application of parking policy for car and motorcycle. The units used for parking revenue is in Indonesian Rupiah.
- Number of trips.....number of trips for car and motorcycles, which are obtained from the output of MARS model.
- Parking fares ....Parking fares in the case study area selected and assumption used in parking charge policy. The unit used for parking fare is in Indonesia rupiah.

$$BRT\ \ fare\ revenue = number\ of\ \ pt\ bus\ \ passengers \times pt\ bus\ \ fares$$ ………………
………………………………………………………………………………**Equation 3.14**

Where :

- BRT fare revenue . Potential BRT fare revenue per year from the application of BRT policy (in Indonesia Rupiah).
- No of passengers .. Number of PT bus passengers, which is obtained from the MARS model outputs (passenger/year)
- PT bus fares.......... Bus fares refer to regulation in the case study (in Rupiah).

All details explanation about public transport improvement policy through BRT Application can be seen in the Appendix A, including the several formulas used to calculate the BRT infrastructure cost. On the other hand, the detail calculation for parking revenue can be seen in the Appendix D. Furthermore, the economic indicators mentioned earlier were used to calculate the net present value (NPV). The net-present value (NPV) calculation was conducted to show a time series of cash flow regarding the implementation of several alternative policy measures in this research.

There were several indicators, which were used to calculate the NPV. All of the indicators selected in calculating the NPV were distinguished into indicator in the group of revenue (money in) and in the group of cost that should be paid to operate or develop the BRT transport infrastructure (money out). In the first group, the indicators selected consist of revenue from fuel saving, parking, and BRT fare ticket. On the other hand in the second group, the indicators selected consist of the cost for BRT operational and maintenance, including the BRT transport infrastructure cost. The formula used to calculate the NPV is as follows :

$$NPV\ (i) = \sum_{t=0}^{n} \frac{(R_{t(A)} + R_{t(B)} + R_{t(C)}) - (R_{t(D)} + R_{t(E)})}{(1+i)^t} - BRT\ initial\ investment$$

……………………………………………………………………………**Equation 3.15**

Where :

- NPV .... Net-present value during the period 2011-2030.
- $Rt_{(A),(B),(C),(D),(E)}$ ... is the net cash inflow (for government) and outflow (allocated by government) in each year for oil revenue ($Rt_{(A)}$), parking revenue ($Rt_{(B)}$), BRT revenue (Rt_C), BRT operating & maintenance cost ($Rt_{(D)}$), BRT infrastructure cost ($Rt_{(E)}$) (Rupiah).
- $BRT_{initial\ investment}$. the cost for BRT initial investment (Rupiah).
- i .... is the interest rate assumptions (in percent per year).
- t .... is the year period of the alternative transport policy measures selected (BRT, parking and cut fuel subsidy) is implemented.

The result of NPV calculation was used to evaluate the economic indicators selected mentioned earlier in order show how effective the combined transport measures can be applied to produce better public policy in the context land use and transport plan for the case study area selected. The detail explanation of the NPV can be seen in the Appendix H. Furthermore, all of the economic indicators, including NPV calculation results for all of alternative policy measures and indicators selected in this study can be seen in the Appendix H (Appendix H1-H3).

In the real practice, the NPV calculation results is important to be discussed for showing what the win-win alternative solutions are, which could be implemented, in order to direct the urban transport system in the framework of sustainability. In the case study area selected, this indicator can be used to show the investment cost and the potential revenue that could be obtained after several alternative policy measures are implemented. Moreover, it can be used by the government as an important information in deciding where the best place to allocate the government subsidy budget in the context of promoting the interaction of land use and transport plan of urban planning in the framework of sustainability.

3.9.4 Efficiency indicator

The efficiency indicator was classified into time and cost aspect for public transport and private vehicles, which consist of car and motorcycle. In the aspect of time factor, travel time is one of the main indicator that should be considered by city residents in selecting the mode of transport for their journey in urban areas. On the other hand, the cost-efficiency factor is also one of the main factor that considered by the city residents in making their trip activities in urban areas. The further detail about weighting given to different journey components are given in the appendix G, page 18 to 323. The formulas below show how travel cost and time for public transport were calculated.

$Cost\ by\ PT = bus\ \ fares$ **..Equation 3.16**

$Travel\ time\,(PT) = walking\ \ time + waiting\ time + \ in\ \ PT\ time + changing\ time + walking\ time$
...Equation 3.17

Where :

- Cost by PT...............Cost paid by city residents for using public transport per trip (Rupiah).
- Bus fares..................the fare of public transport in the case study area (Rupiah).
- Travel time (PT)......total travel time calculation for PT (minutes).
- Walking time...........Walking time from origin to bus stop (minutes).
- in PT time................Driving time of public transport from bus stop in origin to bus stop in destination (minutes).
- Changing time ....changing time (minutes)
- Walking time...........Walking time from bus stop to destination (minutes).

The formulas below show how travel cost and time for car were calculated.

$Cost\ by\ car = car\ other\ \cos t + car\ \ fuel\ \cos t + car\ \ parking\ \cos t$ **.....Equation 3.18**

$Travel\ \ time\ (Car) = \text{walking time} + \text{time driving} + \text{parking searching time} + \text{walking time}$
...Equation 3.19

Where :

- Cost by car ....the information about cost by car per km (Rupiah).
- Car other cost ....car other cost per km (rupiah).
- Car fuel cost ....the fuel cost per liter in the case study area (Rupiah).

- Car parking cost............the parking cost for car (Rupiah).
- Travel time car..............total travel time calculation for car (minutes).
- Car walking time...........Walking time in the origin or destination from origin to parking place (minutes).
- Car time driving............Driving time from the parking place in origin to parking place in destination (minutes).
- Parking searching time ..the time for searching free parking space for car (minutes).

The formulas below show how travel cost and time for motorcycle were calculated.

$$Cost\ by\ moto = moto\ other\ \cos t + moto\ \ fuel\ \cos t + moto\ \ parking\ \cos t$$ ....**Equation 3.20**

$$Travel\ time(Moto) = \text{walking time} + \text{time driving} + \text{parking searching time} + \text{walking time}$$ ....**Equation 3.21**

Where :

- Cost by moto.................the information about cost by moto per km (Rupiah).
- Moto other cost.............moto other cost per km (Rupiah)
- Moto fuel cost................the fuel cost per liter in the case study area (Rupiah).
- Moto parking cost..........the parking cost for moto in the case study area (Rupiah).
- Travel time moto............total travel time calculation for moto (minutes).
- Moto walking time.........Walking time in the origin or destination from origin to parking place (minutes).
- Moto time driving..........Driving time from the parking place in origin to parking place in destination (minutes).
- Parking searching time ..the time for searching free parking space for moto (minutes).

The detail calculation results of efficiency indicators can be seen in the appendix C. In cost aspect, the public transport cost is more cheaper compared to the car and motorcycles after transport policy measures were applied in the model (Appendix C.1-C.3). In the time aspect, the improvement of public transport services reduces the total travel time by public transport system that increases its level of services (Appendix C.4-C.6).

3.10 Summary of the concept plan developed

The concept plan developed in this research has an objective to fill the gap between the issue of urban risk reduction and urban transport sustainability in the context of land use and transport planning. This issue is important to be discussed since one of the main world issue concerned today is related to the rapid urbanization phenomenon that would potentially distribute more people in high-risk areas of the city and the increase of transport carbon emission from transport sector in the next future years (UN/ISDR, 2005, World-Bank, 2010b).

For that reason, it is important to formulate an integrated strategy that can meet the city objectives in the framework of urban risk reduction and urban transport sustainability. The possible land use and transport strategies selected refer to possible strategies in the framework of urban risk reduction and urban transport sustainability. This issue already explained in section 3.6 that discussed about how to formulate the strategies in the framework of urban risk reduction and urban transport sustainability. In the reality, this such formulation strategies might benefit to be applied in the city which has an objectives in the framework of urban risk reduction and urban transport sustainability. For instance, most of the high-risk cities in Indonesia has the objectives to reach the national action plan (PP-Republik-Indonesia-No.61, 2011) to reduce the carbon emission and local action plan (BAPPENAS and BNPB, 2006) to reduce the vulnerability to disaster risk since most of Indonesian cities are located in disaster prone areas (BNPB, 2013).

Moreover, a framework assessment was also developed to evaluate the strategies selected in the formulation process. The framework assessment, including several steps, which should be conducted in this study, was discussed in the section 3.8. The framework assessment developed uses two main indicators that refer to indicators selected based on city objectives, which was categorized into indicators in the framework of urban risk reduction as can be seen in section 3.5.1 and indicators in the framework of urban transport sustainability as shown in section 3.5.2. The indicators in the framework of assessment areas will be applied to evaluate the strategies selected in the formulation process in order to meet the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability.

Chapter 4
Case Study Area Selected & Problems Identification

This chapter is intended to introduce the case study area selected, including its problems and to identify the problems found there. The city of Banda Aceh, which is located in high-risk area to tsunami disaster and also has transport problems, was selected as a case study area in this research. There are three main topics discussed in this chapter. The first is to introduce the case study area selected (4.1). The first part is related to the introduction of the case study area selected (4.1), which consist of the geographical background of Banda Aceh (4.1.1) and the historical background of Banda Aceh as a high-risk city (4.1.2). The second topic is a description of the problems identified in the case study area (4.2), which were categorized into disaster risk problems (4.2.1), land use problems (4.2.2), transport problems (4.2.3). The third part of this chapter discusses the summary problems identified in the case study area (4.3). This part discusses the evaluation of land use plans to plan for tsunami risks and urban transport problems in the case study area, which are representative of problems in developing cities in developing countries.

4.1 Introduction of the case study area

The introduction of the case study area is in two sections. The first describes the geographical background of Banda Aceh city as the case study area (4.1.1). The second narrates the historical background of Banda Aceh city as a high-risk city (4.1.2).

4.1.1 Geographical Background

Banda Aceh is the administrative centre of Aceh Province in Indonesia. It is the largest city in the Province of Aceh. Geographically Banda Aceh is located on the island of Sumatera, at the north-western tip of Sumatera. Therefore, Banda Aceh is the entry point to Indonesia from the west. The sea area of Aceh Province is also bordered on the North, West and East by countries in the continental area of south Asia. Indeed, the location is very strategic for economic activities. It has been supported by several government policies like the setting up of Banda Aceh as an integrated development economic area for the western most areas of Indonesia

(Banda Aceh Spatial Planning, 2010). The geographical location of the case study selected is shown in Figure 4.1 below.

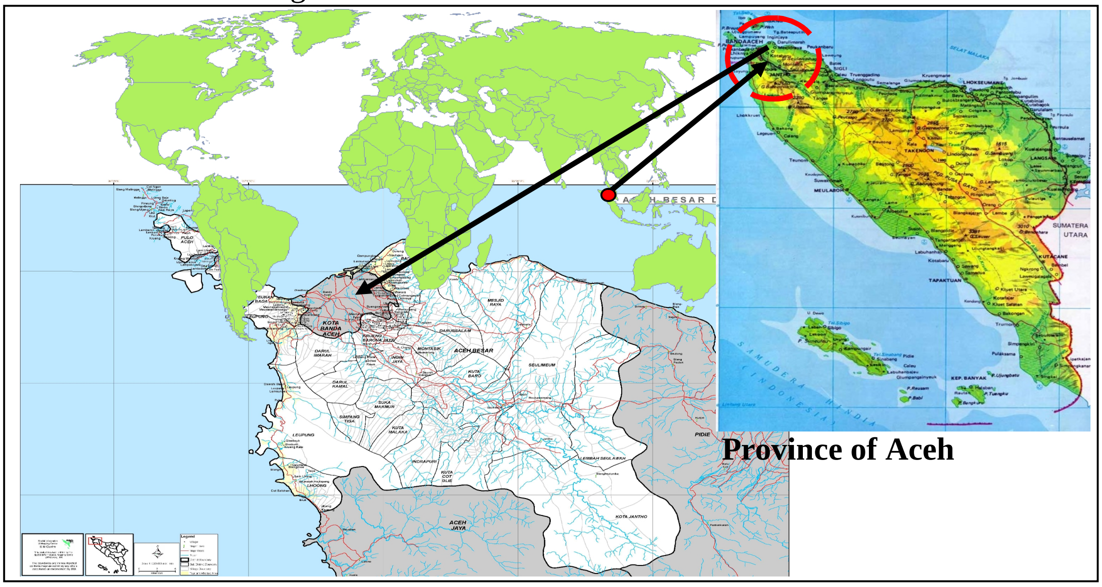

Figure 4.1: Location of Banda Aceh city

Source : **(World-Bank, 2010a); http://www.petaindonesia.org/propinsi/aceh.html**

4.1.2 Historical background of Banda Aceh as a high-risk city

After the huge earthquake and tsunami tragedy in Banda Aceh in 2004, disaster mitigation become a major issue in Indonesia that was discussed in depth at academic and practical forums. Indonesia is an archipelago, which is located over the boundaries where 3 major tectonic plates meet, viz. the Indo-Australian, Eurasian and Pacific plates. Consequently, most cities in Indonesia are very vulnerable to earthquake, volcanic and tsunami disasters. Banda Aceh, located at the north-western tip of the Island of Sumatera was struck by a huge earthquake (over 9 on the Richter scale) followed by a devastating tsunami on Sunday morning 26 December 2004 which was one of the biggest disasters in modern history killing over 200,000 people mostly in Aceh. After the tragedy, the damage from a tsunami disaster became a major issue in Banda Aceh. After the tragedy, tsunami disaster becomes the major issue in Banda Aceh city after the tragedy that occurred in the last December of 2004. However, according data from BNPB[1] in Aceh disaster risk map (Government-of-Aceh, 2011), several types of disasters that have been occurred

[1] BNPB is the national government board for disaster management that work in area of disaster mitigation and disaster emergency response.

and identified in Sumatera Island from 1998-2009, which are described in Figure 4.2 below.

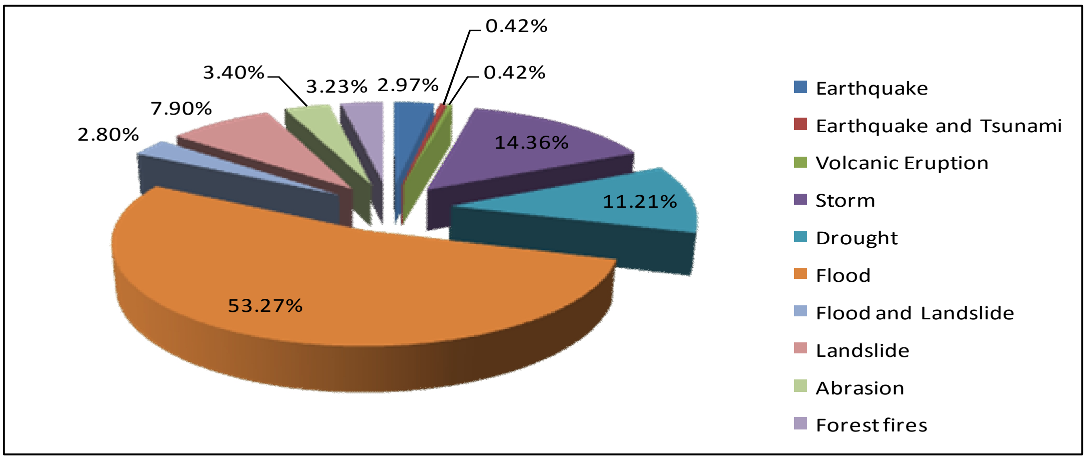

Figure 4.2: Percentage of disasters type that occurred in Sumatera Island, Indonesia

Source : dibi.bnpb.go.id (2010) in Aceh disaster risk map(Government-of-Aceh, 2011)

Figure 4.2 shows the various types of disasters in Sumatera in recent years such as floods (53%), storms (14%), droughts (11%), landslides (8%), abrasion (3%), forest fires (3%), earthquakes (3%), floods with landslides (3%), earthquake and tsunami (0.4%), and volcanic eruptions (0.4%). From all of these types of disasters that have occurred in Sumatera as shown in figure,4.2, most of them (72.%) occurred in the four provinces of Aceh (25%), North Sumatera (20%), West Sumatera (14.%), and Lampung (13%) as shown in Figure 4.3 below.

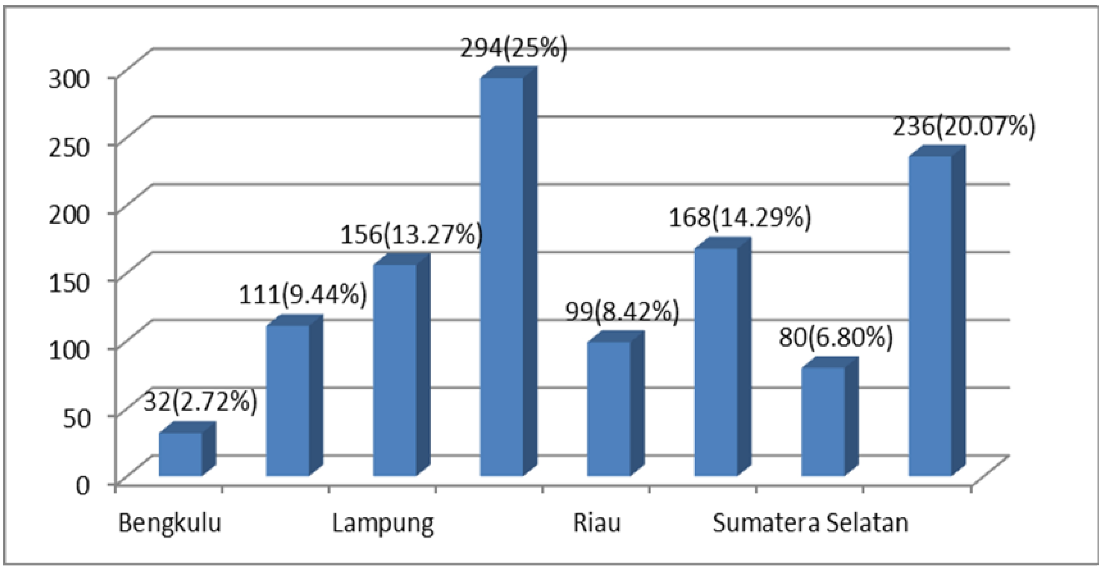

Figure 4.3: Disaster distribution in the provinces level in Sumatera (Indonesia) (Government-of-Aceh, 2011)

However, from all the different types of disaster that have occurred in Sumatera recently, the earthquake and tsunami disaster on 26 December 2004, that smashed the coast of Aceh, was the biggest such disaster in modern history and had the biggest impact compared to all the other types of disasters. The earthquake, which triggered the tsunami disaster, had a magnitude of 9.15 Richter scale (Chlieh et al., 2007), occurred at 7:58 am (local time) on a Sunday, holiday morning, the day after Xmas day. The epicentre of the earthquake was located 255 km south-west of Banda Aceh city in the Indian Ocean and caused tsunami waves with a velocity of 600 kph, which devastated most of the infrastructure for hundreds of kilometres along the shorelines about 25 to 45 minutes after the earthquake (Borrero, 2005). There were 127,720 people who died and 93,285 went missing, while 635,384 people loss their homes (BRR, 2009). In Banda Aceh alone, this disaster killed more than 70.000 people and destroyed or badly damaged over 16.000 homes (JICA, 2005).

Furthermore, in response to the tsunami , the impact of the disaster has forced the government and other stakeholders to rethink and redesign land use plans for the high-risk coastal areas of the city, including whether to allow people to reside in these high-risk areas or not. After the tragedy, the government also started to spread information through mass media about earthquakes happening and whether they have the potential to trigger a tsunami or not using television, radio and information sources from the government board for meteorology, climatology, and geophysics (BMKG, 2013). Learning from such a big tragedy, Syiah Kuala University as a centre of excellence in Aceh also established a Tsunami Disaster Mitigation Centre (TDMRC) in 2006 that is fully supported by the government of Aceh in order to spread knowledge about disaster mitigation in both local and international contexts.

Figure 4.4: Tsunami Disaster Mitigation Research Centre in Banda Aceh (TDMRC, 2013)

4.2 Problem identification in the case study area selected

Problem identification in this research is divided into two categories. The first dimension and the main problem identified is related to tsunami disaster risk in the context of urban disaster mitigation, while the second problem focuses on the issues of carbon emissions from the urban-transport sector. In other words, the first step is to identify the problems in the case study area i.e. to locate the high-risk areas for a natural disaster (focusing on a tsunami disaster). The second problem is to identify the negative impact of human activities caused by the urban-transportation sector, which are classified into problems arising from the land use and transport plans that have an impact on urban transport problems.

Therefore, systematically, the problem identification in this research consists of three parts, namely mapping tsunami disaster risk areas, land uses and transport problem. The first part of problem identification is the mapping of tsunami risk areas. The second part is looking at the land use plans including the history of population distribution before and after the tsunami, which are categorized into pre-tsunami (1985-2000) and post tsunami conditions (2006-2011). The third part discusses the picture of transport policy in the context of national and local issues for the case study area.

4.2.1 Mapping of tsunami disaster risk in Banda Aceh

This sub-section discusses identification of tsunami risk in all zones of Banda Aceh. All the data and information were obtained from government documents and past research done in Banda Aceh after the tsunami. The data and information obtained were then combined to map zones based on the level of risk from a tsunami with the same scale as that in 2004.

In the past, JICA (Japan International Cooperation Agency), a Japanese aid agency that was actively involved in the rehabilitation and reconstruction programs in Aceh conducted a research study about the number of tsunami victims and the housing damage based on the boundary limit from tsunami inundation in 2004.

Figure 4.5 below, shows the zone numbers used in this research for all of the sub-districts in the City of Banda Aceh. There are 9 (nine) sub-districts in Banda Aceh as shown in the Figure 4.5. The city centre is located in sub district Baiturrahman and the main business areas, including government offices are located in sub-districts Kuta Alam, Kuta Raja and Syiah Kuala.

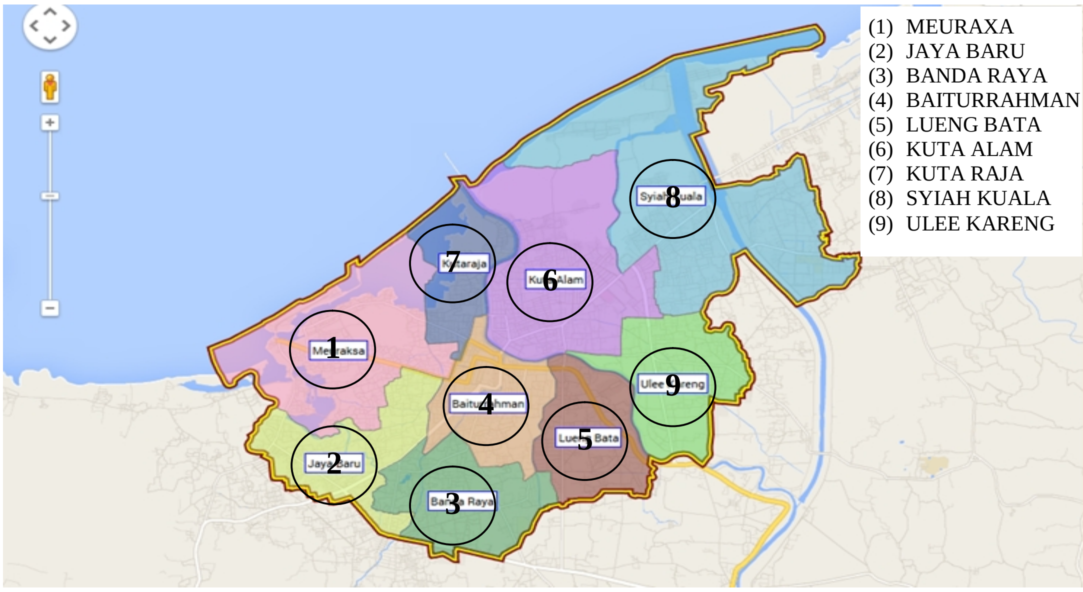

Figure 4.5 : Sub-districts in Banda Aceh city (BAPPEDA, 2013)

Figure 4.6 below shows the distribution of tsunami victims based on the JICA data that was classified based on sub-districts and villages.

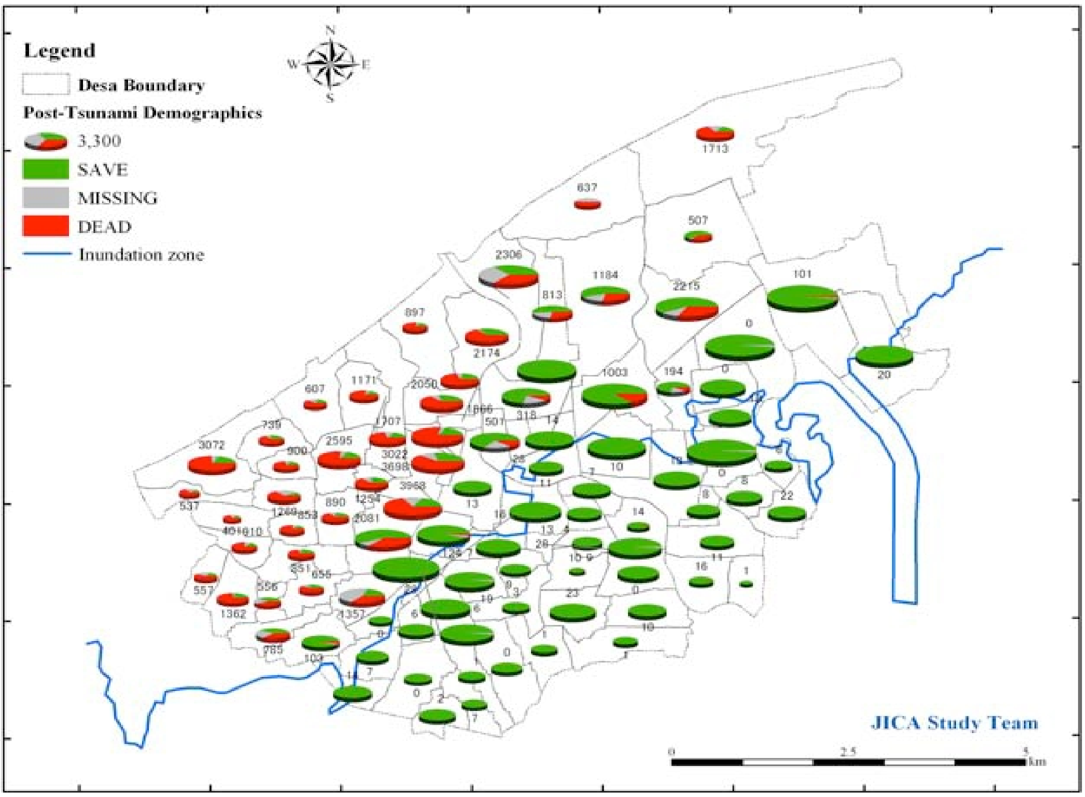

Figure 4.6:The distribution of tsunami victims in based on sub-districts (JICA, 2005)

According to the JICA report, the total number of tsunami victims in Banda Aceh city was 71,435 as shown in the data of 12 April 2005 (JICA, 2005). It can be seen from Figure 4.6 that most of the victims, were from the zones that were most inundated and impacted by the tsunami waves, especially those zones located in the coastal areas. Moreover, 80%, 75% and 61% casualties (people missing and dead) were in the sub-districts of Meuraxa (1), Kutaraja (7) and Jaya Baru (2) according to the JICA data for the sub-districts. In other words, the majority of people that became victims of the 2004 tsunami were in three sub districts along the coast and just inland.

Besides that, according to census data from 2005, the number of residents in the high-risk sub districts of Meuraxa (1), Kutaraja (7) and Jaya Baru (2) were reduced 93.6%, 86.2% and 42.1% respectively after the tsunami. By comparison with the data from JICA, the census data from 2005 revealed that the number of casualties from the JICA survey was not much different from the drops in population after the tsunami. The census data, showing the population in each of the 9 sub-district of Banda Aceh before and after the tsunami tragedy is set out in Table 4.1 below.

No	Sub-Districts	2004	2005	Number of residents decrease	(%)
1	**Meuraxa**	34,592	2,221	32,371	93.6%
2	**Jaya Baru**	21,305	12,340	8,965	42.1%
3	**Banda Raya**	23,995	24,257	-	-
4	**Baiturrahman**	37,715	33,582	4,133	11.0%
5	**Lueng Bata**	19,232	19,284	-	-
6	**KutaAlam**	54,718	35,033	19,685	36.0%
7	**Kuta Raja**	21,632	2,978	18,654	86.2%
8	**Syiah Kuala**	32,590	25,418	7,172	22.0%
9	**UleeKareng**	19,319	22,768	-	-

Table 4.1: Sub-districts population of Banda Aceh city in pre-and post-tsunami tragedy (BPS-Banda-Aceh, 2005)

From Table 4.1, it can be seen that the biggest reductions in population after the tsunami were in sub-districts Meuraxa (1) and Kutaraja (7). These were the two sub-districts in Banda Aceh which were on the coast and were most affected compared to the other sub-districts.

Furthermore, JICA also classified building damage into 4 classes. The level of damage is shown in Fig 4.7 by four colours, red shows that 85% to 100% of all houses were destroyed, orange shows that 50% to 85% of houses were destroyed, yellow shows that 0% to 50% of houses were destroyed whilst blue shows the shallow inundation area where no significant damage was done. These colored areas are shown in the Figure 4.7 below.

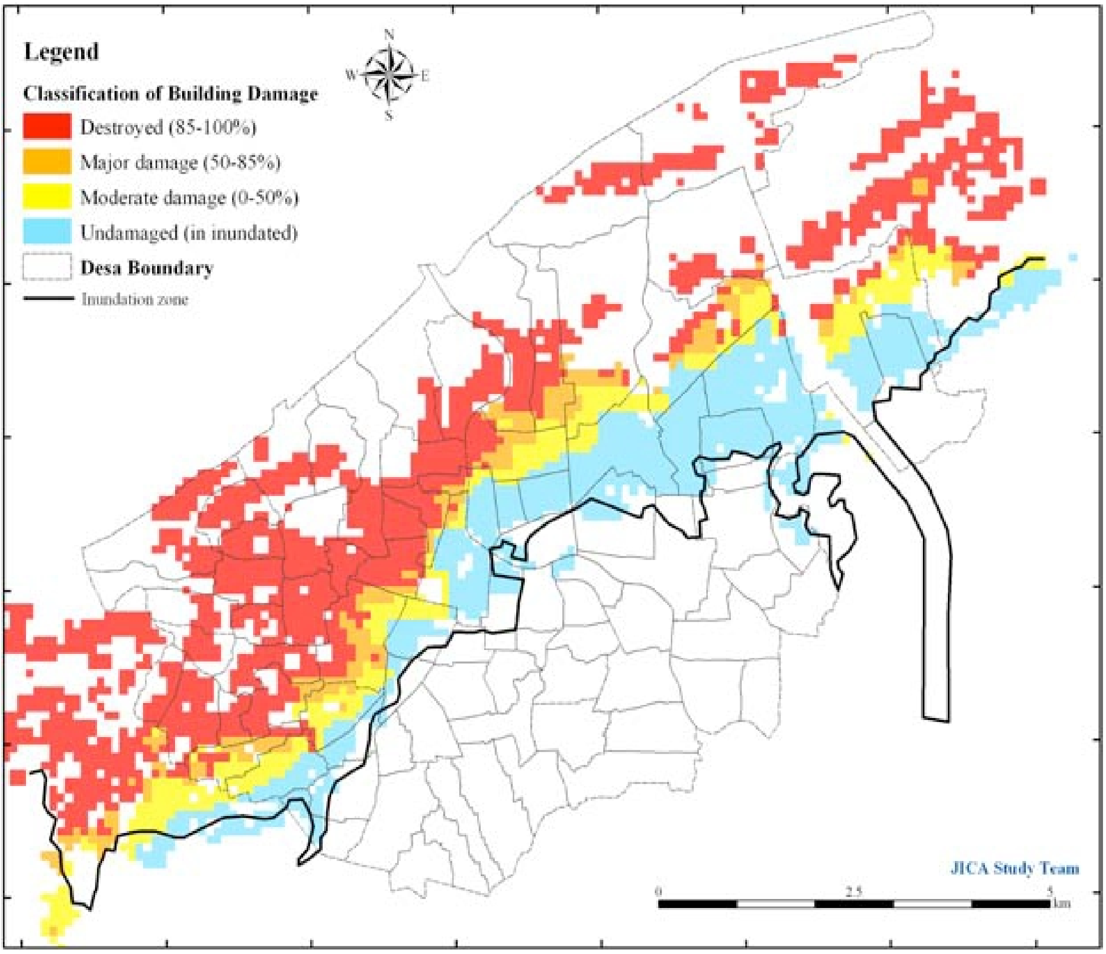

Figure 4.7: Classification of building damage based on tsunami inundation limit (JICA, 2005)

According to the another study (Marchand et al., 2009), the level of damage was divided into 4 categories. The four categories were (1) totally destroyed, (2) major damage, (3) medium damage (minor damage) and (4) very minor damage, which referred to the height of tsunami inundation. The totally destroyed category was where the tsunami inundation was about 6 meters i.e. 2 stories or more. Major damage was defined as where the tsunami inundation limit was below 4 meters, whilst medium damage occurred mostly with inundations of 3 meters or less and below 1.5 meters was classified as the category with very minor damage.

Furthermore, in 2012, the Government of Aceh through the local board for disaster mitigation (BPBD Aceh) in cooperation with the Tsunami Disaster Research Mitigation Centre (TDMRC) released a new tsunami disaster map for the city of Banda Aceh. This new map can be seen in Figure 4.8 below. This map shows tsunami inundation heights in several sub-districts of Banda Aceh city based on the 2004 tsunami. The areas closest to the coast had the highest tsunami inundations that caused more severe damage.

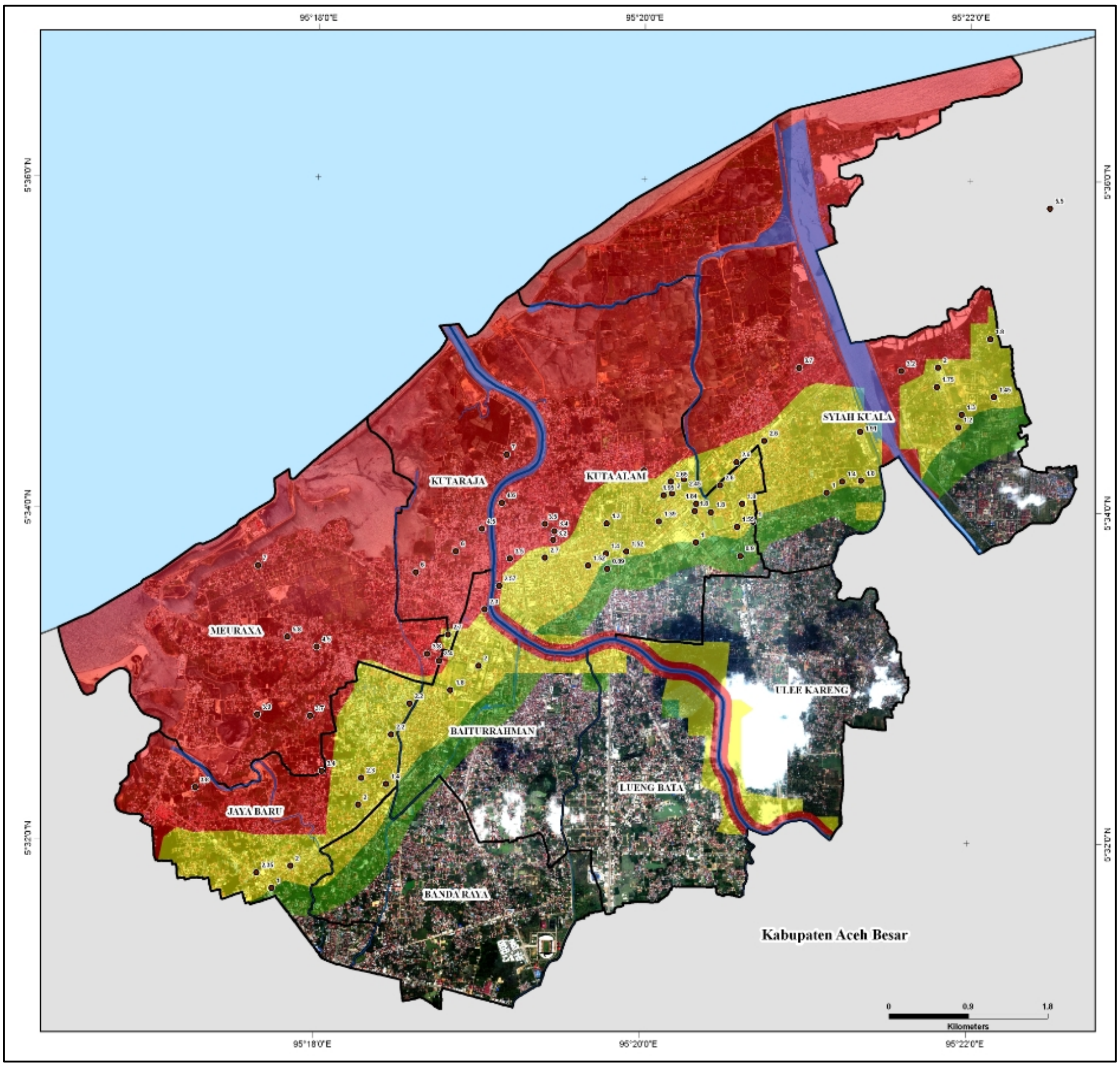

Figure 4.8: Banda Aceh of tsunami disaster risk map (BPBD, 2012)

The data of tsunami inundation heights in the Figure 4.8 were used to identify risk classifications in each zone of the case study area selected in Banda Aceh city. After that, this data was then combined with data from other past studies and research

(JICA, 2005, Marchand et al., 2009, BPBD, 2012). This can be seen in the next Figure 4.9. which follows below. However, it should be noted that the new definition for very minor damage[2] used a new classification i.e. modifying the level of damage from the JICA version as shown in the Figure 4.7 (JICA, 2005). The Figure 4.9 shows the damages scale of tsunami disaster for reinforced concrete housing based on tsunami inundation height in the tsunami tragedy ten years ago in 2004.

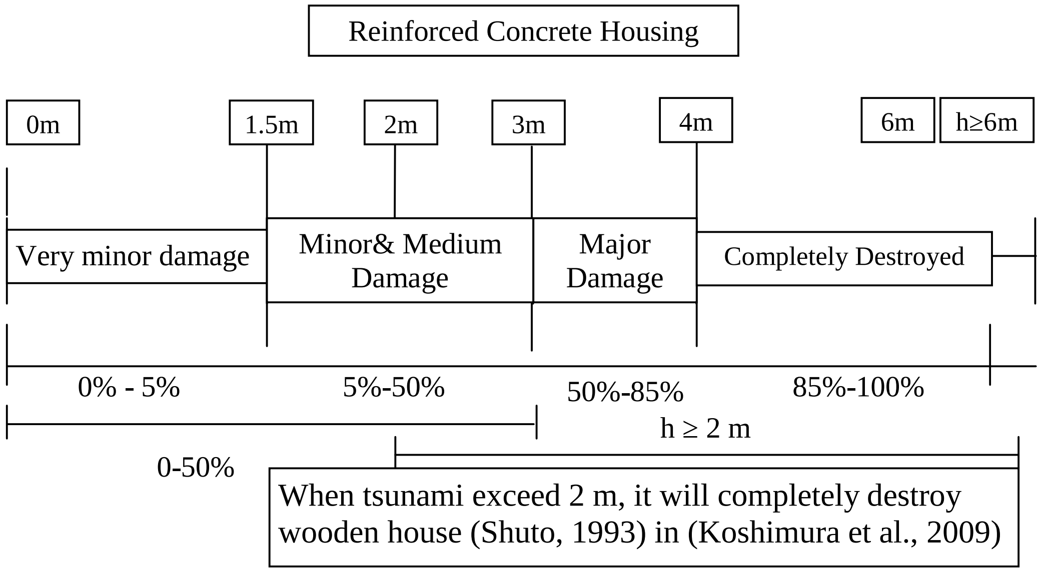

Figure 4.9: Scale of damages based on tsunami inundation height (JICA, 2005, Marchand et al., 2009, BPBD, 2012)

From the Figure 4.9, it can be seen that there were four categories in classifying the level of damage based on tsunami inundation heights. The very minor damage classification was given to those areas with an inundation limit from 0 to 1.5 meters. The level of damage in this area would be 0%-50%. The minor and medium damage is specified for the zone with inundations from 1.5 to 3 meters. The damage level in this area will be 5% to 50%. Next, the major damage classification is areas with inundations from 3 to 4 meters. The level of damage in these areas will be 50% to 85%. Finally, the completely destroyed classification has been given to areas with inundated over 4 meters. The level of damage in these areas will be from 85% to 100%. This is the worst level of damage in the risk classification.

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[2] A new classification of percentage 0%-5% in this research is the author's assessment as a tsunami victim and work as a planner at government agency, where his house was located in the area with very minor damage in zone 8 of the case study area selected.

After that, from the data in the previous Figure 4.8 and the tsunami damage scale as shown in the previous Figure 4.9, which were obtained from the past research in Banda Aceh city, the damage level of tsunami disaster for each zone in the case study selected was classified as shown in Table 4.2 below.

No	Zones Name	Inundation height (m)	Inundation Class	Level of Damage
1	**Meuraxa**	**7.0,5.8, 4.5**	**h≥4m or h≥6m**	**85%-100%**
2	**Jaya Baru**	**3.8,3.4, 2.3**	**3m≤h≤4m**	**50%-85%**
3	**Banda Raya**	**-**	**No inundation**	**0%**
4	**Baiturrahman**	**1.8, 2.0**	**1.5m≤h≤3m**	**0%-50%**
5	**Lueng Bata**	**-**	**No inundation**	**0%**
6	**KutaAlam**	**4.6, 3.5, 1.5, 0.9**	**3m≤h≤4m**	**50%-85%**
7	**Kuta Raja**	**7.0, 6.0, 4.5**	**h≥4m or h≥6m**	**85%-100%**
8	**Syiah Kuala**	**3.7, 2.6, 1.75**	**3m≤h≤4m**	**50%-85%**
9	**UleeKareng**	**-**	**No inundation**	**0%**

Table 4.2: Damage classification based on tsunami inundation(JICA, 2005, Marchand et al., 2009, BPBD, 2012)

Based on the information given in Table 4.2, the sub-district zones in the case study area selected for this research were classified into four general categories as follows:

1) The first category was the red zone areas with two classifications, consist (1) completely destroyed and (2) category major damage, which were defined as very high-risk areas and high-risk areas respectively

2) The second category was the yellow zone with medium damage/minor/very minor damage with tsunami inundation, which was the classified as the medium risk areas.

3) The third category was the green zones without tsunami inundation, which were then classified as low risk areas.

Based on the explanation earlier, the zones classification based on tsunami disaster risk for all zones in the case study area selected of Banda Aceh city in this research can be seen in Table 4.3, which follows overleaf.

No	Zones Name	Level of Damage	Damage Category	Zone Classification
1	Meuraxa	85%-100%	Completely Destroyed	Very high-risk
2	Jaya Baru	50%-85%	Major damage	High-risk
3	Banda Raya	0%	Low risk/no damage	Low-risk
4	Baiturrahman	0%-50%	Medium/minor/very minor Damage	Medium risk
5	Lueng Bata	0%	Low risk/no damage	Low risk
6	KutaAlam	50%-85%	Major damage	High-risk
7	Kuta Raja	85%-100%	Completely Destroyed	Very high-risk
8	Syiah Kuala	50%-85%	Major damage	High-risk
9	UleeKareng	0%	Low risk/no damage	Low-risk

Table 4.3: Classification of zones in the case study area selected based on level of damage

The next step in mapping the tsunami disaster risk areas was to visually present the level of risk on the map of Banda Aceh. The visual presentation process was done using ARCGIS and Google Earth to get clear spatial information about the risk levels from a tsunami resulting in an attractive, interactive map. In reality such a map can help stakeholders and decision makers to easily understand the situation and condition in the areas concerned. Figure 4.10 is an interactive map of Banda Aceh city showing the tsunami affected areas that were developed using ArcGIS software which, was then imported into the Google Earth map.

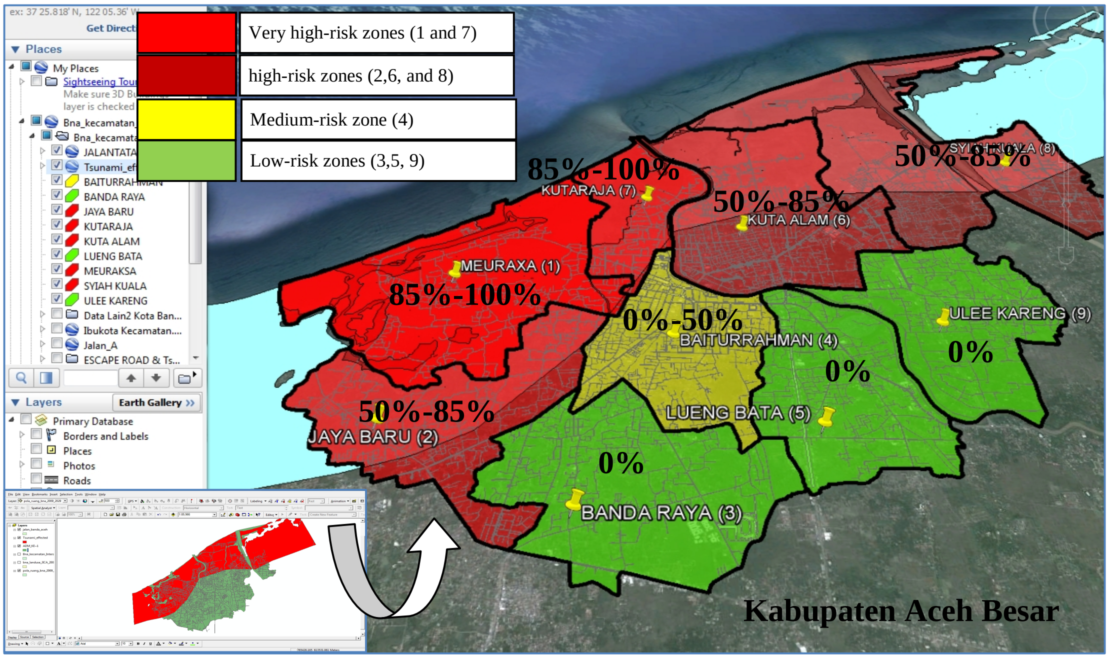

Figure 4.10: Map Banda Aceh city with tsunami affected areas in ArcGIS (BAPPEDA, 2012) using Google Earth

4.2.2 Land use plan in the case study area

After the tsunami tragedy in December 2004, BAPPENAS (the National Development Planning Agency for Indonesia) prepared a future plan (blueprint) for Banda Aceh in the framework of disaster mitigation. In this blue print, the physical zoning of Banda Aceh had conservation areas, restricted development areas and promoted development areas. The master plan was designed and planned to be adjusted with disaster area characteristics for disaster mitigation based on the classification of zone functions as follows : (a) coastal zone (1,7), (b) restricted settlements zone (1,7,6), (c) new promoted development area (3,5,9), (d) Provincial business and administrative centre (6), (e) higher education zone (8) as can be seen clearly in Figure 4.11 below (BRR, 2005). The design of master plan was fully supported by JICA (Japan International Cooperation Agency) in a top down approach to prepare a development concept for long term strategic spatial planning for Banda Aceh.

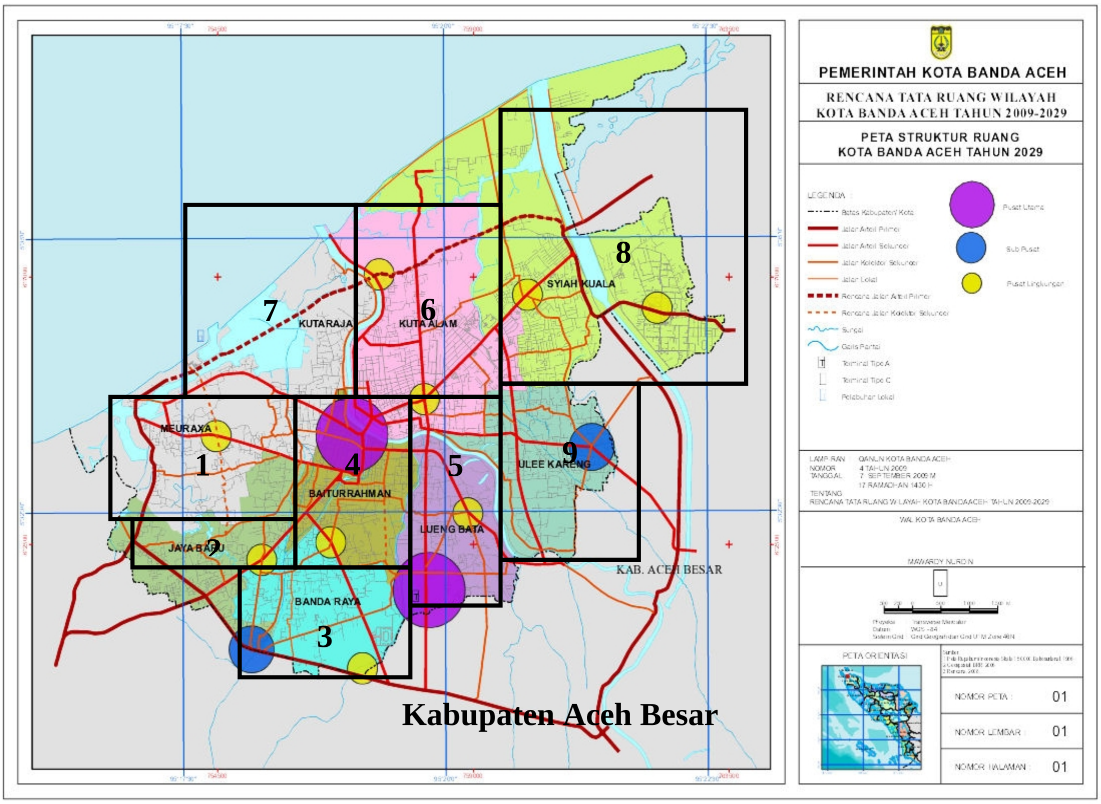

Figure 4.11: Banda Aceh Urban Planning 2009-2029 (RTRW, 2009)

However, there were some problems that could not be solved at that time by the authority in charge of the tsunami emergency response such as property rights in the high-risk areas, compensation costs, land acquisition and availability issues for the newly promoted development areas (BRR, 2005, Nazara and Resosudarmo, 2007).

Because of these problems, most of the residents wanted to return to their original properties before the tragedy, even though they were located in high-risk areas (very high-risk and high-risk areas) and in most cases their homes had been destroyed. The residents still preferred to return to live in these high-risk areas because the centre of activities for the city is located near to the disaster-prone areas of the city. Some residents in high-risk area also argued that they would have to pay higher transport costs if they moved to other areas far from their original home before the tragedy (YAPPIKA, 2005).

Consequently, most people decided to return to their original home site because the government did not offer them any other better choice. Furthermore, a later qualitative research report found that city residents, who were relocated to the newly promoted development areas after the tsunami were satisfied with their new residence but, they were not satisfied with the transportation services. This may be due to better transport services in the high-risk areas as these areas are relatively near to the city centre compared to the low risk areas of the city (Matsumaru et al., 2012).

In response to this problem, the government then introduced the concept of village plans for people, involving the residents in the process of planning using a participatory community method for bottom-up planning. This concept of development planning was supported by funding from USAID (United State Agency for International Development) (Matsumaru et al., 2012). Afterwards, the government decided to revoke the first master plan that was produced with the top down approach, to be replaced with bottom-up planning through the village plan concept (BRR, 2005). The authorities then allowed the residents to return to live in the high-risk areas and new housing development in the high-risk areas was not banned. As a result many new houses were built in the high-risk areas, which had been designated as restricted areas in the first top-down master plan (Steinberg, 2007). However, stakeholders planned escape routes and the building of escape buildings in the high-risk areas for use in case of evacuation as a components of city planning in the framework of disaster mitigation (TDMRC, 2008).

4.2.2.1 Pre-Tsunami Condition (1985-2004)

In the pre-tsunami condition, most Banda Aceh residents were not aware that almost half of Banda Aceh was in areas prone to tsunami disaster risk. The Figure 4.12 below shows the residents distribution in very high risk and high-risk areas of the city (zone classification refer to the previous Figure 4.10).

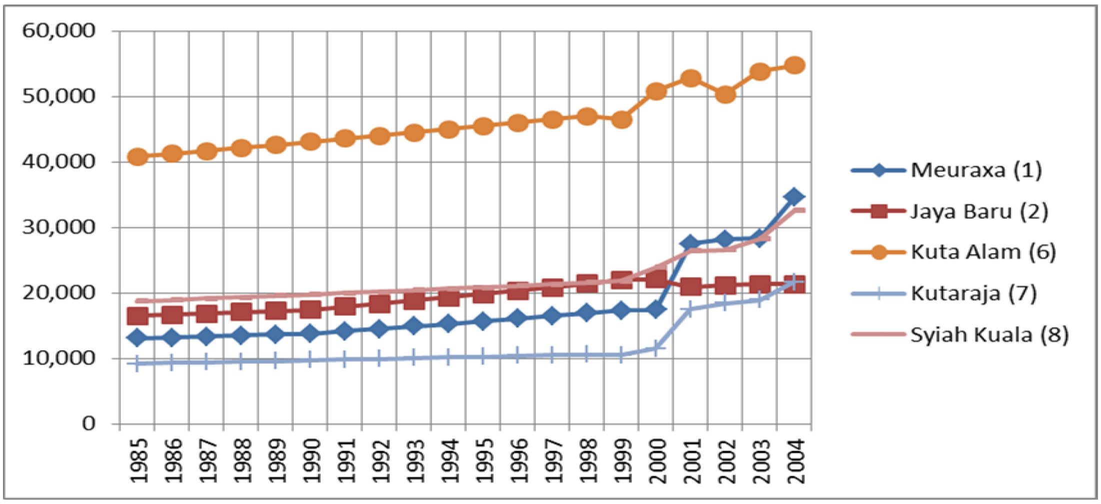

Figure 4.12: Number of residents in very high-risk and high-risk areas before tsunami 2004 (1985-2004) (BPS-Banda-Aceh, 1985-2004)

From the Figure 4.12, it can clearly be seen that the number of Banda Aceh residents in very high-risk and high-risk areas increased gradually from 1985 to 2000. Furthermore, the number of residents in these zones increased steeply from 2001 to 2004, except for Jaya Baru sub-district (zone 2) that remained constant, before the tsunami. In fact, it is obvious that the majority of residents might not realize that some areas in Banda Aceh city are located in high-risk areas for a tsunami in the pre-tsunami era.

Consequently, these areas were very attractive for residential areas since they are located very close to the city centre with good accessibility. Therefore, the sub districts, which are located in disaster prone areas, such as Meuraxa (1), Jaya Baru (2), Kuta Alam (6), Kutaraja (7), and Syiah Kuala (8) became very attractive residential areas for people in Banda Aceh. Similarly, the quantitative evidence for the medium risk and low risk areas also shows the same pattern as the distribution patterns in the very high-risk and high-risk areas of the city from 1985 to 2000 as shown in the Figure 4.13, which follow overleaf.

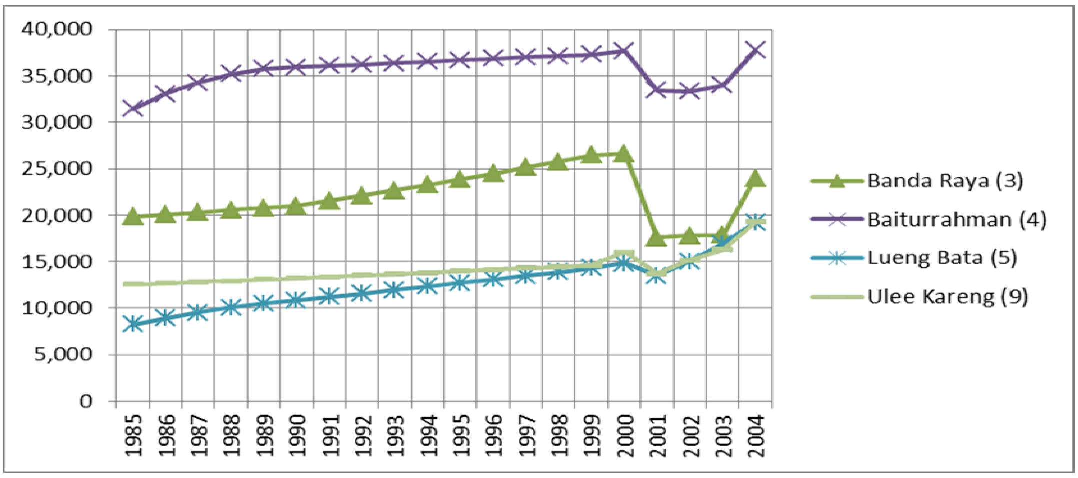

Figure 4.13: Number of residents in medium risk and low-risk areas before tsunami 2004 (1985-2004)(BPS-Banda-Aceh, 1985-2004)

From the Figure 4.13, it can be seen clearly that the number of residents in low risk and medium risk areas increased gradually during the period 1985-2000. However, the number of people that live in these areas decreased significantly after the year of 2000. After that, the number of people in medium and low risk areas remained constant, except for zone 5 (Lueng Bata) and zone zone 9 (Ulee Kareng), where the residents in these zones slightly increased, during the period of time 2001 to 2003. Furthermore, the number of residents in medium and low-risk started to increase significantly again after the year 2003, just one year before tsunami tragedy.

Presumably the significant changes of residents number during 2000-2004 in the low risk areas occurred because there were important events that affected the population distribution in Banda Aceh city at that time. The event may lead to the political situation after the fall of Soeharto regimes in 1998 (Törnquist, 2011). In fact, there was a national security problem at that time because of long conflict between GAM (Free Aceh Movement) and the Government of Republic Indonesia during 2001- 2004. The impact of political situation in Jakarta triggered the conflict escalation that occurred since 1976 (Miller and Bunnell, 2010). This situation affected the resident distributions in Banda Aceh city during that period of time (ITB and UN-Habitat, 2006). In conflict situation, people might tend to prefer the locations near the old city centre (zone, 1,2,6,7,and 8) that relatively safe from conflict situation compared to the other sub-districts of urban areas such as Banda Raya (3), Lueng Bata (5) or Ulee Kareng (9).

The huge earthquake and tsunami that hit the coast of Aceh at the end of December 2004 the biggest tsunami in modern history, had a very significant impact on the ongoing secret peace process between GAM (The Aceh Independence Freedom Movement) and the Government of the Republic of Indonesia. This tragic event accelerated the conflict resolution negotiations to end the war and start the peace processes (Billon and Waizenegger, 2007).

4.2.2.2 Post Tsunami Condition (2005-2011)

After tsunami tragedy in 2004, people become aware that some of sub-districts of Banda Aceh are located in high-risk area to tsunami disasters. Furthermore, Figure 4.14 below shows the number of residents in the sub-districts of Banda Aceh city from 2006-2011 after tsunami tragedy, which were classified into very high-risk and high-risk areas.

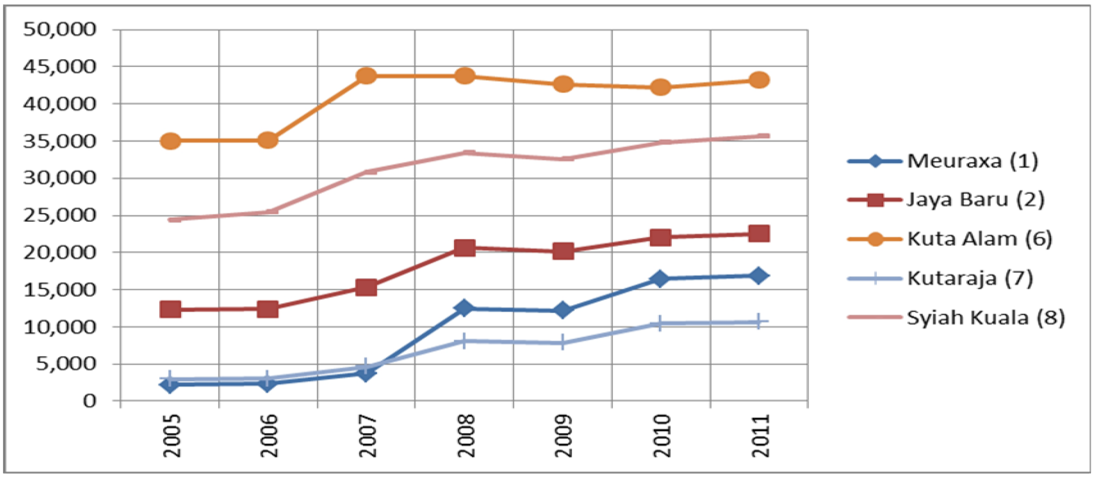

Figure 4.14: Number of residents in very high-risk and high-risk areas after tsunami 2004 (2006-2011)(BPS-Banda-Aceh, 2005-2011)

Figure 4.14 shows that the population in the very high-risk and high-risk areas for a tsunami remained constant two years after the tragedy from 2005 to 2006. In fact, the data shows that the very high and high-risk areas of the city (zones 1, 2, 6, 7, and 8) were not repopulated during these two years after the tragedy. This was partly because so many people from these areas actually died in the tsunami and the remainder moved or were moved out to temporary housing and barracks that were mainly in the low risk areas, Some city residents in fact were still traumatised by the destruction wrought by the tsunami was and did not want to move back. Consequently, there were not many residents that came back to their original house or to a new house on their house site in the two years after the tragedy.

However the population in all high-risk zones. increased significantly after 2007 after many new houses were built in these areas during the reconstruction and rehabilitation programs. A lot of new housing was built in the disaster prone areas after the authorities amended their first blue print to allow new development in the high-risk areas of the city, refer sub section 4.2.2.

At the same time, the population in the medium risk (zones 2 & 4) and the low-risk areas (zones 3,5,9) increased significantly during the first three years after the tsunami, 2005 to 2007. These increases were due to several factors in particular survivors from the devastated high risk areas moved here, also there was a big influx of people involved with the reconstruction programs and also many Acehnese who had left Aceh because of the security situation returned to Aceh after the peace accord with the Aceh Freedom Movement in August 2005. The population in these areas then decreased due to displaced families moving back to their new houses built in the high risk areas and also to emergency workers leaving Aceh after the crash recovery programs were phased out. The populations then evened out in the following years, 2008 to 2011. Figure 4.15 which follows shows the populations in these medium and low risk areas of Banda Aceh after the tsunami.

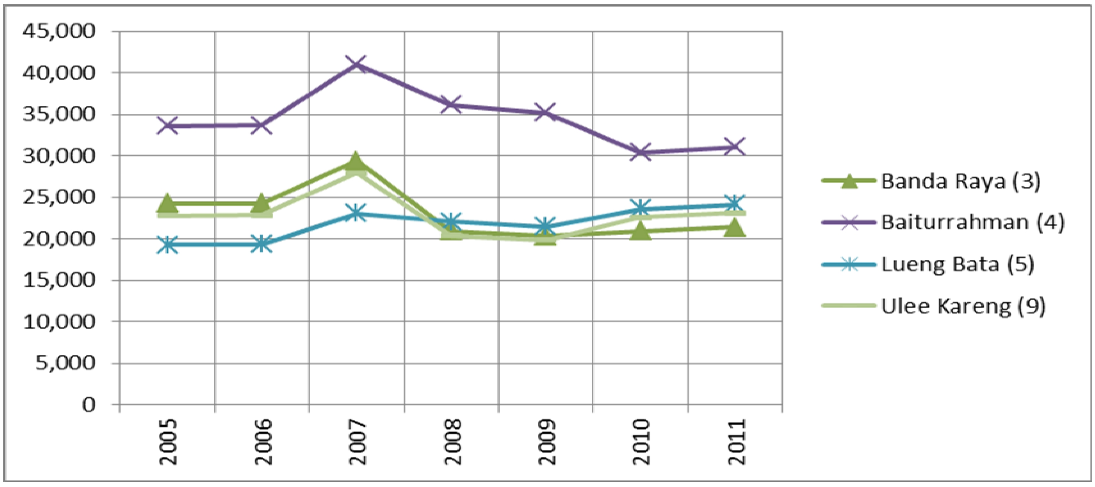

Figure 4.15: Number of residents in medium and low-risk areas after tsunami 2004 (2005-2011)(BPS-Banda-Aceh, 2005-2011)

Actually, the low risk areas of the city, which had not been in high demand compared to the high-risk areas before the tragedy, become very expensive after the tragedy. Meanwhile, the high-tsunami-risk areas (very high-risk and high-risk), which were very attractive before the tragedy, dropped in value after the tragedy (NJOP, 2012). This condition may lead to the answer why the number of residents in low risk areas reduced significantly after the year 2007. Another reason might related to the people that temporarily reside in low risk areas, two years after the tsunami tragedy and then coming back to their original residence after 2007 (ITB and UN-Habitat, 2006).

4.2.3 Transport plan condition in the case study area selected

In this sub section, two issues are discussed which concern problems in the transportation sectors in the case study area. The first issue was related to the national transport policy that has a significant impact in the case study area of Banda Aceh (4.2.3.1). The second issue was the transport problems in the local context of Banda Aceh (4.2.3.2).

4.2.3.1 The picture of national transport policy in Indonesia

The Figure 4.16 below shows the price shows the price of fuel at the pump in Indonesia compared to the world market price. It can be seen that the pump oil price in Indonesia from 1985 to 1997 was in line with the world oil price. That means the government did not spend much of the national budget on subsidies for both petrol and diesel for urban transport during this period.

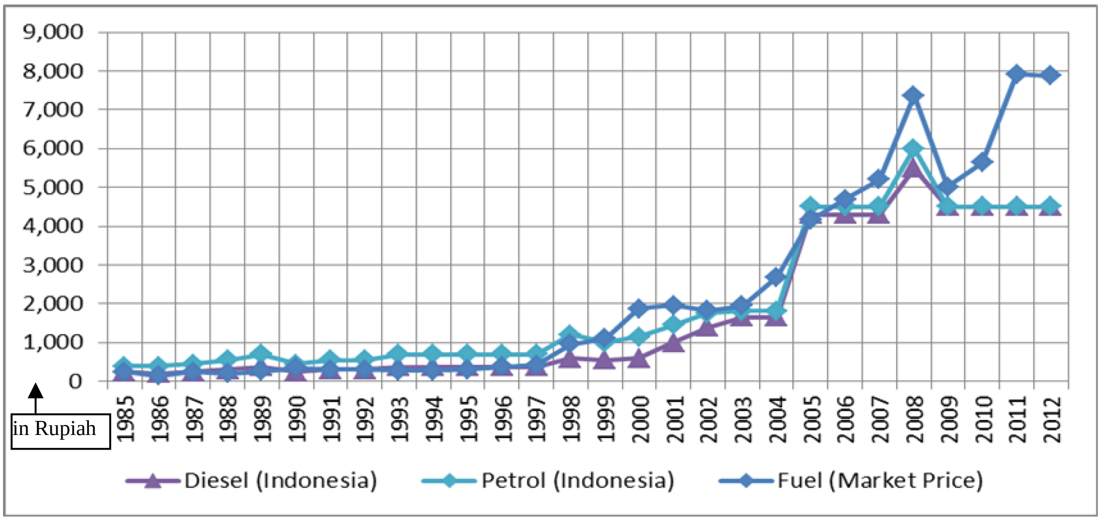

Figure 4.16: History of oil Prices in Indonesia[3](Antweiler, 2012, ChartsBin™, 2009, ESDM, 2012b)

[3] The fuel market price in Indonesia was calculated using data historical crude oil prices from http://chartsbin.com/view/oau and data from Ministry of ESDM Indonesia. The rupiah exchange rate used data from "http://fx.sauder.ubc.ca/etc/USDpages.pdf". The Indonesian fuel market prices calculation include cost of alpha and tax for 10% and 15% respectively.

However, after 1997, the world oil price gradually increased until 2012. In this period, the government subsidy for petrol and diesel increased significantly, even as the world oil price fluctuated. From the Figure 4.16, it can be also seen clearly that the oil subsidy started to increase significantly after the year of 2009 and reached the highest point in 2012. The subsidy fuel increased by Rp. 400 because the economic value of Indonesia oil price increased from Rp. 7,500 in 2011 to Rp 7,900 in 2012 because of the crude oil price and the fluctuation of dollar rate against the rupiah. The calculation of economic value of Indonesia oil price mentioned earlier also compared with other past study, such as a study by CSIS (Centre for Strategic and International Studies) team in Jakarta (Aswicahyono et al., 2011).

Moreover, fuel subsidy (BBM subsidy[4]) in 2011 reached 95.9 trillion rupiah (US$ 9.59 billion). The budget allocation for BBM was very large and significant because it was more than 70% of total energy subsidy budget allocation, while the subsidy for electricity was only 29.8% (Rp. 40.7 trillion or US$ 4.07 billion) from the total energy subsidy (Rp. 136.6 trillion or US$ 13.6 billion) (KEMENKEU, 2010). The total volume BBM subsidy in 2011 was 41.78 million kilolitre. From this total, the allocation for premium (petrol) was 61% of the BBM subsidy, while solar (diesel) and kerosene were 35% and 4% respectively and more than 95% of the BBM subsidy was spent in the transportation sector as shown in in Figure 4.17 below.

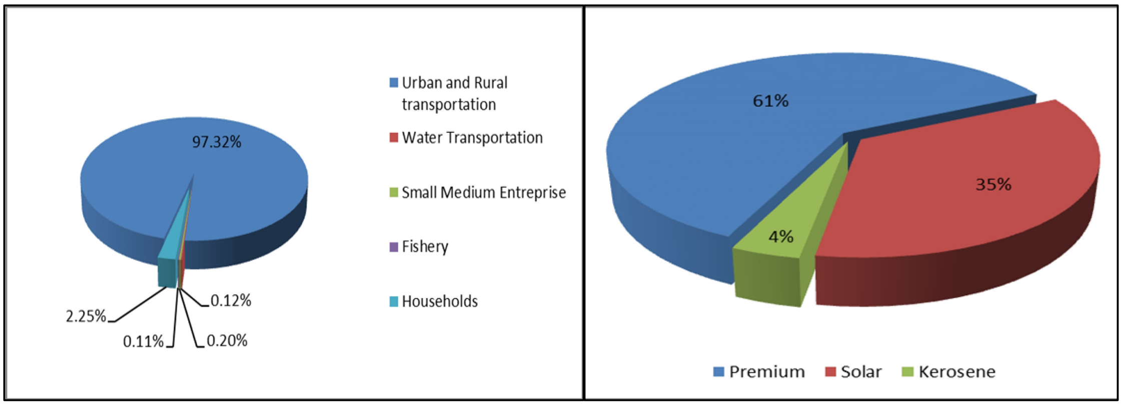

Figure 4.17: Consumption of BBM subsidy per sector and per type in 2011 with BBM volume = 41.78 Juta KL (Legowo, 2012)

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[4] Fuel subsidy in Indonesia is called as BBM (Bahan Bakar Minyak) subsidy. BBM subsidy is one of the items in APBN (National budget of Indonesian Government). The BBM subsidy consists of premium/motor gasoline (petrol), solar (diesel) and kerosene (Conversion rate used in 2010-2011, US $1 = Rp 10.000).

Moreover, it has been projected that in 2025, 80% of the population of Indonesia will live in urban areas compared to only 50% in 2015 (BAPPENAS, 2013). Indeed, the situation in the next future years may also give more significant impact on fuel consumption from urban transport sector as a result of more human activity and mobility in urban areas.

According to World Bank report that refer to SUSENAS 2009 data (National Household Socioeconomic Survey in Indonesia) indicated that the households consumed more than 45% of BBM subsidy, while the rest was consumed by commercial users as business and transport operators. The household was classified into three category, namely rich, medium-rich and poor people category, the data showed that 84% of fuel subsidies were enjoyed by the medium and rich people class, while almost 40% were consumed by rich people. On the other hand, the poor and near-poor people only consumed 16% of fuel subsidy. In addition, the poorest people only consumed less than 1% of fuel subsidy (World-Bank, 2011a). From the data showed earlier, it can be seen that the rich and medium class people consumed more fuel subsidy rather than poor people. However, it is undeniably that the poor people also get much benefit from this policy. On the other hand, the other data also showed that the poor policies in urban transportation sector significantly increased the fuel subsidy for premium in 2011 from Rp. 55.09 trillion as planned in APBN (Indonesian national budget) to Rp. 79.75 trillion Rupiah in realisation as shown in the Figure 4.18. Similarly, the government also spent additional budget more than Rp. 15 trillion for solar subsidy to cover the increase of real demand for diesel

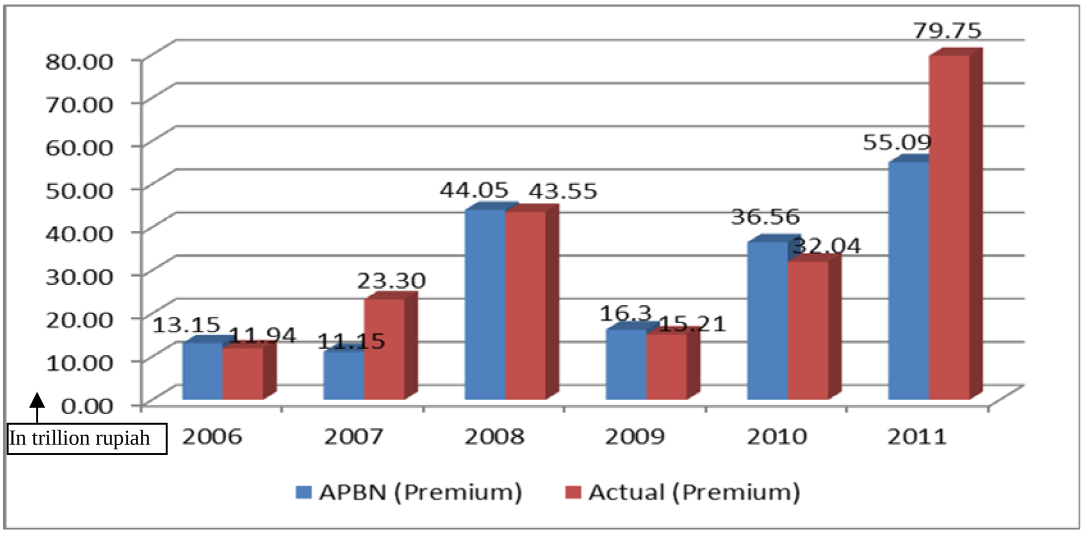

Figure 4.18: Time series of premium subsidy (in trillion rupiah) (Legowo, 2012)

Moreover, the quality level of public transport in Indonesia was very low. Public transport was not comfortable, low level of service (e.g. long duration of waiting and travel time), low level of accessibility, unreliable, consuming too much time and etc. (KEMENHUB, 2012).Consequently, the implications of this situation have attracted more Indonesian people to use private vehicle rather than public transport.

Indeed, number of cars and motorcycles has increased significantly in Indonesia and they tend to increase in the next future years, while number of public transport showed the opposite direction as shown in the Figure 4.19 below.

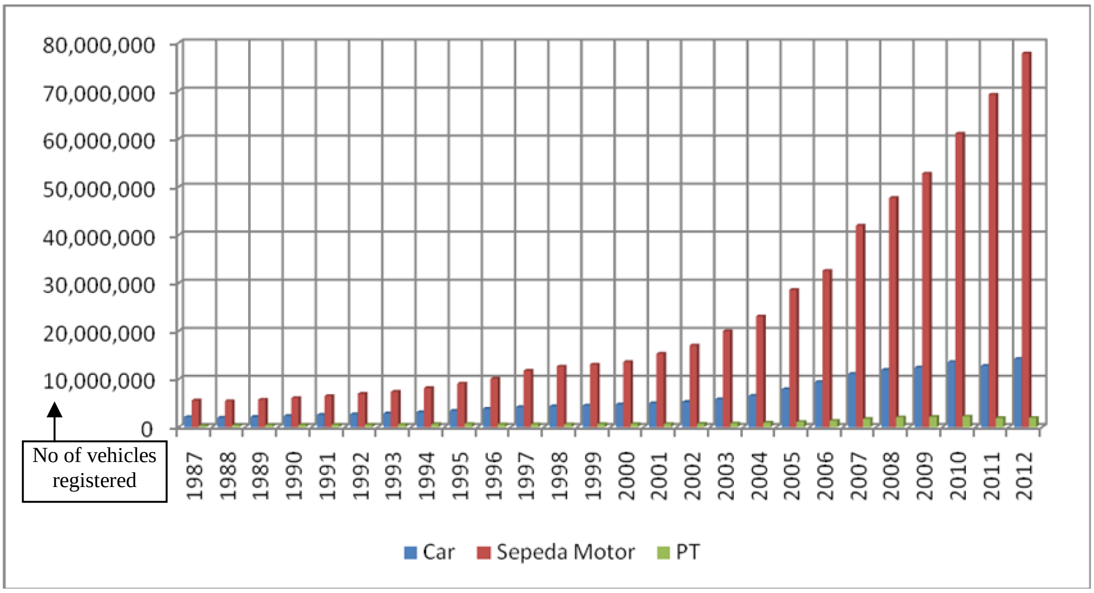

Figure 4.19: Number of vehicle ownership registered in Indonesia(BPS-Indonesia, 2011, KAKORLANTAS, 2012)

From the Figure 4.19 above, it can be seen that the number of vehicle ownership registered have raised more than three decades, which reached more than 92 million vehicles (1 vehicle : 2.6 residents) consist of 15.7% car and 82.7% motorcycle, while the number of public transport significantly decreased to be only 2.07%.

Accordingly, the auto vehicle markets within the ASEAN countries have very high potential and are attractive markets for automotive companies. According to a Deutsche Bank report, the ASEAN (Association of Southeast Asian Nations) countries were categorized as the countries with strong, fast growth economies with average growth rate of GDP more than 5% in 2011 and 2012. The three biggest automotive markets in ASEAN were Indonesia, Thailand and Malaysia. From these three countries, Indonesia has the biggest population and also the highest car ownership within ASEAN (Heymann, 2011). In addition, data from the ASEAN automotive federation also showed that the level of sales for cars and motorcycles in Indonesia had increased significantly and was the highest in ASEAN from 2007 to the September quarter of 2013 (AAF, 2013).

Furthermore, recently, in automotive industry sector, Indonesia government through the Ministry of Industry also introduced their policy for low cost green cars (LCGC) as an alternative to reduce fuel subsidies and this was also expected to give lower middle income people a chance to buy a low-priced car. The Ministry has supported this policy through tax incentives, so that the car price could be considerably lower (Kemenperin, 2013). Consequently, it seems that the pace of growth LCGC car may increase in the future. According to the latest data from GAIKINDO (association of Indonesia automotive industries), the level of LCGC sales number reached one million in 2013 from 923,071 in the year before as shown in Figure 4.20 below.

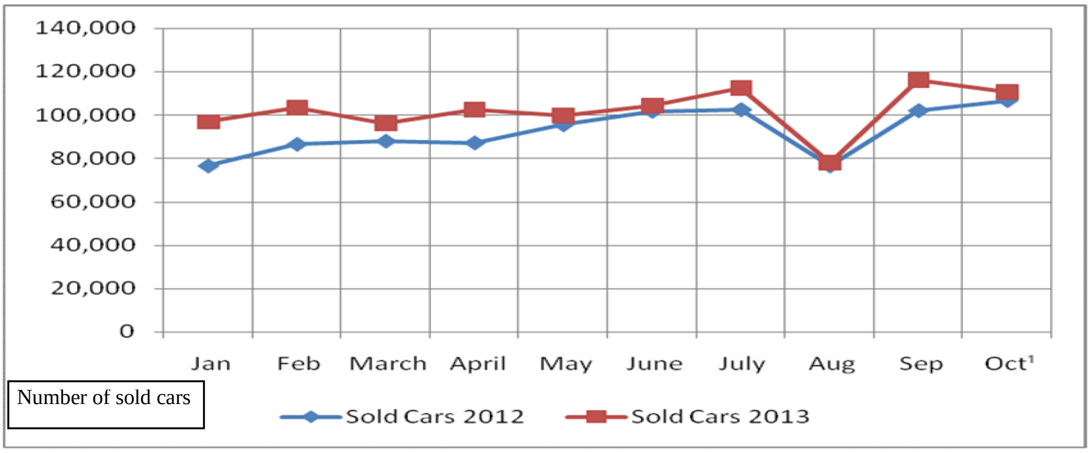

Figure 4.20: Number of LCGC car sales level in 2012 and 2013 (Indonesia-Investment, 2013, GAIKINDO, 2013)

From the data that showed in the Figure 4.20, it can be seen that the number of private vehicles on Indonesian roads will increase significantly in the next few years. Besides, it is clear that policies to attract more people to buy a cheap car will make urban transport problems worse. The implementation concept of promoting sustainable and green development, through LCGC will not reduce the carbon emissions from the transport sector in the future because the urban transport problems will become worse (e.g. more congestion, poorer public transport), especially in the mega-metropolis of Jakarta. More cars on the road will make traffic congestion worse, will increase travel times and thus will waste more fuel. In addition, they will increase carbon emissions and government budgets needed for fuel subsidies.

4.2.3.2 The picture of local transport condition and policy in Banda Aceh

Currently, Banda Aceh (61.36 km^2) is a medium-size city, which has more than 230,000 population (BPS-Banda-Aceh, 2012), with a high level of motorization ownership (154 cars for every 1000 or 800 vehicles per 1000 people, including motorcycles) since the poor transport policies (e.g. absence of a well-integrated public transport system). In 2012, there were 188.072 vehicles registered from 234,371 populations as recorded in census data (1 vehicle: 1.25 residents). 99.36% of them were registered as a private vehicle and only 0.37 % was registered as a public transport. The private vehicles composition consists of 19.25% of cars and 80.75% of motorcycles. The Banda Aceh transportation statistics data can be seen in Table 4.4 below.

No	Data Items	Amount	No	Data Items	Amount
1	Modes of transport		**2**	Road length (status)	
	a. car	36,072		National Road	18,083
	b. Motorcycle	151,311		Provincial Road	40,240
	c. Public transport	689		Local Road	707,343
	d. Total Vehicle	188,072	**3**	Public transport	
	e. Motorisation rate (Vehicle/1000 people)			a. Bus	18
	-include motorcycle	802		b. Minibus	333
	-without motorcycle	154		c. 3 wheeler motor	338

Table 4.4: Banda Aceh Transportation Statistics 2012 (DISHUB, 2012a, DPKKA, 2012)

From the data of Banda Aceh transportation statistics in the Table 4.4 above, it is understandable that why the number of private vehicles has increased significantly in Banda Aceh city. Based economic perspective, one of the reasons might associate with the increase fund flow in Aceh, especially in Banda Aceh that triggered the economic growth during rehabilitation and reconstruction process. In the phase of rehabilitation and reconstruction process after tsunami tragedy, the economic growth in the city increased significantly because Aceh received much assistances from government Indonesia and International organization (World-Bank, 2007). In addition, APBD (Aceh budget revenue and expenditure) Aceh in 2012 was also in the top ten highest in Indonesia as a result of higher sharing revenue from oil and gas after decentralization process and this province was given the status of special autonomy (SETKAB, 2012). In addition, Banda Aceh as the capital of Aceh province is also one of the cities, which had the highest economic growth within the Province of Aceh (World-Bank, 2007). This condition attract more people in the city for having the private vehicles. Figure 4.21 below shows the percentage data comparison of vehicles registered between Banda Aceh city against Indonesia national data both for private and public transport vehicles.

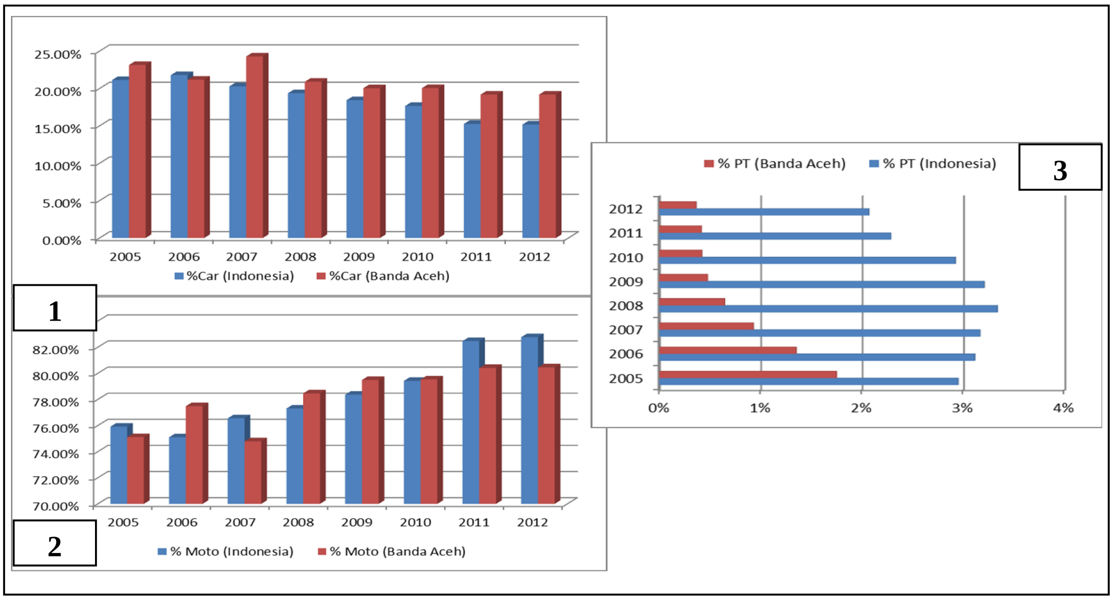

Figure 4.21: Percentage of number of vehicle Ownership of Banda Aceh city vs. Indonesia national data (BPS-Indonesia, 2011, KAKORLANTAS, 2012, DISHUB, 2012a, DPKKA, 2012)

From the Figure 4.21 above, it can be seen that the percentage of car ownership in Banda Aceh was higher compared to the national level during 2005 to 2012, except in 2006, where the percentage of car was higher in national level (Figure 4.21 (1)). On the other hand, in general, the percentage of motorcycle was a little bit lower compared to the percentage of national scale, except in 2006, 2008, 2009 respectively (Figure 4.21 (2)). However, the percentage of public transport in national level was higher compared to Banda Aceh city and it should be noted that the percentage of public transport pattern in the graph shows the similar tendency that tend to decrease both in national level and Banda Aceh city (Figure 4.21 (3)). The lack of government attention to improve the level of public transport quantity and quality and other transport policies (e.g. transport demand management) was not only happened in the national level, but it was also occurred in the local cities level such as Banda Aceh city.

Furthermore, the Figure 4.22 below shows the relation between the average increase of income and the number of vehicles registered from 1985 to 2012 in Banda Aceh city. The increase of nominal income was in line with the increase of private vehicle ownership. It can be seen clearly that the car ownership increased more approximately five and half times, whereas motorcycle ownership rose five times during 1985 to 2012. In contrast, number of public transport decreased approximately more than 4 times from 1985 to 2012.

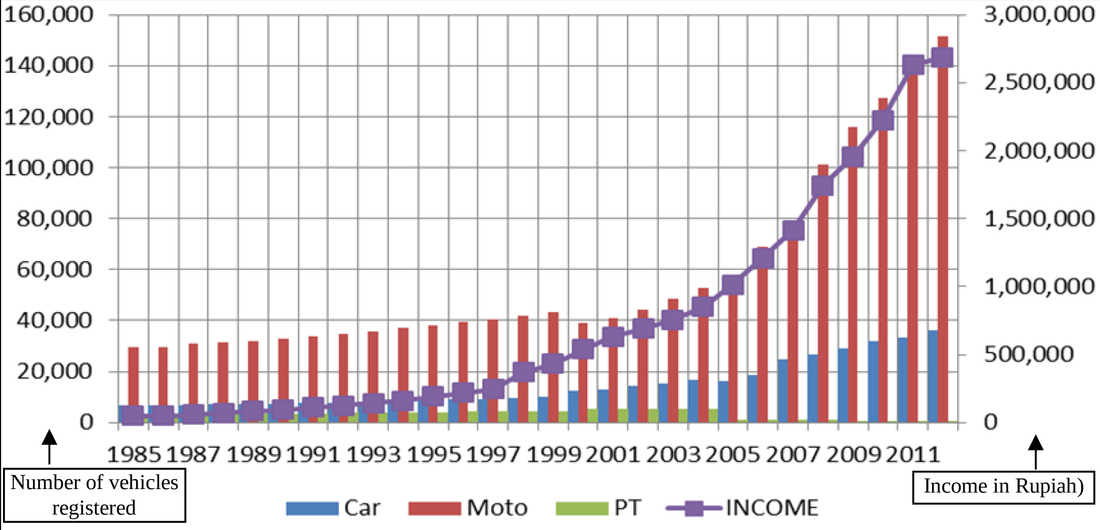

Figure 4.22: Income and number of vehicles registered (World-Bank, 2012, Antweiler, 2012, BPS-Banda-Aceh, 1985-2004, DISHUB, 2012a, DPKKA, 2012)

On the other hand, the fast economic growth, which is represented by the increase of income in Banda Aceh city, was followed by cheap fuel policy through fuel subsidy of Indonesia national policy as shown in Figure 4.23 below.

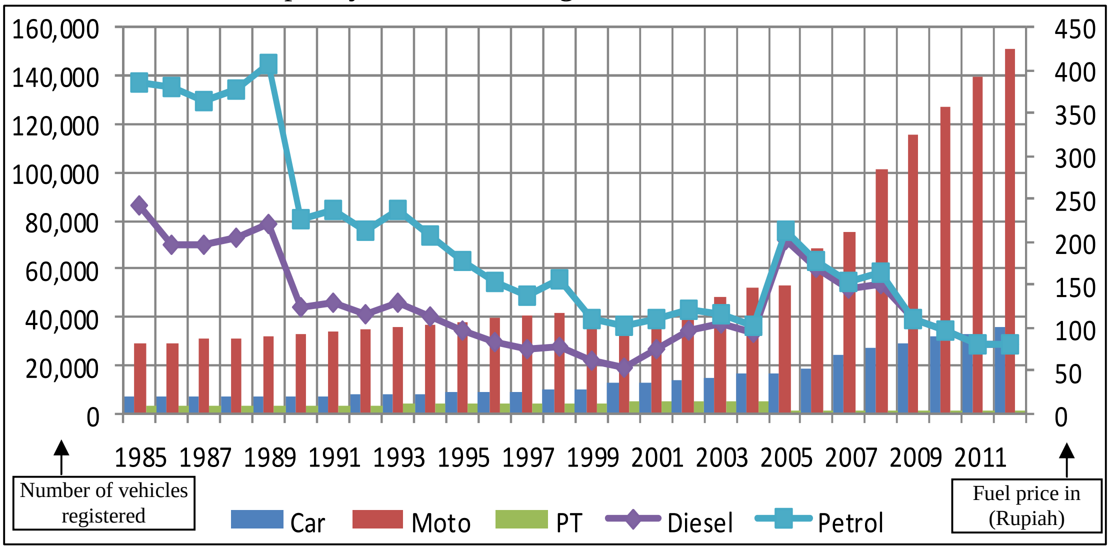

Figure 4.23: Fuel price per liter and number of vehicles registered (ESDM, 2012b, DISHUB, 2012a, DPKKA, 2012).

From the Figure 4.23, it can be seen that the nominal fuel prices increased almost 12 times from Rp. 385 in 1985 to Rp. 4.500 in 2012. However, the real price[5] of fuel compared to nominal income in 2012 decreased almost 5 times lower in almost the past three decades.

On the other hand, the amount of fuel subsidy in general increased significantly after the year of 1999 because the increase of world oil prices as shown in Figure 4.24, which also followed by the decrease of number of public transport as a result of the lack attention of government in improving the public transport system.

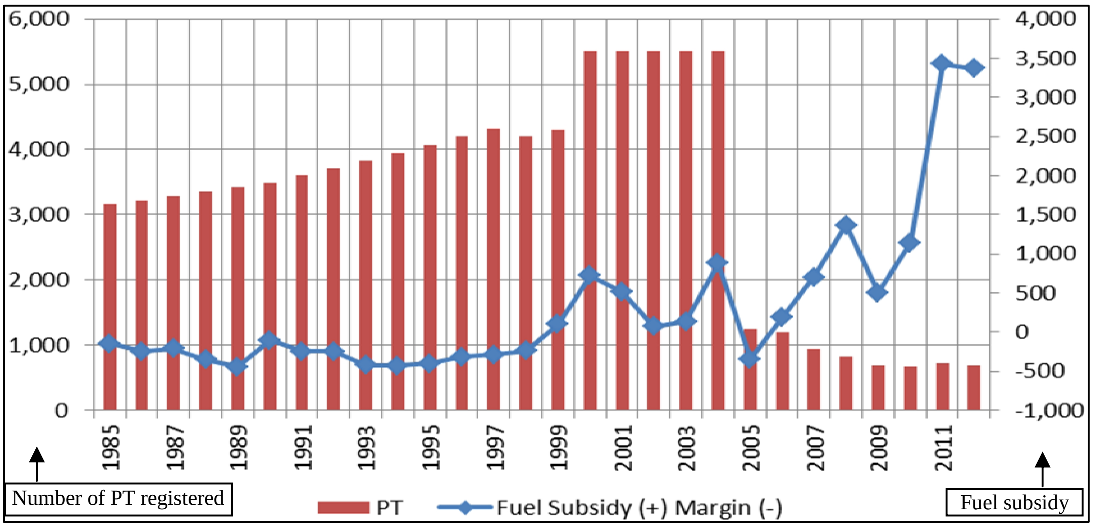

Figure 4.24: Fuel subsidy (in rupiah) and public transport in Banda Aceh city (ESDM, 2012b, DISHUB, 2012a)

This situation was likely attract more people in the city of Banda Aceh to use private vehicles rather than public transport as their modes share because of fuel subsidy (cheap oil price), where its amount increased year by year, and in contrast, the poor of public transport system, where its number decreased continuously after the year of 2004.

In fact, the latest two different surveys in 2000 and 2011 showed that the number of people, who selected private vehicles as their travel modes increased significantly, while the number of people, who used public transport, decreased continuously. The survey results regarding the composition of trip mode choice in Banda Aceh city

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[5] The term of real price is defined as the adjusted price value of nominal price (as shown currency unit) to remove the effects of prices changes over time. For instance in Banda Aceh city, the fuel price in 1985 was Rp. 385, while in 2012 the fuel price was Rp. 4.500 per liter.

region in 2000 and 2011 revealed that the number of people that selected private vehicles as their mode shares increased significantly during the period of time from 2000 to 2011, while the number of people, who used public transport system, decreased in the same period of time. Furthermore, in the year of 2000, private cars were used by 20.32%, while there were 29.22% of people that used motorcycle as the travel mode choice. In fact, public transport was the most popular choice that selected by residents as their travel modes. There were approximately 39.04% of people that used public transport as their travel mode choice at that time, while there were only 11.41% of pedestrian, which can be seen in Figure 4.25.

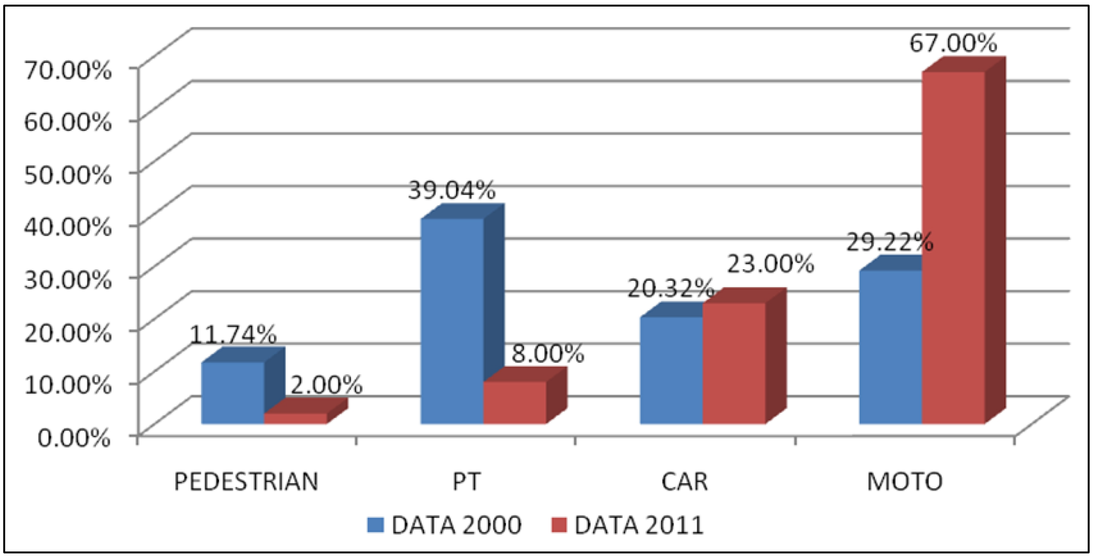

Figure 4.25: Modal split of Banda Aceh city 2000 and 2011 (Kamal, 2002, STTD, 2011)

In contrast, after ten years, the number of trips for the people that used public transport, decreased significantly by 31.04% from 39.04% in 2000 to become only 8% in 2011. This condition may lead to the decrease in size of the public transport fleet that reduced considerably from 5.504 in 2002 to only 689 in 2012. On the other hand, the number of people that selected private vehicles increased significantly more than 55% during the period of time 2000-2011. In particular, the number of people, who selected motorcycle as their travel modes, increased steeply by 37.78% from 29.22% in 2000 increased to 67% in 2011. Moreover, the number of people using car increased by only almost 3% from 20.32% in 2000 to 23% in 2011, which was lower than motorcycles number in over a decade years period.

Moreover, the increase of number Banda Aceh residents that selected private vehicles rather than public transport, may lead to the increase of fuel consumption in the city of Banda Aceh. The time series data in 2006-2011 for amount fuel consumption of vehicles in Banda Aceh city is shown in Figure 4.26 below.

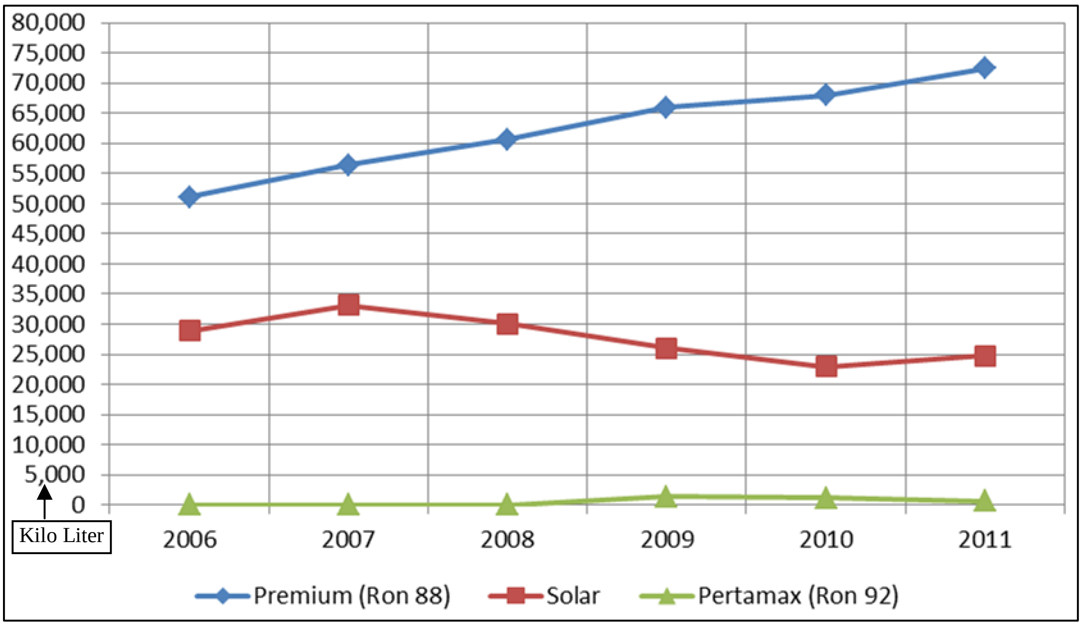

Figure 4.26: Fuel consumption (in kilo-liter) of urban-transportation sector in Banda Aceh city from 2006-2013 (PERTAMINA, 2012)

The data from the Figure 4.26 shows that the number of fuel subsidy consumption increased significantly from 2006 to 2011, while only very small number of Banda Aceh residents that used non-subsidy fuel (e.g. Pertamax Ron 92) during the period of time because price of fuel subsidy was a far more expensive. The subsidy fuel price can be double compare to the non-subsidy fuel price.

Furthermore, Banda Aceh city was also the city that consumed the most amount of fuel subsidy compared to other 23 cities and regencies within the Province of Aceh. According to the latest data from Ministry of Energy and Mineral Resources Indonesia and PERTAMINA, branch Banda Aceh, the consumption of fuel for Banda Aceh city was 14.43% of total fuel subsidy allocation for Aceh Province, where the total amount of fuel subsidy for Province of Aceh was 1.9% of the total realisation in the national level from 33 provinces in 2012. In addition, the amount of fuel subsidy consumption in Banda Aceh city increased by 6.7% in 2012 compared to the previous year in 2011 (ESDM, 2012c, PERTAMINA, 2012).

4.3 Summary of Problem in the case study area selected

This sub section summarizes two problems in the case study area. The first problem is related to land use planning that can affect residential distribution in high-risk areas of the city in order to reduce the risks from potential future disasters. The second problem is related to the existing transport plan in the case study area selected that potentially increases carbon emissions from the urban transport sector.

4.3.1 Problem related land use planning

Based on statistics from 1985-2011, the bottom-up policy implemented after the tsunami significantly attracted many people to reside in areas of the city that are high-risk for tsunami because most of the high-risk areas are located close to the core area of the city and because of lower land prices there. After the tragedy, the land price in high-risk areas became relatively low, whereas previously the land price in these areas before the tragedy was relatively high because of the proximity of the high-risk areas to the centre of the city. Also during reconstruction after the tsunami a major part of the housing aid was used for building back houses in high risk areas which had been destroyed by the tsunami. As a result, stakeholders had to plan and widen escape routes and build escape buildings in these high-risk areas as part of the city's long term strategic planning in the framework of urban risk reduction.

Also after the tsunami, the price of land in low-risk areas, close to the city centre increased significantly and became much more expensive compared to before the tsunami. This situation also affected people's preferences for household location. The increase of land prices in the low risk areas of the city made people choose to live in high-risk areas or on the outskirts of the city, which still had relatively cheap land compared to the low risk inner zones (NJOP, 2012). Moreover, they might prefer to buy cheaper land price in low risk areas of other administrative city (Kabupaten Aceh Besar), which is bordered with the Banda Aceh city, even the locations are relatively far away from the city centre. On the other hand, they may also prefer to buy the land in high-risk areas of the city with lower price rather than buying land in low-risk areas, which were more expensive.

This type of development process not only puts more people in high-risk areas of the city but at the same time creates urban sprawl which may lead to increased use of private vehicle that will result in higher fuel consumption for urban transport.

In the context of city planning, both the top-down and the bottom-up concept planning methods had the objective to reduce disaster risk. In the context of disaster mitigation, the top-down concept was interpreted into the planned-retreat policy (JICA master plan) and the bottom-up method (the village plan) was defined as the accommodation-protection policy (Dronkers et al., 1990). The first concept of development was planned to reduce the disaster risk by minimizing the population in high-risk areas through land use planning & zoning processes. In this mode of development, new housing development is banned from rebuilding in the disaster prone high- risk areas of the city. By contrast, with the second method, the authorities allowed new development to be redeveloped in high-risk areas. However, this strategy had to be supported by urban infrastructure and facilities such as escape routes and escape buildings as an alternative strategy in the framework of urban risk reduction.

Moreover, in worldwide practice, both of these policies have weaknesses. The planned-retreat policy for reducing exposure to disaster faces several problems such as property use rights, compensation costs, lack of financial resources (Arthurton, 1998, Rannow et al., 2010). On the other hand, the protection-accommodation policy attracts new development into high risk areas, which might not be expected, and sometimes even hard structural defences can fail as happened in New Orleans (Nicholls and Cazenave, 2010).

Nevertheless, in the case study area selected, the authorities selected the accommodation land use strategy to be implemented in Banda Aceh. Consequently, the population in high-risk areas increased significantly during the period 2005-2012 as explained earlier in sub section 4.2.2.2. Furthermore, this condition will also affect the distribution of population in future years in these parts of the city. Moreover, in reality, most of the housing built in the high-risk areas of Banda Aceh was built below the standard of housing needed to fulfil the requirements for safe housing in disaster prone areas because of lack of supervision and other factors, especially for houses that were built during the rehabilitation and reconstruction phase (Steinberg, 2007).

4.3.2 Problem related to transport planning

In general, the urban transport problems in the Banda Aceh city are related to the increase in use of private vehicles and the decline in public transport because of poor transport policy implementation in the local context (e.g. poor public transport system; poor transport demand management e.g. parking policies/pricing) and national level (e.g. fuel subsidy). In fact, the planning paradigm at the level of policy making for urban transportation in the city is still focussed on how to move vehicles rather than on how to move people and goods with good accessibility and mobility. Therefore, most of the public policy implementation in the urban-transport sector is focussed on the supply side rather than managing demand with good accessibility and mobility. The expansion and development of road infrastructure is one of the compulsory programs that have been placed on the priority list for the government public expenditure budget (business as usual development program) in order to provide good accessibility and mobility for private vehicles rather than allocating a bigger budget to improve public transport (RTRW, 2009).

Consequently, this policy increases the dependency of the city on private vehicles, both motor-cycles and cars, because travel in the urban areas using private vehicles is more convenient and comfortable, faster and cheaper. In contrast, trips using public transport are neither comfortable nor convenient rather they are unreliable, difficult to access and can even be more expensive. In fact, this was proven by the rapid increase in the number of private vehicles and on the other hand, it was also followed by the significant decrease in the number of public transport vehicles based on the secondary data obtained (DPKKA, 2012, DISHUB, 2012a). Furthermore, from the latest transport surveys (Kamal, 2002, STTD, 2011), it can also be clearly seen that the number of people that selected private vehicle transport increased significantly, while the number of city residents that used public transport decreased considerably.

In Indonesia, the dependency on cars has also increased the amount of fuel used forcing the government to increase the budget allocation for fuel subsidy for the urban-transport sector since Indonesia is no longer a net oil-exporting country. This condition will be harmful for Indonesia’s long term national economy since as the number of private vehicles keeps continuously increasing in future years they will require a much bigger budget for fuel subsidy.

4.3.3 Summary of land use and transport problems

Table 4.5 below shows the summary of problems related land use plan in the case study area selected that increased the number people that reside in high-risk areas of the city. In other words, this condition increased the level of city vulnerability to the disaster at this time and in the next future years.

No	Problem related land use (Cause)	Effect	Impact
1	No zoning plan	People can reside in any zones, including zones in high-risk areas.	Increase new housing development in high-risk areas
2	Cheaper land/rent price in high-risk areas	People more behave to maximize the benefit by looking cheap price.	Increase number of new people that reside in high-risk areas
3	Good accessibility in high-risk areas	People more behave to maximize the benefit by looking the location with good accessibility	Increase number of new people that reside in high-risk areas

Table 4.5: Summary problem related land use plan (urban disaster mitigation)

As can be seen in Table 4.5, there are three main problems related to land use that need to be considered in this research. The lack of land-use planning in Banda Aceh did not deter people from living in the high-risk areas of the city. On the other hand, the increase in land prices in low risk areas and the decrease in high risk areas after the tsunami attracted more people to live in the high-risk areas rather than in the low risk areas. Also, the higher accessibility of the high-risk areas also attracted more people to live in these areas of the city.

Furthermore, Table 4.6 below shows the summary of problems related transport plan in the case study area, which potentially increased the carbon emission from urban transport sector.

No	Problem related transport	Effect	Impact
1	Poor public transport (E.g. not comfort, unreliable etc.)	People prefer to use private vehicles because the service of public transport is poor	Number of private vehicles on the road increase; increase consumption of fuel subsidy
2	Poor in other transport policy (e.g. poor parking management)	People prefer to use private vehicles because parking price is cheap	Number of private vehicles on the road increase; increase consumption fuel subsidy
3	Fuel subsidy (cheap oil price)	People prefer to use private vehicles because fuel price is cheap	Number of private vehicles on the road increase

Table 4.6: Summary problem related transport plan (urban transport sustainability)

As can be seen in Table 4.6, there were also three main problems identified related to the existing transport planning. Firstly, poor public transport made most people in Banda Aceh choose to use private vehicles rather than public transport. Secondly, this condition was also supported by a lack of planning of other urban transport policies such as poor policies for parking management applied by the local government. This condition also tends to increase the number of people that prefer to use private vehicles rather than public transport. Lastly, the fuel subsidy given by the national government might also tend to increase the numbers using private vehicles rather than public transport.

Chapter 5
Concept Implementation for the Case Study Area

This chapter is intended to introduce the implementation of the concept to combine strategies for urban risk reduction and urban transport sustainability for the case study area. Banda Aceh city, which is located in an area of high-risk for tsunamis and also has transport problems, was selected as the case study area. This chapter consists of several sections that are presented as logical steps for the implementation of the concept to combine strategies for disaster mitigation and for land use-transport planning, in the case study area. All of the sections in this chapter follow the flow of steps proposed in a methodological approach, arranged systematically from first step until last step, in order to find the strategies, which best fit the case study area (5.1).

In the context of the case study area selected, the development plan concept should be directed to reach the objectives of Banda Aceh city as a high-risk city in the framework of sustainability (5.2). The application of a generic concept plan (refer to chapter 3) was then applied in the case study area selected (5.3). Two types of general strategies were outlined that can help Banda Aceh to reach high-risk city objectives in the framework of sustainability. Firstly, land use strategies in the framework of urban risk reduction. Secondly, strategies related to land use and transport in the framework of urban transport sustainability. After that, these two types of strategies were combined in an integrated land use and transport plan in order to reach a sustainable city agenda for Banda Aceh.

For that reason, the discussion about formulation strategies in Banda Aceh study as the case study area focuses on three important issues, namely (1) land use strategies in the framework of disaster mitigation for Banda Aceh city (5.3.1), (2) land use plan and transport strategies for Banda Aceh city in the framework of urban transport sustainability (5.3.2) and (3) the combined strategies for the case study area selected, which was then called as Banda Aceh Integrated Land use and Transport Planning (BILT) (5.3.3). Last but not least, The summary of concept plan developed for the case study area selected was also discussed in the last part of this chapter (5.4).

5.1 Methodological approach for concept plan implementation in the case study area

The objective of methodological approach developed in this chapter is to be used for finding the best combined strategy of disaster mitigation and conventional land use-transport plan that fit with the characteristics of the case study area selected. The methodological approach selected for concept implementation in the case study area selected refers to the generic concept plan as discussed in the previous chapter 3. On the other hand, problem identification and analysis in the case study area selected are refer to the chapter 4 previously. This methodological approach was adopted from the approach as explained in the generic plan concept in Chapter 3. The methodological approach for implementing the concept plan in the case study area selected is shown in Figure 5.1 below.

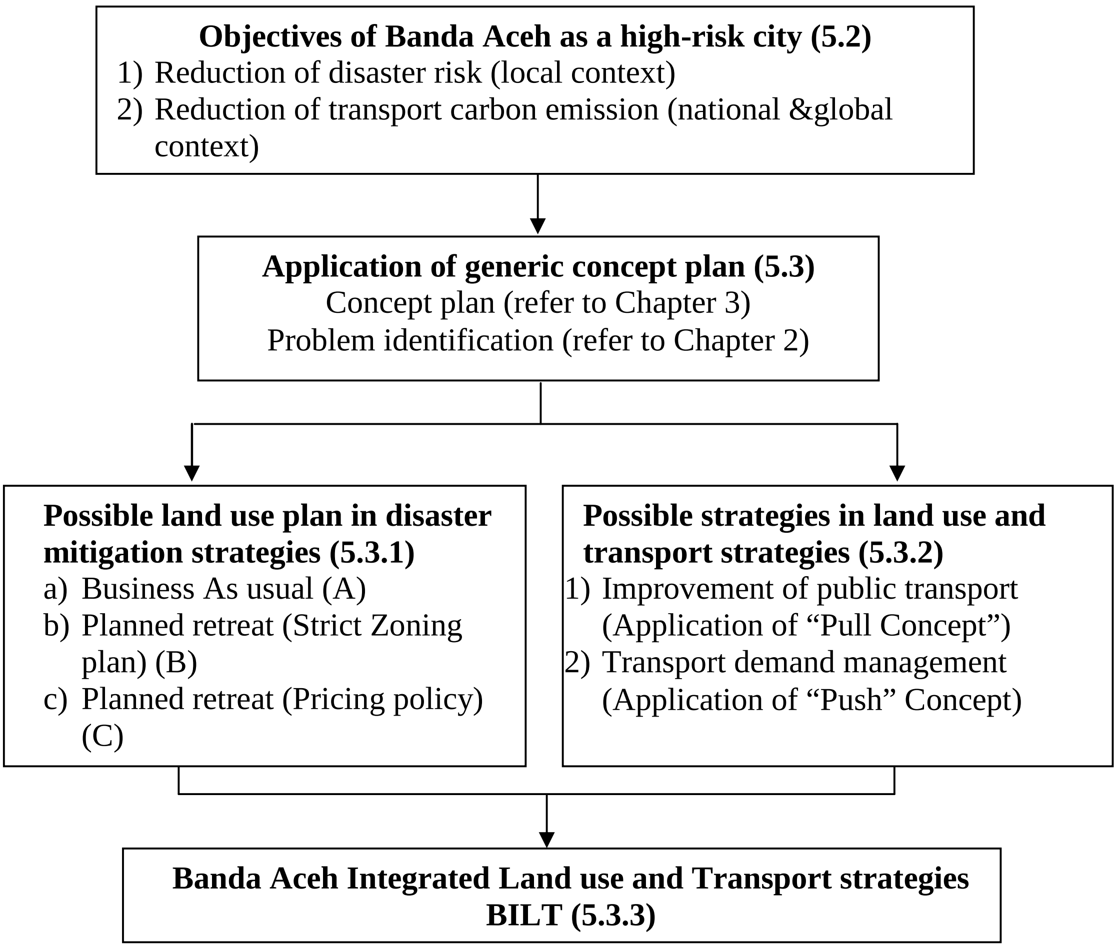

Figure 5.1: Methodological approach for concept implementation in the case study area selected

5.2 Objectives of Banda Aceh city as a high-risk city

In the context of Indonesia as a developing country, the government has also actively participated in campaigning the issue of sustainability such as UNFCC meeting in Bali that produced the Bali road map (UNFCC, 2007b). Two years later, after the G20 Pittsburgh (U.S) summit meeting and further meeting in Copenhagen (Denmark), the top leader of Republic of Indonesia declared that Indonesia would implement the strategic plan in reduction of carbon emission by setting target 26-41% in 2020 (PP-Republik-Indonesia-No.61, 2011).

Furthermore, the target of carbon emission reduction has been becoming the national development planning agenda through regulation of national action plan in greenhouse gas reduction (GHG), which was also known as the action plan of RAN-GRK[6](BAPPENAS, 2011). In the real practice, this action was also implemented in several Indonesia government ministry programs. For instance, the ministry of transportation formulated the national action plan of Indonesia's carbon emission reduction initiative as shown in Figure 5.2 below.

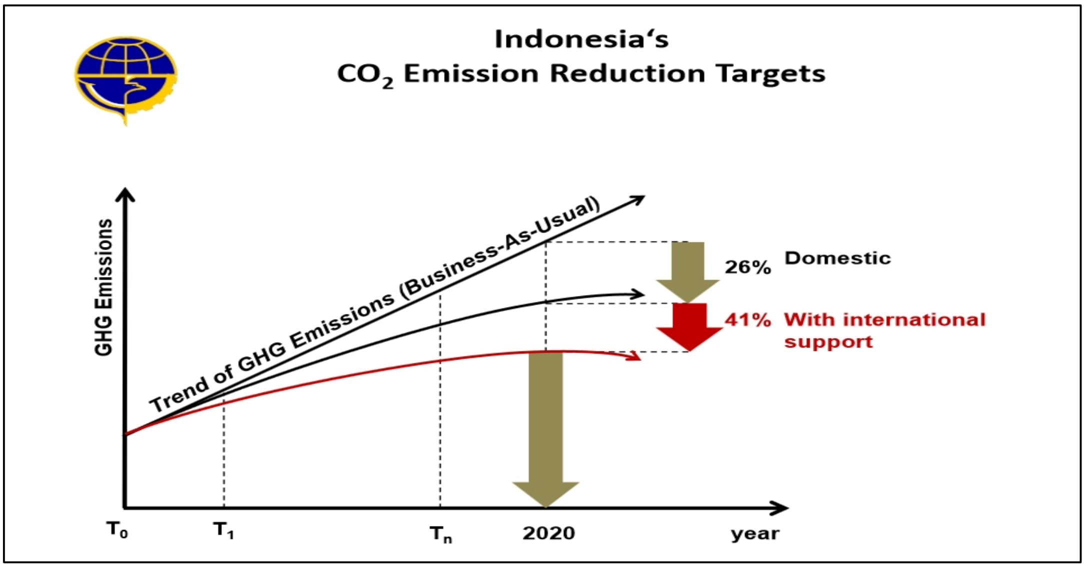

Figure 5.2: National action plan of Ministry of Transport, Republic Indonesia (Boediarto, 2013)

[6] The national action plan of GHG reduction in Indonesia is explicitly expressed in government regulation of Presidential Decree (Perpres No. 61 Tahun 2011 tentang Rencana Aksi Nasional Penurunan Emisi Gas Rumah Kaca or RAN-GRK). In English, it is called as "National action plan for GHG reduction".

In the reality, Ministry of National Development Planning (BAPPENAS) has been also implementing the sustainable urban transport improvement project that fully supported by the Ministry of Transportation. Several Indonesian cities (Yogyakarta, Solo, Bogor and Palembang) were selected as pilot project for sustainable urban transport. In these cities, several urban transport policies such as improvement of public transport and parking management were introduced and implemented in order to reach the sustainability city agenda (SUTIP-Project, 2011).

Therefore, in the local context of Banda Aceh city as the case study area selected in this research, the concept of urban sustainable development was categorized into two objectives regarding the city long term strategic planning. The first program is related to national action plan program of Indonesian government (Indonesian national action plan) in reduction of carbon emission and disaster risk. This action plan program has a target to reduce 26% (minimum target) or 41% (maximum target) of carbon emission in the next future years of 2020 (PP-Republik-Indonesia-No.61, 2011). The second program is associated with the local action plan of local government of Banda Aceh in disaster risk reduction program in Banda Aceh local action plan (RTRW, 2009), which refer to the national action plan in disaster risk reduction (BAPPENAS and BNPB, 2006). In addition, the important issue of urban risk reduction was also addressed by Banda Aceh Mayor in United Nations Forum on 09 February 2011 in New York, in a paper, which had the title : “Cities at Risk - Addressing the Challenges of Disaster Risk in Urban Setting” (TDMRC, 2011). Therefore, the objectives of Banda Aceh city defined in this research are as shown in the Figure 5.3 below:

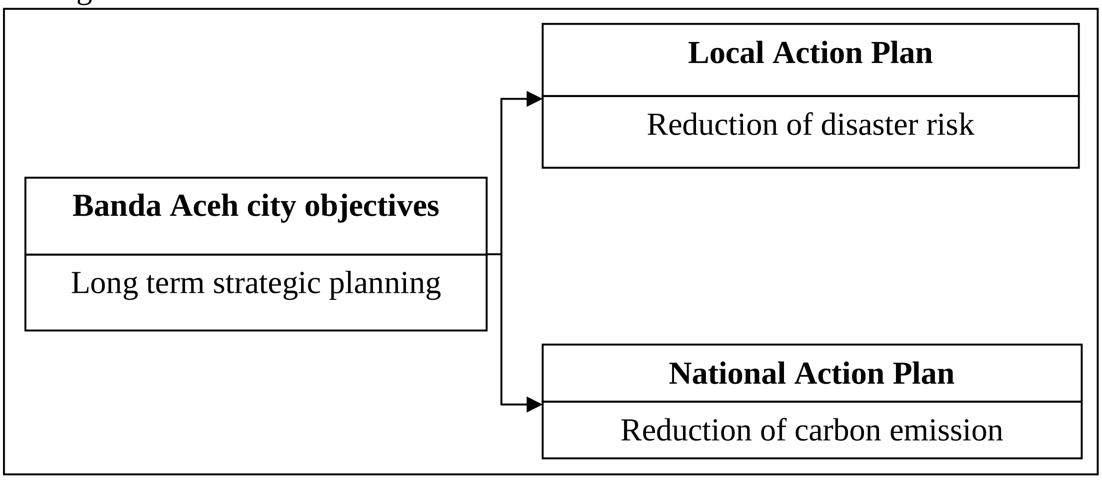

Figure 5.3: objectives of Banda Aceh city as a high-risk city in the framework of urban risk reduction and urban transport sustainability

5.3 Application of generic concept plan

In this section, the generic concept plan for high-risk city in the framework of urban risk reduction and urban transport sustainability, which was developed in chapter 3 was applied in a case study area selected. The problems identified and problem evaluations in Banda Aceh city referred to the discussion in chapter 4.

In the context of the case study area selected, the implementation of generic plan concept was directed to reach the objectives of the Banda Aceh city in the framework of urban risk reduction and urban transport sustainability as discussed in the previous sub section 5.2. The strategies proposed in the concept plan developed were categorized into the strategies in the framework of urban risk reduction and the strategies in the framework of urban transport sustainability. The strategies proposed in the framework of urban risk reduction was a response against the land use problems identified in the case study area selected, which contributed to the increase of vulnerability to tsunami disaster. On the other hand, the strategies proposed in the framework of urban transport sustainability was a response against to the urban transport problems in the case study area selected, which contributed to the increase of carbon emission. It was expected that the combination of these two different strategies could help the Banda Aceh city to reach the sustainability city agenda in the framework of urban risk reduction and urban transport sustainability.

For that reason, the discussion of strategies formulation in this sub-section consist of three important part. The first part discussed about the land use strategies proposed in the framework of urban risk reduction in order to reach the local action plan of Banda Aceh city (RTRW, 2009, BAPPENAS and BNPB, 2006). The second part discussed about the land use and transport strategies in the framework of urban transport sustainability in order to reach the national and global action plan of Banda Aceh city regarding carbon emission reduction issue (PP-Republik-Indonesia-No.61, 2011, UNFCC, 2013). Last but not least, the last part discussed about the integration of disaster mitigation strategies into land use and transport plan interaction for Banda Aceh city in order to reach the local, national, and global sustainability city agenda. It is important to provide this concept of development plan in order to give the new insight about how to integrate the aspect of disaster risk in urban planning to promote the land use and transport plan strategy in achieving the city sustainability objectives.

5.3.1 Land use strategies in urban risk reduction

The selection of strategies proposed for Banda Aceh city in the framework of disaster mitigation refer to the land use strategies in disaster mitigation from the literature reviews (Dronkers et al., 1990, IPCC, 2001, IPCC, 2007) and it is also refer to the concept plan in the national level (BAPPENAS and BNPB, 2006) and local action plan in Banda Aceh city (RTRW, 2009, Government-of-Aceh, 2011).

In general, the land use strategies proposed in the framework of disaster mitigation for Banda Aceh city were distinguished into three categories that consists of business as usual strategies (accommodation strategies), planned-retreat with law enforcement, planned-retreat with pricing policy. All of the strategies proposed have an objective to reduce the disaster of risk. The description of all strategies proposed can be seen in Table 5.1 below.

Disaster mitigation strategies		**Description of strategies**
A	**Business as usual (Accommodation)**	• Allowing housing development in high-risk areas for future development (2011-2030)
B	**Planned-retreat (Strict zoning plan with law enforcement)**	• Banning new development in high-risk areas for future development (2011-2030)
C	**Planned-retreat (pricing policy)**	• Allowing high-risk areas to be used as restricted areas development (2011-2030)

Table 5.1: Disaster Mitigation Strategies for Banda Aceh city

Furthermore, the implementation of disaster mitigation strategies in Banda Aceh city also refers to the result of tsunami disaster risk analysis for each zone in the case study area selected as explained in chapter 4 (level of disaster risk classifications). As mentioned in the chapter 4, the zone classifications based on risk level were classified into four risks categories, namely : very high-risk, high-risk, medium-risk, and low risk areas as shown in the previous table 4.1. The zones classifications were used to identify where the zones that may be allowed to be used as residential/new promoted development areas or to be kept as protected areas that refer to each strategy as mentioned in the previous Table 5.1.

5.3.1.1 Business as usual land use plan (Accommodation)

In the business as usual strategy, the high-risk areas of the city were allowed to be used as residential areas. The objective of this strategy was to reduce disaster risk by providing early warning system of tsunami disaster, which use to detect tsunami disaster in advance, and improving the housing quality standard that should refer to building code regulation (TDMRC, 2008, Munadi and Dirhamsyah, 2009). However, in the context of Banda Aceh city, it should be noted that most of housing development in high-risk areas did not refer to building code regulation because of the weakness of law enforcement.

Therefore, the city residents were allowed to make the new housing development in all zones of the Banda Aceh city, including the high-risk areas of the city. However, in the case of tsunami warning system issues warning after the huge earthquake that potentially cause a tsunami (BMKG, 2013), the residents in high-risk areas should run away from coastal areas as soon as possible in order to reach the low risk areas or the nearest evacuation facilities (e.g. escape buildings), which were developed in high-risk areas of the city (Goto et al., 2012, Simanjuntak, 2008). In this strategies, evacuation plan played the main role to reduce the number of disaster victims because in very high-risk areas, the tsunami inundation height could be possibly more than 7 meters (BPBD, 2012). The land use plan in this strategy can be seen in Table 5.2 below. All the land availability in high-risk areas of the city can be used as housing residential areas or new promoted development areas.

No	Zones Name	Level of Damage	Zone Classification	Land use policy
1	Meuraxa	85%-100%	Very high-risk	100% development
2	Jaya Baru	50%-85%	High-risk	100% development
3	Banda Raya	0%	Low-risk	100% development
4	Baiturrahman	0%-50%	Medium Risk	100% development
5	Lueng Bata	0%	Low Risk	100% development
6	KutaAlam	50%-85%	High-risk	100% development
7	Kuta Raja	85%-100%	Very high-risk	100% development
8	Syiah Kuala	50%-85%	High-risk	100% development
9	UleeKareng	0%	Low-risk	100% development

Table 5.2: Description measures in business as usual (accommodation) strategy

5.3.1.2 Planned-retreat land use plan with strict zoning plan

In the planned-retreat strategy with law enforcement, the very high-risk areas of the city were strictly prohibited to be used as residential areas in the context of long term strategic planning. The objective of this strategy was to reduce disaster risk by minimizing number of people that reside in very high-risk areas through strictly law enforcement of zoning plan. Therefore, in this plan, The new development in the very high-risk areas of the city was banned. In other words, there was no new future development in the disaster prone areas, where the level of damage in the areas were more than 85% of damage level based on tsunami tragedy in 2004 (JICA, 2005).

For instance, in the real practice, it was assumed that the government did not issue any longer the new permit for building development, which is known as IMB[7] for new housing development in very high-risk areas (Pemkot-Banda-Aceh, 2013). Therefore, the description of measures in planned-retreat strategies with law enforcement for each zone in this research for long term strategic planning of Banda Aceh city 2011-2030 is shown in Table 5.3 below.

No	Zones Name	Level of Damage	Zone Classification	Land use policy
1	Meuraxa	85%-100%	Very high-risk	No development
2	Jaya Baru	50%-85%	High-risk	50% development
3	Banda Raya	0%	Low-risk	100% development
4	Baiturrahman	0%-50%	Medium Risk	75% development
5	Lueng Bata	0%	Low Risk	100% development
6	KutaAlam	50%-85%	High-risk	50% development
7	Kuta Raja	85%-100%	Very high-risk	No development
8	Syiah Kuala	50%-85%	High-risk	50% development
9	Ulee Kareng	0%	Low-risk	100% development

Table 5.3: Description measures of planned-retreat (law enforcement) strategy

As can be seen in Table 5.3 above, this strategy did not allowed the new housing development in very high-risk areas of the city, which have category damage 85%-100% (completely destroyed). However, in the second category of high-risk areas,

[7] IMB is abbreviation of izin mendirikan bangunan in bahasa Indonesia. It is an permit that should be fulfilled of the city residents if they want to build a building in the case study area selected.

which have level of damage 50%-85% (major damage), the authority still kept 50% of land availability to be used as a new housing development or other development. Similarly, the medium high-risk areas also could be used as the new development area by using allocation of 75% land availability. Lastly, there was no restriction development plan in low risk areas in this strategy because the low risk areas are used for the new promoted development areas.

5.3.1.3 Planned-retreat strategy with pricing policy

The planned-retreat policy through pricing policy was a new policy that introduce in this research. The objective of this strategy was to reduce the disaster risk by minimizing number of people that reside in high-risk areas through pricing policy. However, this policy was not as strict as the planned-retreat with strict zoning plan. This policy still kept the land availability for the new development in very high-risk areas. 15% of land availability in very high-risk areas were allowed to be used as the new development for residential areas in the future. On the other hand, there were 75% land availability in the high-risk areas that were allowed be used as a new promoted development areas. In addition, similarly with previous planned-retreat strategy, there was no restriction development plan in low risk areas in this strategy.

Furthermore. this strategy applied the land tax pricing in the areas, which were identified as high-risk areas with level damage more than 50% (see column 5 Table 5.4 for detail). In this case, the land tax in high-risk areas was a far expensive compared to the land tax in low risk areas, which had an objective to attract people to reside in low risk areas rather than in high-risk areas of the city. The description of policy measures in this strategy can be seen in Table 5.4 below.

No (1)	Zones Name (2)	Zone Classification (3)	Land use policy (4)	Pricing policy (5)
1	Meuraxa	Very high-risk	15% development	200%
2	Jaya Baru	High-risk	75% development	20%
3	Banda Raya	Low-risk	100% development	-
4	Baiturrahman	Medium Risk	100% development	-
5	Lueng Bata	Low Risk	100% development	-
6	KutaAlam	High-risk	75% development	20%
7	Kuta Raja	Very high-risk	15% development	200%
8	Syiah Kuala	High-risk	75% development	20%
9	Ulee Kareng	Low-risk	100% development	-

Table 5.4: Description measures of planned-retreat strategy with pricing policy

5.3.2 Land use and transport plan in urban transport sustainability

In the context of Banda Aceh city, all the possible strategies in land use and transport plan were directed to reach the city objectives of urban transport sustainability. However, it should be noted that the land use strategies in the framework of urban risk reduction that mentioned earlier in section 5.3.1 were integrated in the land use plan in the framework of urban transport sustainability. For that reason, there were two type of land use strategies, which were combined in this study, as an alternative solution in promoting the concept of sustainable development.

Firstly, the business as usual plan (accommodation) as the land use strategy in the framework of disaster mitigation was combined with the concept plan of centralized concentration strategy as the land use strategy in the framework of urban transport sustainability. In this case, the zones in high-risk areas of the city, which are located near to the old core area (city centre), were allowed to be used as a new promoted development areas. In the perspective of urban transport sustainability, the objectives of this strategy is to reduce sprawl development that potentially increase the length of commuting and travel time that impact on high carbon emission from urban transport sector.

Secondly, the planned retreat plan as the land use strategy in the framework of disaster mitigation was combined with the concept plan of decentralized concentration as the land use strategy in the framework of urban transport sustainability. In this strategy, the new promoted development areas were directed to low risk areas rather than to high-risk areas of the city. This concept plan referred to long term strategic spatial planning of Banda Aceh city (RTRW, 2009). At this time, the main core area of the city is in sub-district of Baiturrahman, which was defined as zone 4 (medium risk area) in the research. However, in the long term strategic plan of Banda Aceh city, the second main core of the city would be in sub district of Lueng bata (low risk area), which was defined as zone 5 in this research since after tsunami tragedy in 2004. In the context of planning practice, it can be seen that the authority has been aware that the old city centre and some sub-districts near to old city centre are located in disaster prone areas.

Furthermore, all transport plan strategies for Banda Aceh city in this research were also directed to reach the objectives of the city in the framework of urban transport sustainability. In macroscopic scale, three main problem identified in the city related to transport problem were poor public transport system, poor transport policy in managing demand, and fuel government subsidy (cheap oil) as discussed in chapter 4. For that reasons, the transport plan strategy proposed for Banda Aceh city in this research is shown in Table 5.5 below.

No	Transport plan	Description of measures
1	Improvement of public transport	Bus rapid transit (BRT) with high level of services
2	Transport demand management	New parking charge scheme
		Cut fuel subsidy

Table 5.5: Transport plan measures in the framework of urban transport sustainability

As can be seen in Table 5.5, the transport plan strategy consist of public transport improvement and transport demand management strategy. The strategy of public transport improvement was applied through promoting Bus Rapid Transit (BRT), while the transport demand management (TDM) strategy consisted of parking management scheme and fuel subsidy reduction/pricing. The implementation of these transport policy measures referred to concept of "pull" and "push" that were already generally discussed in chapter 3. The improvement of public transport system was a part of the pull concept, which has an objective to improve the attractiveness of public transport system in order to promote modal shift from private vehicles to public transport system. On the other hand, the policy measures in transport demand management were applied to discourage people for using private vehicles in order to attract more city residents to use public transport system.

In the real policy practice in Indonesia context, the implementation strategy of improvement public transport system and transport demand management referred to the transport strategies of Indonesia government program in urban sustainable improvement project through SUTIP project, which was fully supported by National Agency Planning and Ministry of Transport (SUTIP-Project, 2011). The policies implementation could be seen in several pilot project cities, such as Bogor, Jogjakarta, Palembang and Solo. In the level practice, Bus rapid transit (BRT) and parking management are two alternative measures that could be adopted as the local action plans in order to achieve the target of national urban transport policy.

5.3.2.1 Improvement of public transport system through introduction of Bus rapid transit (BRT)

In the context of Banda Aceh city, the objective of public transport improvement strategy was to attract people to use public transport rather than private vehicles. As mentioned earlier in the chapter 4, one of problems, which influenced people to use private vehicles rather than public transport in Banda city, was related to poor service of public transport system. In other words, the recent public transport services in the city has low quality, such as poor condition, low level of accessibility, long waiting time, long duration of travel time, unreliable, uncomfortable and inconvenience.

In the real practice, the Banda Aceh authority also planned an urban transport plan to promote bus rapid transit (BRT) as an alternative for public transport mode in the city. It was estimated that the BRT project spent more than 32 billion rupiah for buses procurement and bus stop shelter development (DISHUB, 2012b). The Figure 5.4 below shows the new concept plan of bus rapid transit and the bus stop shelter proposed as a part of BRT plan development concept in the case study area.

Figure 5.4: Promoting Bus Rapid Transit (BRT) (DISHUB, 2012b)

Furthermore, the other important factors that should be considered were related to improving the level services of bus rapid transit such as travel time and waiting time. Therefore, it was expected that the people that use private vehicle could shift to public transport system. However, it should be noted public transport sectors in Indonesia cities were mostly operated by the private sectors with lack control of government (Dirgahayani, 2012). Therefore, the government regulatory reform for public transport industry should be implemented in this condition. This effort has an objective to reform the informal system of existing public transport from unregulated structure to a formal and efficient public transport system that fits with the local context in order to achieve the quality standard of public transport services (Cervero and Golub, 2007, CDIA, 2011). For that reason, there were three important factors that discussed regarding the plan of transport strategy, which could be applied in the reality and to be tested in Banda Aceh MARS model in the context improving the quality of bus rapid transit services.

Improving Public transport infrastructure

In this research, the BRT infrastructure plan use the same network both for BAU and planned-retreat strategy. The BRT service route refer to existing network of public transport route in Banda Aceh city (DISHUB, 2008), which can be seen in the Figure 5.5 below.

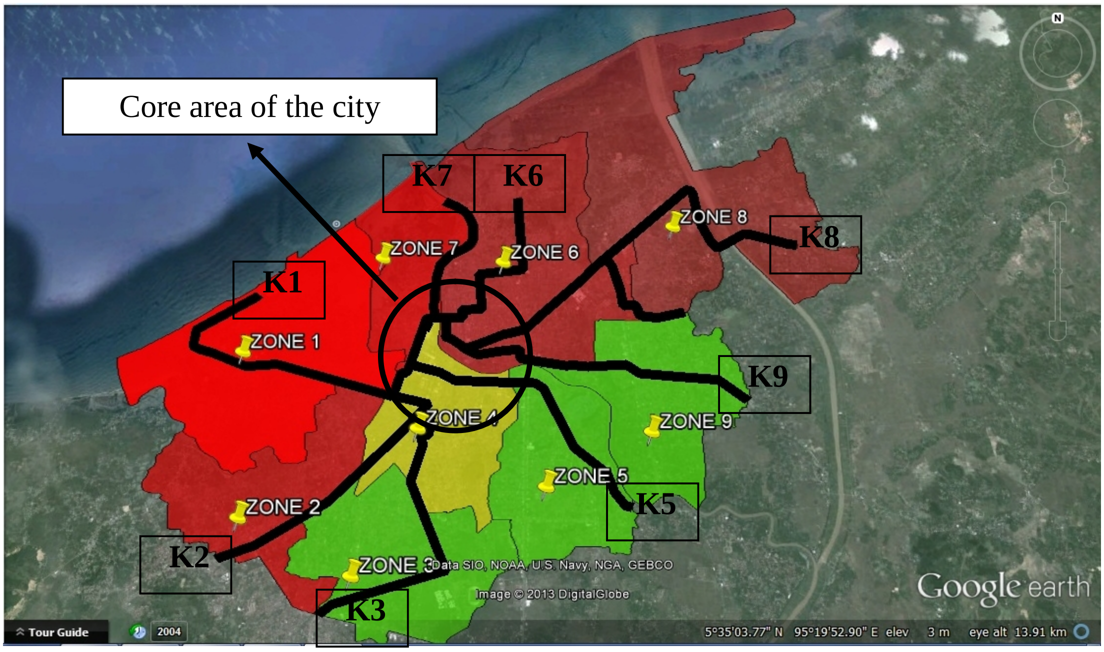

Figure 5.5 : BRT concept plan in BAU and planned-retreat strategy

From the Figure 5.5, it can be seen that both of the land use strategy use the same public transport referred to existing road network route, which all of the routes are directed to the old city centre, which is located in medium risk areas (zone 4). The same BRT network is selected in order to see the direct effect of different land use policy measures applied when the BRT strategy is applied in the model. The other aspect, it is considered that there are still city residents in the high-risk areas of the city both in the BAU and planned-retreat strategies, where the city residents should be given the same level of BRT services.

However, it should be also noted that it is also possible to run the different BRT network in different land use strategies selected, which has an objective e.g. reducing the attractiveness of high-risk areas of the city in order to support the city vision in the framework of urban risk reduction. In this case, the level of services of BRT to low-risk areas can be increased to give more accessibility of public transport for the city residents in low-risk areas rather than in the high-risk areas of the city. In this strategy, it is expected that this strategy could increase the attractiveness of low-risk areas to be selected as residential areas rather than the high risk areas of the city.

In fact, the poor public transport services in the low risk areas of the city attracted more people to reside in high-risk areas of the city. The residents, who were relocated to the new promoted development area in the low risk area of the city satisfied with the quality development of their new residence in the rehabilitation and reconstruction process. However, they did not satisfy with the location of their new housing, which increase the travel distance to their centre of activities, and followed with the low quality of the public transportation services (Matsumaru et al., 2012). In addition, another qualitative research also revealed that some residents in high-risk area do not want to move to low risk areas because the locations are farther to the city centre compared to their original residence and they should pay more transport cost (YAPPIKA, 2005).

Moreover, the application of strategy e.g. different BRT network in different land use strategy need the full support from the politician. In this context, the full understanding of policy makers regarding the combined concept of urban disaster risk reduction and urban transport sustainability need to be improved. In this case, the plan of different BRT networks, which are implemented in different land use strategies can be proposed to be implemented in the further research of this research.

Improving Public transport frequency

The improvement of public transport frequency was planned to increase the supply of public transport services. This measure has an objective to improve the level of service BRT public transport system such as headway times, waiting times and changing times in order to make travel time by public transport more reliable and faster compared to existing condition. The headway time of public transport should be in range 5 - 10 minutes. In the context of Indonesia, the improvement of public transport frequency referred to the examples application of sustainable Urban Transport Improvement Program such in Indonesia such as Trans Jakarta (Jakarta), Trans Jogja (Jogjakarta), Trans Musi (Palembang) and Trans Pakuan (Bogor) (Dirgahayani, 2012).

Public transport fares

The public transport fares might also play the main role in affecting the people choice to use public transport rather than private vehicles. In Banda Aceh city, the cost of public transport refer to the government regulation about standard tariff for public transport within Province of Aceh (PERGUB, 2008, PERGUB, 2009). In 2008, the price of public transport within Banda Aceh city is Rp. 3000 (IDR). This price increased by Rp. 1000 from Rp 2.000 to Rp. 3000 as a result of the increase of fuel price. The latest price in 2013 is Rp. 4.000. The transport cost within the Banda Aceh city was single trip and the price was flat for all zones (PP-Walikota, 2013).

The ticket price for BRT planned in this study also referred to the Sustainable Urban Transport Improvement Program such as Trans Jakarta (Jakarta), Trans Jogja (Jogjakarta), Trans Musi (Palembang) and Trans Pakuan (Bogor). In the current practice, all the bus fares in these cities through the BRT program were subsidized by government. For instance, the fare of Bus Trans Jakarta was subsidized by local government ($0.38 cents) in 2004. Furthermore, the amount of the subsidy reached $50 million (USD) at the end 2012 (Prayudyanto et al., 2013). The BRT ticket price could be vary from Rp 3.000 to 4.000 (SUTP, 2013a). However, in the case study area selected, it was assumed that the BRT tariff plan referred to the new regulation of Banda Aceh city (PP-Walikota, 2013). Moreover, in the model application, the government subsidy for public transport fare was applied referred to learning lesson from the BRT Trans Jakarta case study. In this context, the fare of public transport could be also reduced to attract more residents to use public transport system.

5.3.2.2 Parking charge scheme

The second policy instruments is parking charge policy. It is expected that this alternative policy measure could affect the travel by private vehicles and promote the modal shift to public transport system. The parking charge in Banda Aceh city referred to the local government regulation. Before the year of 2012, the parking charge was Rp 1000 for car and Rp. 500 for motorcycles (Pemkot-Banda-Aceh, 2004). However, after 2012, the Banda Aceh government increased double the parking charge for car and motorcycle, which became Rp 2000 and Rp 1000 respectively. In the parking charge strategy, it is assumed that the parking charge is five time more expensive compared to the price in 2012. The parking charge is flat all day whether it is in peak or off-peak hour and there is no restriction time as refer to the real condition in Banda Aceh city (Pemkot-Banda-Aceh, 2012a).

Furthermore, the parking charge in urban areas in the city of this study had different scenario between BAU (accommodation land use strategy) and planned-retreat (law-enforcement and pricing policy). In BAU land use strategy, the parking charged in all zones are flat as shown in Figure 5.6 below.

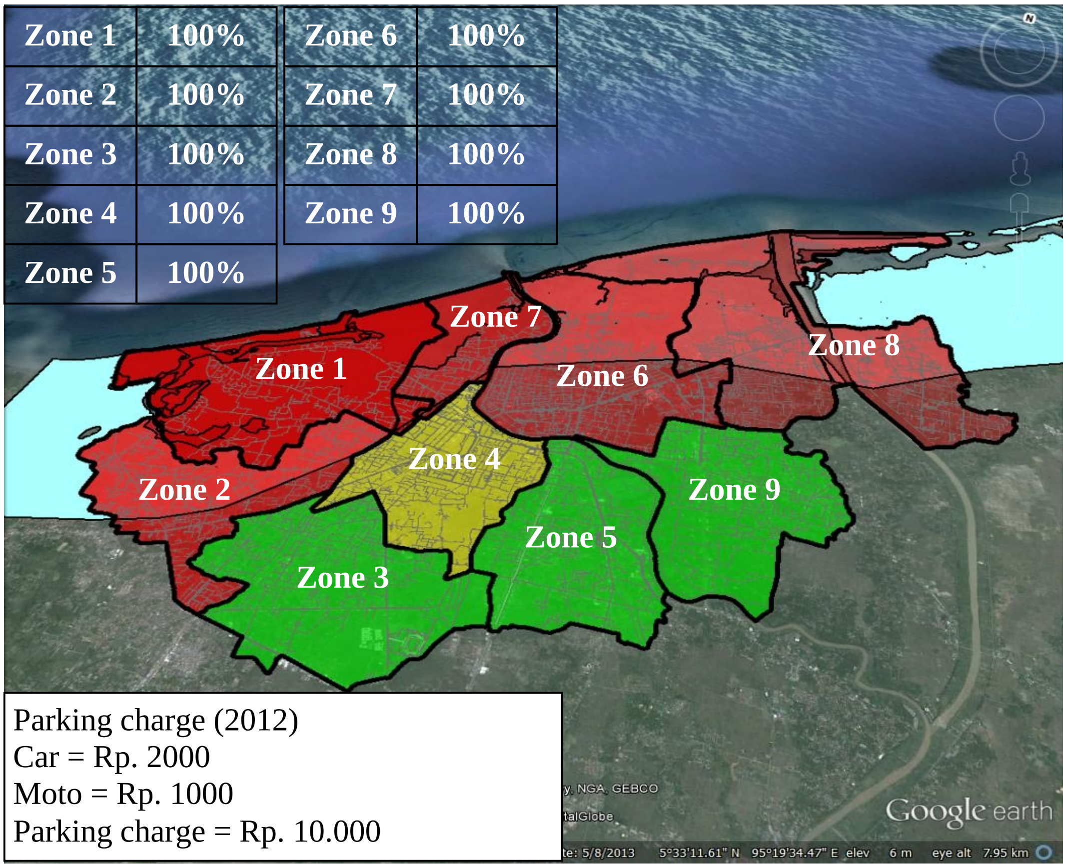

Figure 5.6: Percentage of parking charge in all zones of Banda Aceh city 2011 for BAU (Accommodation) strategy

On the other hand, in the planned-retreat strategy, the parking charge was not applied flat price for all zones. In this land use strategy, 100% of charged parking were only applied in the old city centre and some business zones such as zone 4 (Baiturrahman), zone 6 (Kuta Alam and zone 7 (Kuta Raja), including some zones, which are located in high-risk areas such as Zone 2 (Jaya Baru) and Zone 8 (Kuta Alam). In this case, It was expected that the implementation of this policy measures could reduce the attractiveness of the high-risk areas to be selected as the residential areas.

On the other hand, the parking charge in low risk areas was reduced 80% cheaper compared to the expensive price that applied in this policy measures. In this context, the parking charge that should be paid in low risk zones zone 3, zone 5 and Zone 9 were only 20% of the parking charge applied in this study. In other words, the parking charge in these areas were two times more expensive compared to actual price in the year of 2011. Figure 5.7 below shows the application of percentage of parking charge applied in each zone of Banda Aceh city for planned-retreat strategy in this study.

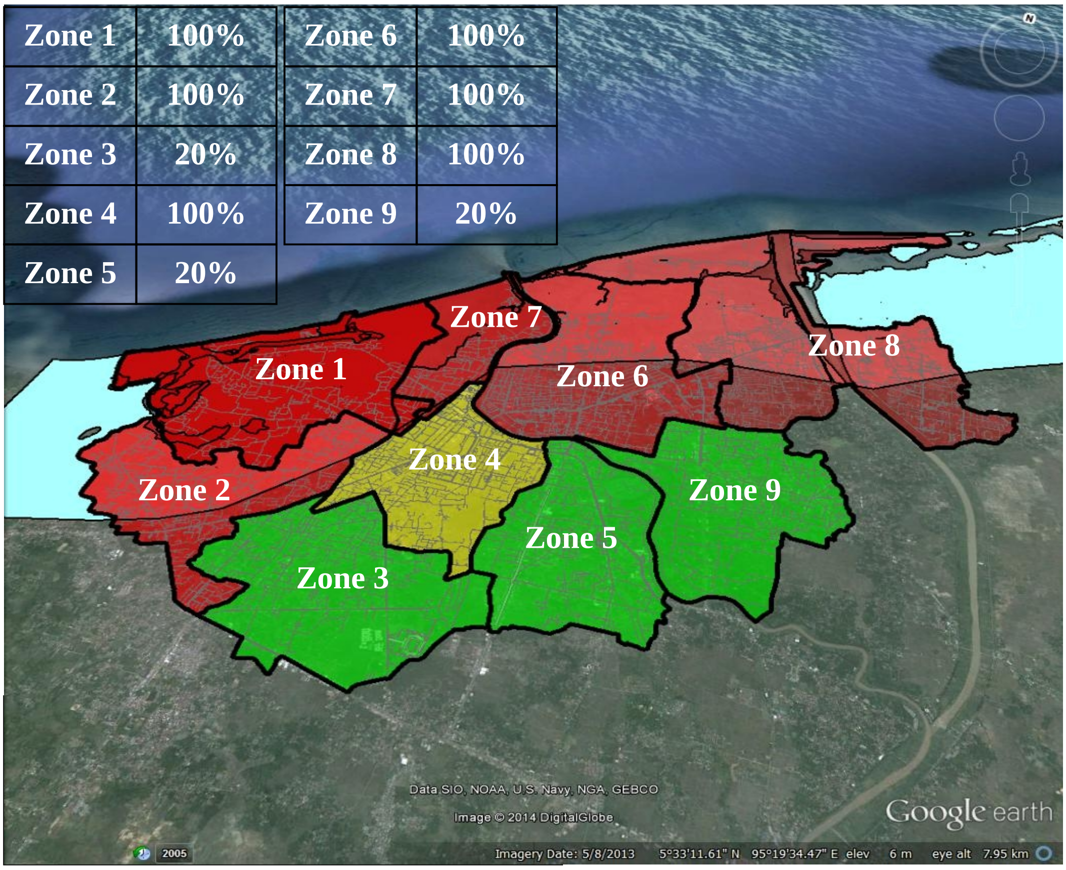

Figure 5.7: Percentage of charged parking in all zones of Banda Aceh city 2011 for Planned-Retreat strategy

According to a case study of sustainable urban transport project in Palembang city (the capital of South Sumatera Province), the flat parking charge with no restriction time in CBD area increased the number of private vehicles, which parked in the long time duration. Therefore, the new parking charge with more organize vehicle parking was recommended to be implemented (SUTP, 2013b). In the latest urban transport project in Solo city (size 44.03 km^2), the old flat parking rate Rp. 2000 all day (US$ 0.17) will be replaced with a new parking charge up to Rp5000 (USD 0.42) per hour in certain areas of the city (SUTP, 2014).

Moreover, in the case of Jakarta city (664 km^2), the Jakarta local government implemented the parking charge for private vehicles in the city in 2012. The parking charge in the city increased up to four times compared to as it was (Pemprov-Jakarta, 2012). In the case of Banda Aceh city, the application of the new parking charge strategy in Banda Aceh MARS model could be applied up to four or five times compared to the parking price after 2012 (Rp 2000) or it can be 10 times more expensive compared to the parking charge in 2011 (Rp 1000) in order to increase the government revenue from parking sector. The Figure 5.8 below shows the government revenue from parking sector. The parking revenue was then compared with the increase trend of private vehicles number in Banda Aceh city during the period of time 2006-2011.

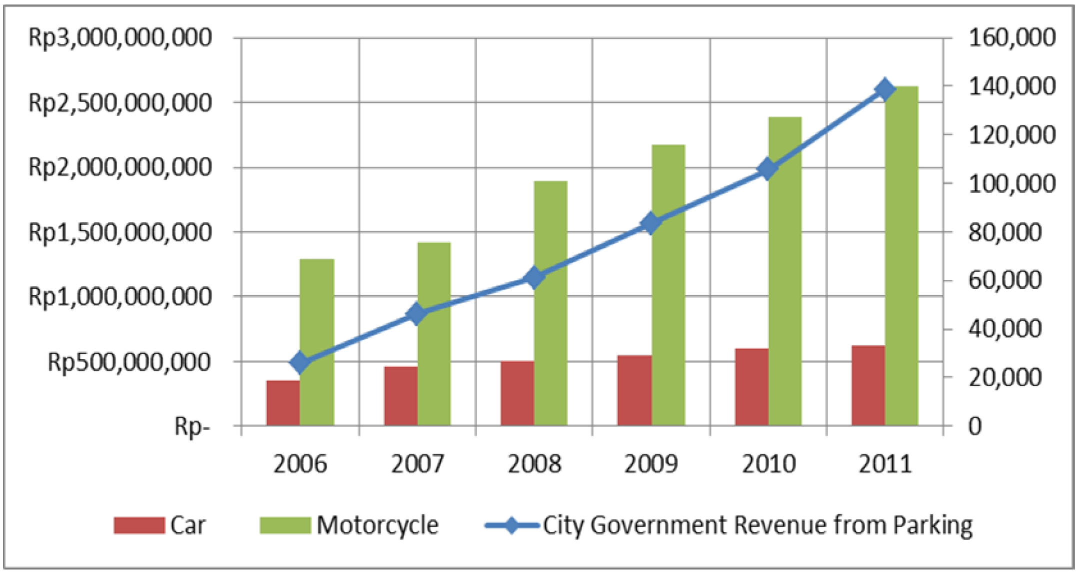

Figure 5.8: Government revenue from parking sector and the private vehicle ownership in Banda Aceh city (DISHUB, 2010, Saky, 2012, DISHUB, 2012a, DPKKA, 2012)

From Figure 5.8, it can be seen that the increase of private vehicles number in the city contributed significantly to increase the government revenue from parking sector. On the other hand, the increase of private vehicles also potentially increase the carbon emission from urban-transport sector. In the national level budget, it could also has an impact on the increase of fuel subsidy because more than 95% of fuel subsidy was spent in urban transportation sector (Legowo, 2012). For that reason, it was expected that the introduction of more expensive parking charge could increase the government revenue from parking sector. On the other hand, it was also expected that the expensive parking charge could reduce the attractiveness the city residents to use private vehicles in order to reduce government fuel subsidy.

5.3.2.3 Reduction of fuel subsidy (cut fuel subsidy)

The reduction of fuel subsidy increases the cost of travel by private vehicles. It is expected that this policy could discourage Banda Aceh residents to use private vehicles. Simultaneously, this policy also introduced to promote modal shift from private vehicles to public transport system. Furthermore, this policy could also help government to save subsidy budget allocation in the national budget expenditure planning (APBN). Therefore, the subsidy budget in other sectors such as for education and health could be increased significantly in the next future years.

Therefore, in the strategy fuel subsidy reduction, the fuel price input in future MARS model (2011-2030) of Banda Aceh city used the non-subsidy fuel price. In 2011, the price of fuel subsidy was double compared to non-subsidy fuel price. Therefore, the fuel price increase in the model can be increased more than 100% or double. For instance, Table 5.6 below shows the difference fuel price between premium Ron 88 (subsidy) and Pertamax Ron 92 (non-subsidy). The non-subsidy fuel policy was applied as do something strategy in the Banda Aceh MARS future model.

No	Transport Strategy	Fuel Product	Price per Liter
1	Business as usual	Premium RON 88	Rp 4.500
2	Fuel subsidy reduction	Pertamax Ron 92	Rp. 10.000

Table 5.6: Fuel product in for fuel subsidy and non-fuel subsidy (ESDM, 2011)

5.3.3 Banda Aceh integrated land use and transport planning (BILT)

All land use and transport strategies that were mentioned and discussed earlier in section 5.3.1 and 5.3.2 are then combined to reach the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability. The several land use and transport policies measures selected in the BILT are shown in Table 5.7 below.

Land-use plans in the framework urban risk reduction & urban transport sustainability	Transport Policy measures					
	BAU (1)	**BRT (2)**	**Parking (3)**	**Cut fuel Subsidy (4)**	**BRT, Parking (5)**	**BRT, Parking and Cut fuel subsidy (6)**
Business as usual (Accommodation) (A)	A1	A2	A3	A4	A5	A6
Planned-retreat (law enforcement) (B)	B1	B2	B3	B4	B5	B6
Planned-retreat (pricing policy) (C)	C1	C2	C3	C4	C5	C6

Table 5.7: BILT Strategy land use and transport in the framework urban risk reduction and urban transport sustainability (1)

As can be seen in Table 5.7 above, there were 18 (eighteen) combinations of possible land use and transport policy measures that could be selected to be applied in the case study area selected, which have range from A1 to C6. However, some transport strategies that mentioned in the table above (A5, B5, C5, A6, B6 and C6) are combined “push and pull” strategies, which are expected can give better results. Therefore, there were 18 (eighteen) policy measures that planned to be tested in Banda Aceh future model 2011-2030.

5.4 Summary of concept plan developed in the case study area selected

In a summary, it can be seen that the application of concept plan through application of land use and transport plan strategy in this research has an objective to help the high-risk city in achieving the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability. In the real practice, it has been discussed that the Banda Aceh city, which is located in hazard prone areas to potential disaster of tsunami hazard, need such this development plan concept in order to reach the long term strategic city agenda in the local, national and global level.

However, Banda Aceh city cannot ignore the importance aspect of carbon emission reduction program in urban transport sector, which has become as an Indonesian national agenda to promote the concept of sustainable development. However, the city authority should also note that the concept of development plan in this city should also consider the important aspect of disaster risk since several zones in this city, are located in hazard prone to tsunami areas. The absence of disaster aspect in urban planning could potentially attract more people to reside in high-risk areas of the city. In other words, this condition can increase the city vulnerability to disaster risk in the next future years that might be dangerous for future generation in Banda Aceh city. On the other hand, the lack of planning in the transport side also gives the negative impact on the increase of potential carbon emission from urban transport sector that might reduce the quality of life of city residents in the long run.

For that reasons, this chapter introduced the application of a concept development plan in a high-risk city that could be applied to reach the city objective in the framework of urban risk reduction and urban transport sustainability. Several land use plan in the framework of urban risk reduction were combined with several transport strategies in the framework of urban transport sustainability as discussed in sub section 5.3.3. The combination of the strategies proposed was implemented to reach the sustainability high-risk city objectives, such as in the case of Banda Aceh city as explained earlier in the previous chapter 4. The implementation of the strategies selected in this chapter then is discussed in the chapter seven (7) of this research.

Chapter 6
Banda Aceh MARS Model Calibration and Validation

6.1 Introduction

In the context of urban planning, land use and transport interaction (LUTI) plan plays the main roles in achieving the city objectives in the framework of urban transport sustainability. In the context of long term strategic of city planning, LUTI model is an alternative tool that can be used as an initial basis in decision making process for understanding the impact projection of land use changes over the transport infrastructure or vice versa in order to reach the city objectives in the framework of sustainable urban development. Moreover, the LUTI models have been promoted to be used in urban transport planning for finding city strategies based on city objectives in the context of sustainable urban development. For instance, it can be seen from several application of MARS LUTI Model that were applied in several European cities and Asian cities (Pfaffenbichler et al., 2010).

However, there are no LUTI model that consider the aspect of disaster risk in its sub land use model as discussed earlier in the chapter 2. At this time, most of LUTI models only deal with the issue of urban transport sustainability, which ignore the important aspect of the integration of disaster mitigation in land use planning. In this context, it is important to include disaster risk factor in the LUTI model to understand and investigate how people perceive the risk in their housing location choice, similar with other factors that were already applied in the existing LUTI models such as accessibility, rent, green areas and other factors.

Furthermore, as discussed earlier in the chapter 2, several past studies also emphasized that the disaster risk was one of the factors that play the main role in promoting the concept of urban sustainable development. (Shaw et al., 2009, ADPC, 2013). Therefore, it is needed a LUTI model as an scientific approach, which can represent the land use and transport interaction through modelling approach in the real practice, to be applied for long term strategic planning of the high-risk cities, which are located in disaster prone areas such as Banda Aceh city.

For that reason, this chapter presented the calibration process of dynamic land use and transport interaction (LUTI) MARS (Metropolitan Activity Relocation Simulator) model for Banda Aceh city. This LUTI model was originally developed for the city of Vienna (Pfaffenbichler, 2003). However, the current MARS model does not involve the aspect of disaster risk in its land use sub model. Therefore, the aim of Banda Aceh MARS model developed was to introduce disaster risk factor, which was not recognized in the conventional MARS model as an innovation in the aspect of land use and transport modelling.

For that reasons, systematically, this chapter consists of several sections that presented as the logical steps regarding how the Banda Aceh MARS Model calibration was done. The second section in this chapter (6.2) discussed about Banda Aceh MARS model and its modification and application for Banda Aceh high-risk city, including the research hypothesis about the disaster risk. Therefore, the discussion in this section was distinguished into the MARS model application for Banda Aceh condition before the tsunami tragedy (6.2.1) and for Banda Aceh condition after the tsunami tragedy (6.2.2). After that, the calibration results of pre tsunami model were discussed in section 6.3, while the calibration results of post tsunami model were discussed in section 6.4. Last but not least, the description of Banda Aceh future model 2011-2030 were discussed in section 6.5. Figure 6.1 below shows the structure regarding how the discussion of Banda Aceh MARS model was presented in this chapter.

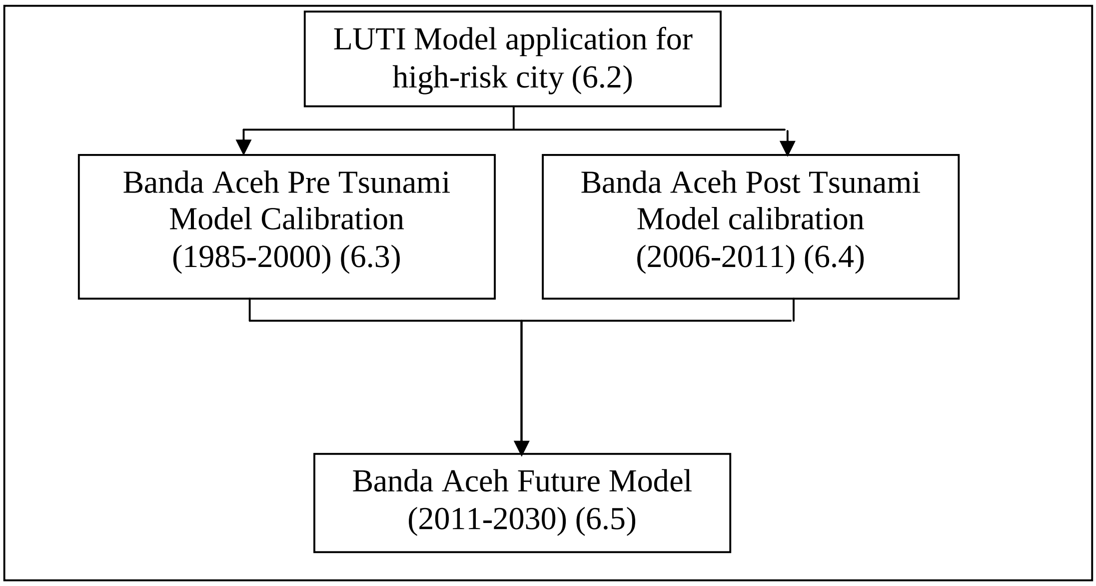

Figure 6.1 : The structure discussion of Banda Aceh MARS model calibration

6.2 Banda Aceh MARS Model as LUTI model application for a high-risk city

In the context of urban sustainable development issue, most scholars in urban planning areas agreed that the integration of disaster risk into land use planning plays a major role in directing the city to reach the sustainability city agenda e.g. (Baker, 2010, Ishiwatari and Onishi, 2012). Therefore, it is important for urban planners for having the LUTI model, which consider the aspect of disaster risk it its sub land use model. Banda Aceh MARS LUTI model was created to be used as a LUTI model application for a high-risk city, by adding the disaster risk factor in the its sub land use model of conventional MARS model. In this context, the disaster risk factor is related to how people respond to information or their experience about disaster risk based on tragedy in 2004 regarding their housing location choice in the Banda Aceh city.

The Banda Aceh MARS model calibration for high-risk city application consists of the following steps : (1) calibration and validation of the model before tsunami tragedy (Pre-tsunami model 1985-2000, without disaster risk factor)); (2) calibration and validation of the model after tsunami tragedy (Post-tsunami model 2006-2011, with disaster risk factor).

In the process of pre-tsunami calibration and validation (1985-2000), the disaster risk factor was not included in the model because it was assumed that the Banda Aceh residents were not aware the risk to tsunami hazard. Therefore, the land use coefficients in this model only considered the indicators accessibility and rent in the process of calibration. On the other hand, in the process of tsunami calibration and validation for post tsunami model (2006-2011), the sub land use model of MARS was modified by including disaster risk. After tsunami tragedy, it was assumed that the people are aware that some sub-districts in Banda Aceh city are located in disaster-prone areas. However, the location choice coefficients for accessibility and rent for this model were imported from the pre tsunami model. Therefore, the sub land use coefficients in this model used the previous land use coefficients of pre-tsunami model. After that, the new value of disaster risk coefficient was obtained in the process of calibration of this model. It was expected that the disaster risk factor gives the better fit results with the census data. In other words, it was hypothesized that the increase of potential vulnerability to tsunami disaster in high-risk zone reduces the attractiveness of that zone.

6.2.1 Banda Aceh Pre Tsunami Model (1985-2000)

The sub land use of Banda Aceh LUTI pre-tsunami model (1985-2000) consists of variables accessibility and rent. In this model, it was assumed the accessibility is a positive or good thing, while rent is a negative or bad thing, because the city residents should pay more regarding housing preference location if the rent is more expensive relative to the other zones. In other words, the increase of the accessibility parameter in a certain zone increases the relative attractiveness of that zone.

On the other hand, the increase of rent in a certain zone reduces the attractiveness of that zone. Therefore, the sign expected for accessibility is positive, while the sign for rent should be in negative sign. In this period of time (pre-tsunami), it was also assumed that the residents did not realize that some areas in Banda Aceh city are located in high-risk area to tsunami hazard. Therefore, In Banda Aceh LUTI Model of MARS, the choice model for residential location from zone i to zone j is calculated with a logit model as follows (Pfaffenbichler, 2008) :

$$N_j^{in}(t) = P^{in}(t) * \frac{a^{in} \times e^{(b^{in} \times {}^{WP}Acc_j^{PC,PT}(t) + e^{in} \times R_j^{D}(t))}}{\sum_j a^{in} \times e^{(b^{in} \times {}^{WP}Acc_j^{PC,PT}(t) + e^{in} \times R_j^{D}(t))}} \quad \textbf{..........(6.1)}$$

Where :

- N^{in}_j (t)...............Number of population demanding a residential place in zone j in the year t.
- P^{in}(t) ....Total population looking for new housing in the year t.
- a^{in}_j (t) ....Attraction to move into zone j in the year t.
- ${}^{WP}Acc^{PC,PT}_j$(t) ...Aggregated accessibility of workplace from zone j in the year t
- R^D_j(t)................Monthly rent for domicile in zone j in the year t (Rp – Indonesia Rupiah)
- b, e ....Parameters for calibration, which are derived using the results observed data from time series statistics data.

6.2.2 Banda Aceh Post Tsunami Model (2006-2011)

Banda Aceh LUTI post tsunami model (2006-2011) introduced a new variable, which was not recognized in conventional MARS model for normal city, like Vienna or Leeds MARS model. The risk to natural hazard, as a new variable introduced in LUTI model issues, was added in the model to consider the high-risk area of the Banda Aceh city to tsunami hazard. In this model, variable of disaster-risk was measured based on the high-risk areas, which was identified based on the past studies in the case study area selected as discussed in chapter 4 (JICA, 2005, Marchand et al., 2009, BPBD, 2012).

The formula used to calculate the risk referred to the application concept of disaster risk reduction in land use planning (NEDA, 2008) which was adopted from the "*hazard-risk model*" in the context of natural hazard management (Taylor, 2006), which was already explained in the chapter 2 and chapter 3. The mathematical expression for expressing and calculating the risk to tsunami hazard in the case study area selected can be seen as follows :

$$Hr_j = Pb.hazard\ \ risk_j \times E_j \times V_j \quad \text{......................................}\textbf{Equation 6.2}$$

Where :

- Hr_j .... disaster risk index in zone j (index risk) (No unit).
- Pb. Disaster $risk_j$ .. Assumption of probability of disaster risk in zone j within certain period of time (1 time in 30 years).
- E_j .... The potential of city element at risk (percentage of areas) that may be exposed to the tsunami risk in zone j. It is called the level of exposure (0%-100%) (%).
- V_j.......................... The degree of damage level (e.g. fatalities and building damage) as a result of tsunami inundated in zone j of Banda Aceh city. It is called as level of vulnerability (0%-100%) (%).

As can be seen in the equation 2, the risk was derived from the factor such as (1) the probability of hazard occurred, (2) the potential of city element at risk that exposed to disaster risk, and (3) the level of damage from tsunami hazard. In this context, the return period of tsunami disaster risk, 10 years or 500 years of return period may be used to consider the disaster risk probability for urban land use planning (Geist and

Parsons, 2006). In the context of Banda Aceh, it was estimated that the return period of the earthquake with magnitude 7.5 Mw to 9.5Mw[8] in the Sumatera-Andaman fault would be in the range 50 years to 500 years. Moreover, it was also estimated that the similar earthquake with magnitude more than 9 Mw, which would trigger the similar tsunami as in the tragedy 2004, would be in the next 400 or 500 years (Thio et al., 2005, SDC, 2009). However, it should also be noted several incidents of earthquake that occurred in the period 2005-2013. During this period of time, there were several incident, where the authority announced the potential of tsunami hazard coming to the city (BMKG, 2013). In this case, if the city residents hear the tsunami early warning system or if they obtain any information about the potential tsunami, they should run away as soon as possible from the coastal areas of the city. In this case, the potential disaster risk that perceived by city residents might be more frequent rather than scientific explanation based on the modelling results that mentioned earlier. In the current practice, the tsunami response preparedness, which was implemented by the city authority of Banda Aceh, referred to the tsunami tragedy that happen in 2004 (e.g. tsunami drilling/evacuation practice) (Simanjuntak, 2008). In this context, it was assumed that the Banda Aceh city residents perceive the hazard tsunami risk based on the tragedy in 2004 if they hear the emergency alarm from tsunami early warning system for evacuation process.

For that reason, the probability of hazard in Banda Aceh post tsunami model used the assumption of the return period of 30 years tsunami for similar tragedy in 2004, which was applied in the context of urban planning. This assumption referred to the range of 10 years to 500 years the tsunami return period that would be possible to applied in the context of city long term strategic planning (Geist and Parsons, 2006).

The level of exposure data referred to the data of tsunami inundation limit in each zone of Banda Aceh city based Banda Aceh disaster risk map (Government-of-Aceh, 2011), which already discussed in the previous chapter 4 as shown in figure 4.9 and table 4.2. The level of exposure was defined based the zone percentage that exposed to the tsunami based on tragedy in 2004. Furthermore, the level of vulnerability referred to the past studies that conducted in Banda Aceh (JICA, 2005, Marchand et al., 2009), which can be seen in the figure 4.8, 4.10 and the summary

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[8] Mw is moment magnitude scale that used to measure the size of energy that released by the earthquake

table 4.3 in chapter 4. After that, all of the data obtained for each variable mentioned earlier in each zone were used to calculate the disaster risk using the formula (2) aforementioned. The level of risk in very high-risk areas were higher compared to high-risk areas and medium risk areas, while the level of disaster risk in low risk areas of the city was zero. The zones classification based on risk level can be referred to figure 4.12 in chapter 4, which was visualized using Google Earth.

Therefore, in the post tsunami model (2006-2011), it was assumed that the residential preference location is influenced by the factor such as accessibility, rent and risk to tsunami hazard. In this context, the choice model for residential location from zone i to zone j in Banda Aceh post tsunami model is now adapted with a logit model as follows:

$$N_j^{in}(t) = P^{in}(t) * \frac{a^{in} \times e^{(b^{in} \times {}^{WP}Acc_j^{PC,PT}(t) + e^{in} \times R_j^D(t) + h^{in} \times Hr_j(t))}}{\sum_j a^{in} \times e^{(b^{in} \times {}^{WP}Acc_j^{PC,PT}(t) + e^{in} \times R_j^D(t) + h^{in} \times Hr_j(t))}}$$

…………………………………………………………………………..Equation 6.3

Where :

- $N^{in}_j(t)$, $P^{in}(t)$, $a^{in}_j(t)$, ${}^{WP}Acc^{PC,PT}_j(t)$, $R^D_j(t)$ are defined as in Eq. 1
- $Hr_j(t)$ .... The risk of the possibility disaster occurrence from tsunami hazard in zone j in the year t.
- h .... parameter for the risk in calibration process, which are derived using the results of observed data from statistics data.

Furthermore, it was also assumed that people prefer to reside in low-risk area rather than in high-risk areas because disaster risk is assumed as a bad or negative thing that should be avoided by the city residents. In other words, it was also assumed that the increase of disaster risk level in certain zone reduces the attractiveness of that zone. In this context, the sign obtained for disaster risk variable is expected to be in negative since the city residents assumes this factor as a negative thing (bad). For the accessibility and rent factor, the assumptions used were similar with the explanation earlier in the pre tsunami model. The expensive housing rent reduce the attractiveness of certain zone, while the increase of accessibility in certain zone increases the attractiveness of that zone.

6.3 Calibration of Banda Aceh Pre-Tsunami Model

This section discussed about the calibration and validation of Banda Aceh Pre Tsunami Model (1985-2000). Systematically, the presentation of Banda Aceh Pre Tsunami model result was discussed in two sub sections, which consist of transport (6.3.1) and land use model calibration process (6.3.3). After that, the results of Banda Aceh MARS model, which consist of transport (6.3.2) and land use (6.3.4) results, were compared with the census/survey data, which were obtained from the city of Banda Aceh, for validation process using time series data 1985-2000. The calibration process was important to be done to show that the Banda Aceh MARS pre tsunami model can provide the credible results for the past land use and transport interaction of Banda Aceh city in time series data 1985-2000.

Furthermore, the zoning system in pre tsunami model referred to the sub-district administrative boundaries of Banda Aceh city, which are consist of 9 zones explained earlier in chapter 4 Figure 4.5 (page 131). The distribution residents in 9 zones of pre tsunami model then were compared with the census data using time series data 1985-2000. Figure 6.2 below show the zoning system of Banda Aceh pre tsunami model with residents distribution data in 1985.

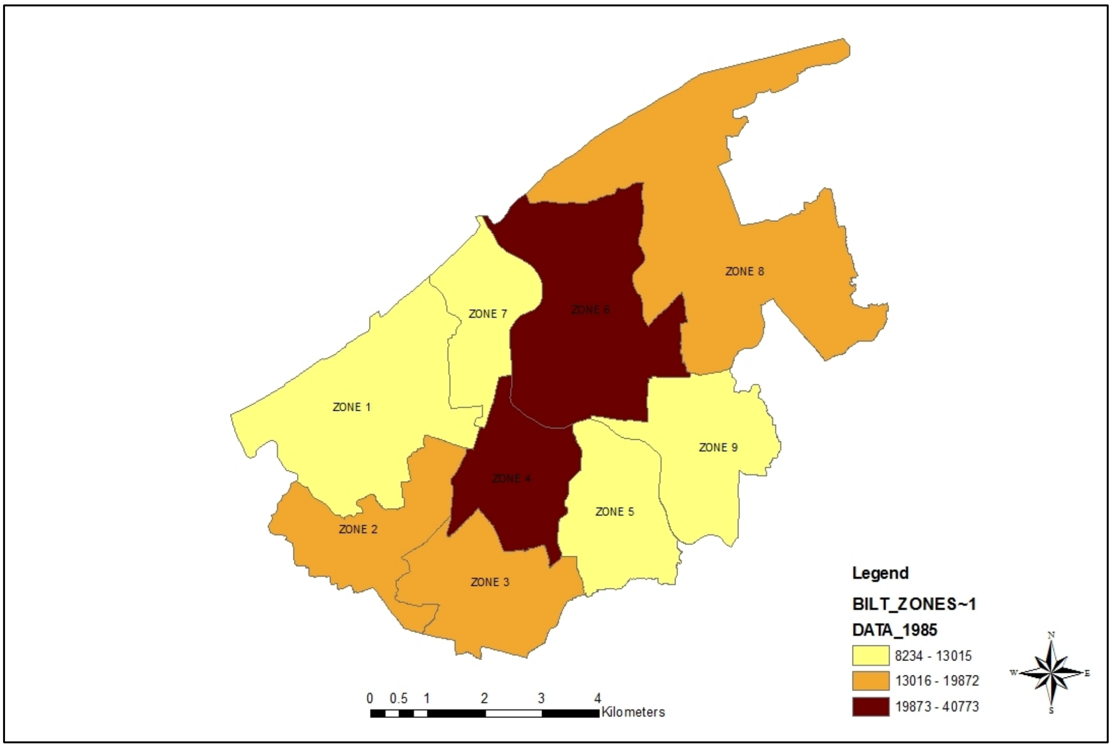


Figure 6.2: Zoning system in Banda Aceh Pre-Tsunami Model (1985-2000) with residents distribution in 1985 (BPS-Banda-Aceh, 1985-2000)

There are two types of data that were used in the calibration process of Banda Aceh MARS model 1985-2000. Firstly, the data related land use and transport in the year of 1985 was used as data input for a base year in the pre tsunami model. Secondly, the census and data observed in 2000 were used in model calibration process using optimization feature supplied in VENSIM. In this context, the process of model calibration directed the model results based on data input in 1985 to be fitted with the data observed in the year of 2000. Furthermore, there were two process that should be followed in calibrating the Banda Aceh MARS pre tsunami model that were explained in the next two sub sections.

6.3.1 Transport sub model calibration of pre-tsunami model

This process was started with the adjustment process of k mode factor for each mode of transport selected. In this context, the k modes selected (pedestrian, public transport, car, and motorcycles) were adjusted to be fitted with the modal split data based on transport survey in the final year of model simulated (Kamal, 2002). In the calibration process, MARS can give output by peak and off-peak. However, the modal split data for peak and off-peak in the calibration process were set the same by considering the limitation data in Banda Aceh city (see Table 6.1 for k values).

For finding the parameters that fit with the data observed, several automated optimizations process using optimization feature in VENSIM were conducted using k values constrains in the range 0.8 to 1.2 because this range was considered “as the value not too far from 1”. In the revision process, it was also conducted using the same alpha values as in the original MARS Model. However, the alpha parameters for walking were higher compared to the values in the original MARS model by considering the weather temperature in Indonesia compared to in Europe. The alpha parameters for walking was increased to 5 for peak and still the same for off-peak. Table 6.1 below shows the k modes found using range 0.8 to 1.2 in the final calibration of pre-tsunami model to be fitted with the modal split data.

Mode share	Pedestrian	PT Bus	Car	Motorcycle
K mode peak	0.9	1.1	1.2	0.8
K mode off-peak	0.8	1.2	0.8	0.8

Table 6.1: K mode for calibration parameters in the final of pre-tsunami model 1985-2000 (MARS 1985) (k mode in range 0.8-1.2)

6.3.2 Transport results of Banda Aceh Pre-Tsunami Model

Figure 6.3 below shows the modal split result of Banda Aceh MARS pre tsunami model calibration that compared with data observed in 2000.

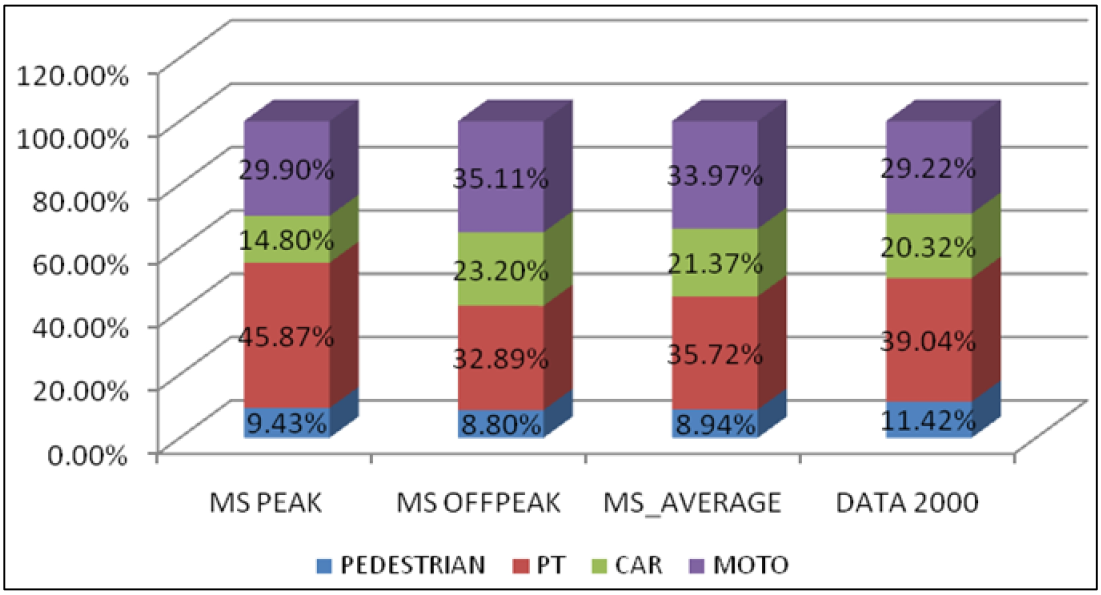


Figure 6.3 : Comparison of modal split of Model 2000 (MARS 1985) and observed data in 2000 (Kamal, 2002)

As can be seen in the Figure 6.3 above, the results of MARS1985 calibration for modal split showed quite well correlation with the data observed in the year of 2000. Firstly, it can be seen that the MARS 1985 result shows that the public transport was the most mode transport that selected by Banda Aceh city residents in the year of 2000. The calibration model result shows that there were 35.72% of people in average that selected public transport as their travel mode in the year of 2000, which was not too far from the data observed. The data showed that there were approximately 39.04% of people that used public transport as their travel mode choice in urban areas of the city. Secondly, the MARS 1985 results also show that there were 21.37% and 33.97% of Banda Aceh city residents that selected cars and motorcycles as their travel modes respectively. These calibration results were slightly difference with the data observed in the year of 2000 (20.32% for car and 29.22% for motorcycle). Lastly, there were 11.74% city residents that prefer non-motorized mode as their travel modes based on data observed in 2000. The result of MARS 1985 calibration for this mode was 8.94%, which was also quite close to the data observed in the year 2000 (11.42%).

6.3.3 Land use sub model calibration of pre tsunami model

The land use sub model calibration was the second step, which was conducted in calibrating the MARS model after the k mode in sub transport model was already set up. The process of calibration in this part used the calibration option, which is supplied by VENSIM.

Before the process of calibration was started, the time series of residents distribution data were imported into the VENSIM DSS. In this context, time series data from 1985 to 2000 in 9 zones of the case study area selected were used to calibrate the Banda Aceh pre tsunami model. After that, the 15 years' time series were used to get the response coefficients that fit the model results with the census data in 2000 (BPS-Banda-Aceh, 1985-2004) using optimization setup features in VENSIM. The response coefficients obtained in Banda Aceh pre-tsunami model consist of two coefficients, namely accessibility and rent that refer to equation (6.1). The selection of optimization setup in VENSIM allows the model to get the response coefficient that fit with the real data refer to the government census. The summary of calibration process is shown in a number, which is then called as payoff. The payoff is a number that summary the process of simulation that showed at the end of the process simulation or optimization for comparing the difference between model results and actual data. The lower payoff value means that the model results are closer to the observed data. In other words, maximizing payoff means that the difference between model results and data to be close to zero as possible (see VENSIM manual for detail). In this case, the weight selected should be equal to the one over the standard deviation (SD) of prediction error. In this case, the zero data for base year were excluded for calculating the value of SD.

Table 6.2 below shows the response coefficients for parameter accessibility and rent for Banda Aceh pre tsunami model after 93 simulations with payoff equal to -479.34.

Coefficients obtained in Banda Aceh Pre Tsunami Model (1985-2000)	Applied to parameter of sub land use model
"b(r) in" = 4.06	Accessibility (Acc_j)
"e(r) in" = -0.10	Rent (R_j)

Table 6.2 : Land use coefficients found in the calibration of Banda Aceh Pre-Tsunami Model (MARS 1985)

Moreover, the confidence bounds were calculated by setting payoff value = 4. In VENSIM, this payoff setting value gives 95% confidence bounds. This process was done because the values obtained in the optimization process have some uncertainty. Therefore, it is also needed to know the uncertainty by testing the sensitivity of payoff obtained. As mentioned earlier, the weight chosen was obtained from the difference value between the model results and data observed. In this context, the weight used in the optimization process is equal to the one over the standard deviation of time series data census 1985-2000 and the results of MARS model for 15 years simulation. Table 6.3 below shows the results of payoff value sensitivity test for 95% confidence bounds using optimization control in VENSIM by setting payoff value equal to 4.

Sensitivity = Payoff_Value = 4 **The base payoff = -479.34**	**Applied to parameter of sub land use model**
3.87 <= "b(r) in" = 4.06 <=4.18	Accessibility (Acc_j)
-0.14 <= "e(r) in" =-0.10 <=-0.06	Rent (R_j)

Table 6.3 : The parameter estimates and 95% of confidence bounds

From Table 6.3, it can be seen that the 95% confidence intervals for coefficient accessibility were between 3.8756 for lower bound and 4.18727 for upper bound. On the other hand, the lower and upper bounds coefficient estimated for rent were -0.145259 and -0.0646406 respectively.

In summary, it can be seen that the both sign of each parameter had the correct sign as expected in the assumption. The positive sign in accessibility parameter means that the increase of accessibility increases the attractiveness of certain zone in the case study area selected. On the other hand, the negative sign in rent parameter means that the increase of rent reduces the attractiveness of certain zone in Banda Aceh city.

According to the calibration results, the model and the quantitative evidence showed that the distribution of Banda Aceh residents were influenced by the parameters accessibility and rent. The residents preferred to select the housing locations, which had low rent and high accessibility (trade-off between rent and accessibility) based on time series data 1985-2000.

6.3.4 Land use results of Banda Aceh Pre-tsunami model

Figure 6.4 below shows the comparison between the result of MARS 1985 for model results in 2000 versus the census data in 2000.

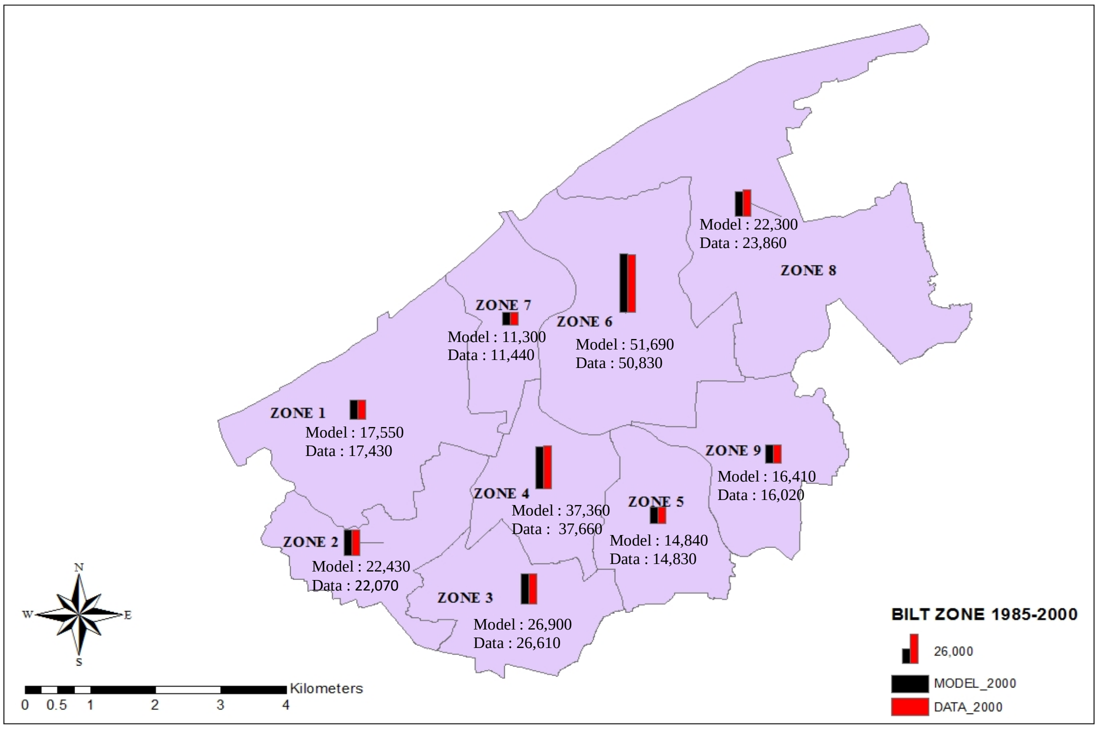


Figure 6.4 : Comparison of residents distribution of model 2000 and actual data in 2000 (BPS-Banda-Aceh, 1985-2000)

From Figure 6.4, it can be seen clearly that the model results of MARS 1985 correlated well compared to the census data in 2000. Moreover, Table 6.4 below shows the differences between the model results and the government population census data in each zone of Banda Aceh city.

Zone	Zone Names	Model 2000 (MARS 2006)	Data 2000	Delta	Diff in %
1	Meuraxa	17,550	17,430	120	0.69%
2	Jaya Baru	22,430	22,070	360	1.63%
3	Banda Raya	26,900	26,610	290	1.09%
4	Baiturrahman	37,360	37,660	-300	-0.80%
5	Lueng Bata	14,840	14,830	10	0.07%
6	Kuta Alam	51,690	50,830	860	1.69%
7	Kutaraja	11,300	11,440	-140	-1.22%
8	Syiah Kuala	22,300	23,860	-1,560	-6.54%
9	Ulee Kareng	16,410	16,020	390	2.43%

Table 6.4 : Residents of MARS 1985 compared to Census data in 2000 (BPS-Banda-Aceh, 1985-2000)

From Table 6.4, it can be seen that the lowest difference was 10 in Zone 5 (Lueng Bata), while the highest one was 1,560 in zone 8 (Syiah Kuala). From the results, it can be also seen that MARS underestimate zone 8 (-6.54%) and the two other zones, which were zone 4 (-0.80%) and zone 7 (-1.22%).

Furthermore, the R^2 value obtained regarding the correlation between pre-tsunami model results and census data in 2000 for residents distribution was 0.995, which can be seen in the Figure 6.5. In other words, the result of MARS 1985 was quite credible for forecasting the residents distribution of Banda Aceh city. The R^2 value correlation obtained was also quite well and quite similar to the result of other MARS models such as for the city of Vienna and Leeds, where the R^2 obtained were 0.9415 and 0.9075 respectively (Pfaffenbichler, 2008, Pfaffenbichler et al., 2010).

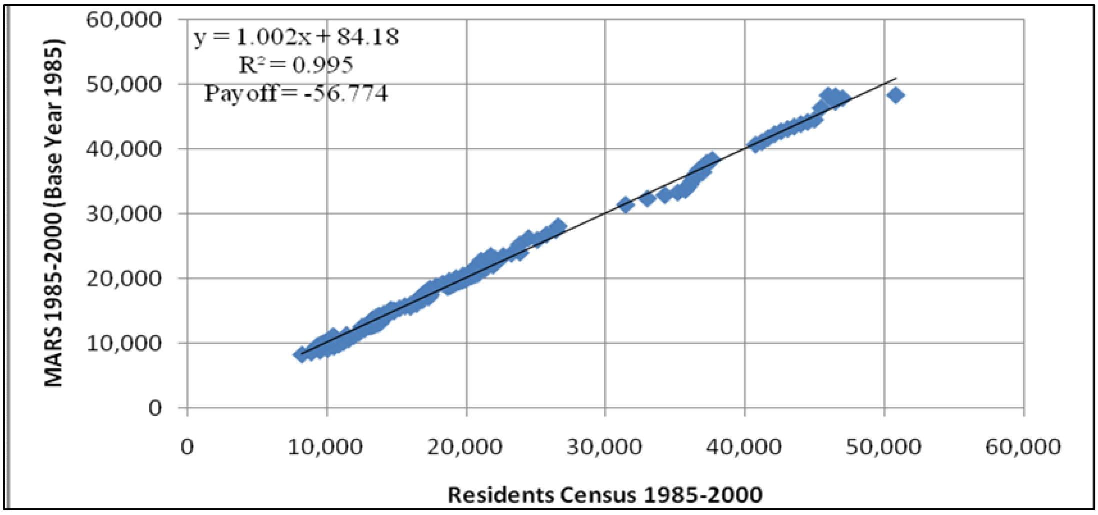


Figure 6.5 : Correlation the result of MARS 1985 residents distribution with time series census data 1985-2000 (BPS-Banda-Aceh, 1985-2000)

In summary, the Banda Aceh MARS pre tsunami model worked quite well. The conformity between model results and the real data refer to census data in time series 1985-2000 was very good. Moreover, it can be also seen that the most attractive zones in the city were zone 4 and zone 6, which are located in the core areas. These two zones are the zones, which were classified as the zones with the highest population compared to other zones in the case study area selected. Furthermore, it also can be seen that the number of population in the zone 2, 3 and 8 were lower compared to in the zone 4 and 6, which are located in the core area of the city. In addition, the lowest density population based on data observed and model outputs were in the zone 1, 7, 5 and 9.

6.4 Banda Aceh Post Tsunami Model (2006-2011)

This section discussed about the calibration and validation of Banda Aceh Post-Tsunami Model (2006-2011). Similar with the result of pre tsunami model (1985-2000), the result presentation of Banda Aceh Post Tsunami model result (2006-2011) was also discussed in two sub sections namely, land use and transport results. The result of Banda Aceh MARS post tsunami model then was compared with the census/survey data that obtained from the city of Banda Aceh for validation process using time series data 2006-2011. Similar with the explanation in the previous section, the calibration and validation process of post tsunami model was also important to be done to show that the Banda Aceh MARS 2006 can provide the credible results for the past land use and transport interaction of Banda Aceh city during the period 2006-2011.

Furthermore, the zoning system in post tsunami model was also the same with the zoning system in pre tsunami model that also referred to the sub-district administrative boundaries of Banda Aceh city, which are consist of 9 zones (Figure 6.2). However, the tsunami inundation limit based on tsunami tragedy in 2004 was needed to be considered in the zoning system of post tsunami model 2006-2011 because several sub-districts in Banda Aceh city are located in high-risk areas of tsunami. In the sub land use model, the disaster risk was added in the sub land use model during this period of time as shown in equation (6.3) mentioned earlier.

Similar with the process in the pre tsunami model. There were two types of data, which were used in the calibration process of Banda Aceh MARS post tsunami model. Firstly, the data related land use and transport in 2006, which was used as data input for a base year in the post tsunami model. Secondly, the census and data observed in 2011 were also used in model calibration process using optimization feature supplied in VENSIM. In this context, the model calibration directed the optimization process to get the model results that fit with the data observed in the year of 2011 after five years simulation in the model (2006-2011).

6.4.1 Transport sub model calibration of post tsunami model

In the reality, high growth rate ownership and loss of public transport services after tsunami tragedy expect different k values for mode choices compared to the Pre tsunami Model. In this part, the transport survey, which was conducted in Banda Aceh city in 2011, was used to calibrate the transport model results of Banda Aceh post tsunami model 2006-2011 (STTD, 2011). After that, the results of MARS 2006 modal split in the year of 2011 were compared with the result of modal split based on the past survey that conducted in Banda Aceh city aforementioned. In the mode share calibration, the k mode values of each mode were adjusted in the range 0.8 to 1.2 order to fit the Banda Aceh MARS 2006 model results with the modal split data in year of 2011. Table 6.5 below shows the final calibration parameters in Banda Aceh post tsunami model.

Mode share	Pedestrian	Public transport	Car	Motorcycle
K mode peak	0.8	0.8	1.2	0.8
K mode off-peak	0.8	1.2	0.9	0.8

Table 6.5: k mode for calibration parameters in the final of post-tsunami model 2006-2011 (MARS 2006)

From Table 6.5, it can be seen that the final calibration parameters obtained for peak and off-peak were significantly different. This results were also different with the results in the final calibration obtained in the pre tsunami model. This different results of calibration parameters obtained were influenced by the different condition and situation between pre and post tsunami model as explained in detail in chapter 4 regarding the explanation of land use and transport condition (section 4.2). The “abnormal condition” in the post tsunami model during the period 2006-2011 related high growth of private vehicles and loss of public transport contributed to the calibration parameters obtained as shown in Table 6.5. For instance, the significant calibration parameters obtained were showed by public transport and car between k mode peak and off-peak. The reduction of city residents that prefer to use public transport system after the tsunami tragedy increased the value of calibration parameters for public transport in the off-peak (0.9) compared to in the peak (1.2) to fit with the same data observed for peak and off-peak in 2011 (STTD, 2011).

6.4.2 Transport results of Banda Aceh Post-Tsunami Model

Figure 6.6 below shows the modal split result of MARS 2006 calibration that compared with data observed in 2011 based on k mode calibration parameters as shown in Table 6.5 earlier.

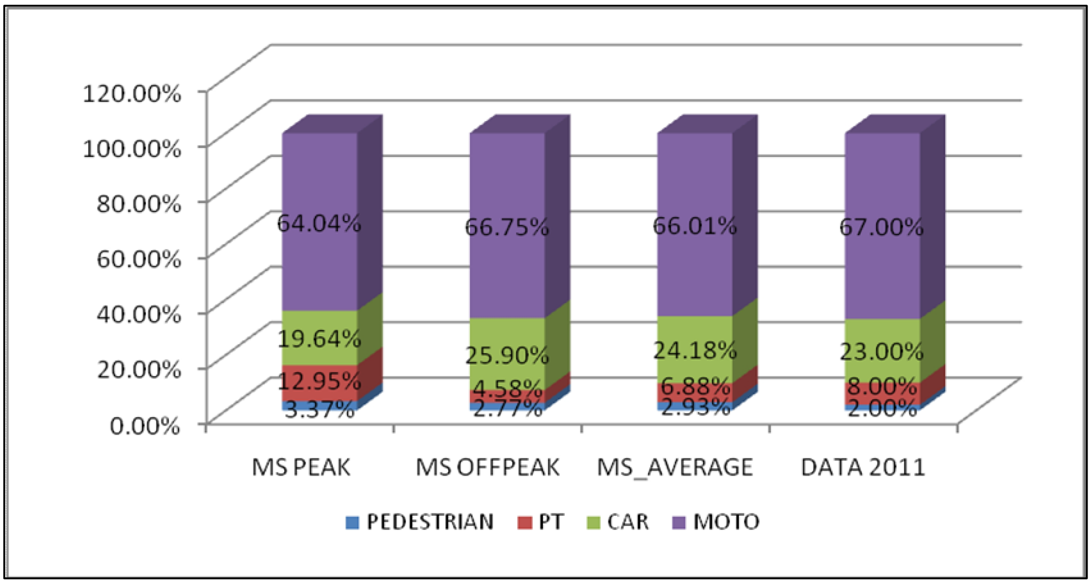


Figure 6.6 : Comparison of modal split of MARS 2006 and observed data in 2011 (STTD, 2011)

As can be seen in the Figure 6.6 above, the results of MARS 2006 calibration for modal split in 2011 also showed quite well correlation with the modal split based on data observed in the year of 2011. Firstly, it can be seen that there were 66.01% of people that selected motorcycle, while there were 24.18% of people that prefer cars as their travel mode in the year of 2011 based on the model calibration in average result. This result was very close to the data observed in 2011. The data shows that there were approximately 67% of people that used motorcycle as their travel modes, while there were 23% of people that prefer to selected cars as their travel mode.

Secondly, the calibration results of MARS 2006 also show that there were 6.88%% of Banda Aceh city residents that used public transport as their travel mode. This results also consistent with the data observed in the year of 2006, where the data shows that there were 8% of people that used public transport as their travel mode. Lastly, the MARS 2006 also demonstrated that there 2.93%% of city residents that prefer walking, which was quite close with the data observed in 2011 (2%). This value had a big decline compared to before the tsunami tragedy (11.42% in 2000).

6.4.3 Land use sub model calibration of post tsunami model

In this part, the time series data population in 9 zones of Banda Aceh city from 2006 to 2011 were used to get the response coefficients that fit the model results with the census data in 2000 (BPS-Banda-Aceh, 2005-2011). This process was also similar with the process that conducted in Banda Aceh pre tsunami model calibration.

However, the response coefficients obtained in Banda Aceh post-tsunami model consist of three parameters, namely accessibility, rent and disaster risk, which refer to the equation (6.3). The disaster risk calculation refer to equation (6.2). Table 6.6 shows the response coefficients for parameter accessibility, rent and disaster risk. The confidence bounds for "b(r)in, e(r)in and h(r)in" was computed by setting payoff value = 4 in using similar optimization process as explained earlier in Banda Aceh pre tsunami model 1985-2000, which can be seen in Table 6.6 below.

Sensitivity = payoff_value = 4 **The base payoff = -158.661**	**Applied to parameter of sub land use model**
2.61 <= "b(r) in" = 4.43 <=6.4	Accessibility (Acc_j)
-1.54 <= "e(r) in" =-1.39 <= -1.24	Rent (R_j)
-0.1 *<= "h(r)in" = -0.1 <= 0.1	Disaster risk (H_j)

Table 6.6 : Land use coefficients found in the calibration of Banda Aceh Post-Tsunami Model (MARS 2006) with disaster risk factor.

As can be seen in the Table 6.6, the coefficient obtained for disaster risk was negative, which was as expected because it was assumed that disaster risk is a bad thing that should be avoided by the residents. In other words, the increase of disaster risk reduce the attractiveness of high-risk zones, which are located in disaster prone area, compared to other zones, which are located in low risk areas of the city.

In the reality, the number of population that reside in these areas increased year by year as shown in the census data discussed earlier in chapter 3 (BPS-Banda-Aceh, 2005-2011). In this case, it can be seen that there might be other factors that attract the Banda Aceh city residents to reside in the high-risk areas of the city refer to quantitative evidence of time series data 2006-2011. The population might increase from exogenous growth and from internal moves. Some people still move back due to various reasons including development by NGOs in high risk areas, which made choices for supply limited too. However, it should be noted that all of these factors were not modelled in MARS. Moreover, even disaster risk coefficient now is negative, but then the model predicts a lower number when this factor is included in model. In other words, the disaster effect give very small impact in reducing the attractiveness of high-risk areas of the city.

In this context, there are several factor related disaster risk issue in the reality that could be possible to be considered regarding why people still prefer to reside in high-risk areas of the city. Firstly, it might be related to the desire to come back to the high-risk areas of the city was still high during that period. This condition might be related to their memory about their original residence, where they were grown up and live before the tsunami tragedy. Secondly, it might be related to the development process during rehabilitation and reconstruction process, where there were many housing that rebuilt in the high-risk areas of the city. Lastly, it might be related to the location of new promoted development (proposed by the city authority), which was quite far from the centre of activities. In this context, most of residents in high-risk areas do not want to pay expensive transport cost if they move to the other areas far away from their original residence before the tragedy. Table 6.7 below shows the land use coefficients obtained for the post tsunami model without disaster risk factor.

Sensitivity = payoff_value = 4 **The base payoff = -158.684**	**Applied to parameter of sub land use model**
2.57 <= "b(r) in" = 4.39 <= 6.36	Accessibility (Acc_j)
-1.54 <= "e(r) in" =-1.39 <= -1.24	Rent (R_j)

Table 6.7 : Land use coefficients found in the calibration of Banda Aceh Post-Tsunami Model (MARS 2006) without disaster risk factor.

From Table 6.7 above, it can be seen that the sign obtained for parameters accessibility and rent without including the disaster risk parameter were the same as the post tsunami model calibration with including the disaster risk parameter (see Table 6.6). The coefficient obtained for accessibility was positive, while the coefficient obtained for rent was negative. Both coefficient sign obtained for this parameters were also as expected in the assumption. In the next sub section, the results of Banda Aceh Post Tsunami Model with and without including disaster risk factor were compared in order to see the effect of adding the disaster risk factor in the sub land use of the Post Tsunami Model.

6.4.4 Land use results of post tsunami model

Table below shows the result of Banda Aceh post tsunami model with disaster risk factor.

ZONE	Zone Names	Model 2011_hr (MARS 2006)	DATA 2011	Delta	Diff
1	**Meuraxa**	16,750	16,860	-110	-0.65%
2	**Jaya Baru**	22,080	22,540	-460	-2.04%
3	**Banda Raya**	22,100	21,370	730	3.42%
4	**Baiturrahman**	28,610	31,070	-2,460	-7.92%
5	**Lueng Bata**	20,800	24,130	-3,330	-13.80%
6	**Kuta Alam**	42,970	43,180	-210	-0.49%
7	**Kutaraja**	8,600	10,670	-2,070	-19.40%
8	**Syiah Kuala**	34,810	35,650	-840	-2.36%
9	**Ulee Kareng**	21,090	23,090	-2,000	-8.66%

Table 6.8 : Residents of MARS 2006 with "hr" compared to resident census data in 2011 (BPS-Banda-Aceh, 2006-2011)

From Table 6.8 above, it can be seen that the lowest difference was 110 in Zone 1 (Meuraxa), while the highest difference was in zone 5 (Lueng Bata) (3,330). On the other hand, table below shows the result of Banda Aceh post tsunami model without including disaster risk factor in the model.

ZONE	Zone Names	Model 2011 (MARS 2006)	DATA 2011	Delta	Diff
1	**Meuraxa**	16,740	16,860	-120	-0.71%
2	**Jaya Baru**	22,060	22,540	-480	-2.13%
3	**Banda Raya**	22,100	21,370	730	3.42%
4	**Baiturrahman**	28,620	31,070	-2,450	-7.89%
5	**Lueng Bata**	20,800	24,130	-3,330	-13.80%
6	**Kuta Alam**	42,970	43,180	-210	-0.49%
7	**Kutaraja**	8,604	10,670	-2,066	-19.36%
8	**Syiah Kuala**	34,820	35,650	-830	-2.33%
9	**Ulee Kareng**	21,100	23,090	-1,990	-8.62%

Table 6.9 : Residents of MARS 2006 without "hr" compared to resident census data in 2011 (BPS-Banda-Aceh, 2006-2011)

From Table 6.8 above, it can be seen that the lowest difference was -120 in Zone 1 (Meuraxa), while the highest difference was in zone 7 (Kutaraja) (-2,066). From the results, it can be seen that the model underestimate all of the zones, except for zone 3. The two zones, which had highest differences, were zone 7 (-19.36%) and 5 (-

13.80%). Both of these values were higher compared to the highest difference in the Pre Tsunami model (e.g. -6.54% for zone 8). Table 6.9 also showed similar results with Table 6.8. This issue might be related to the condition of Banda Aceh city after the tsunami tragedy. Furthermore, Figure 6.7 below shows the correlation between the model outputs of the post tsunami model "*with and without*" disaster risk factor with time series data 2006-2011.

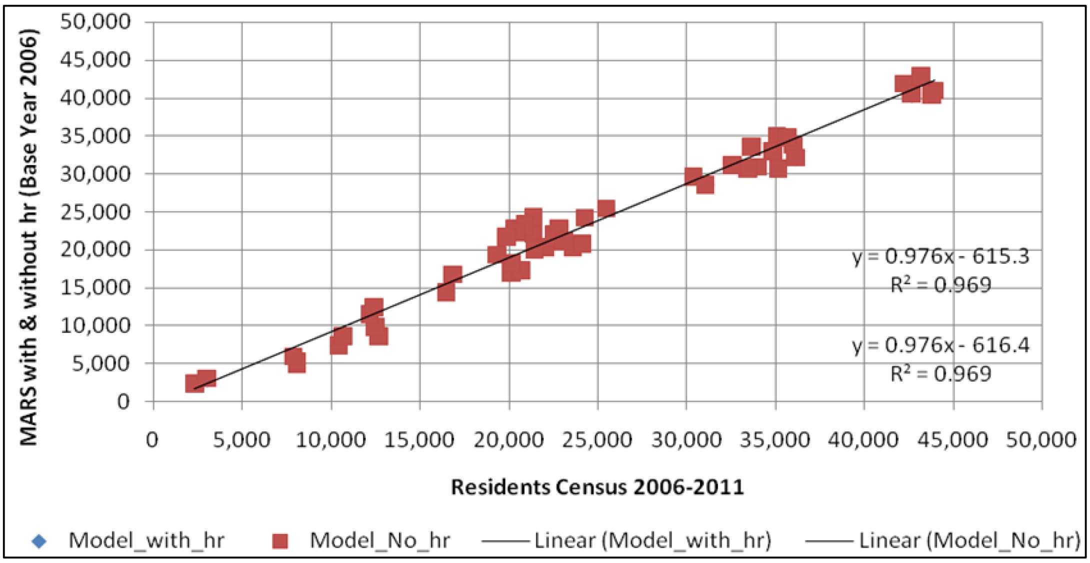


Figure 6.7 : Correlation the result of MARS 2006 residents distribution with time series census data 2006-2011 (BPS-Banda-Aceh, 2006-2011)

As can be seen in the Figure 6.7, the R^2 value obtained regarding the correlation between the model results and census data in 2011 for residents distribution was 0.969 both for model with disaster risk and without this factor. However, the final payoff obtained for the model with disaster risk (-158.661) was very slightly better compare with model without this factor (-158.684). Similar with the result of Banda Aceh MARS1985, the results of Banda Aceh MARS 2006 was also quite well.

In summary, the Banda Aceh MARS post tsunami model also worked quite well. The conformity between model results and the census data (2006-2011) was also quite well for several zones (<10%). However, there were also several zones that have high differences between the model outputs and census data such as in zone 5 and 7 (>10%). These results might relate to the condition in emergency situation, which was fast and affected by NGOs development plan rather than based on free market system (e.g. trade-off between land price and transport cost), which was not considered in the MARS model. In this context, the MARS model has the limitation in response this condition.

6.5 Banda Aceh MARS future model 2011-2030

Banda Aceh MARS future model was used to forecast the Banda Aceh future image in 2030. This model was developed based on the calibration results of Banda Aceh post tsunami model. The disaster factor was included in this model because the calibration results of post tsunami model showed the expected sign, which was as hypothesized in the first place and it was thought good practice to include response which should exist despite the minimal impact.

Figure 6.8 below shows the systematic process regarding how the development process of Banda Aceh future model, which refer to behaviour land use and transport interaction in pre tsunami model and post tsunami model.

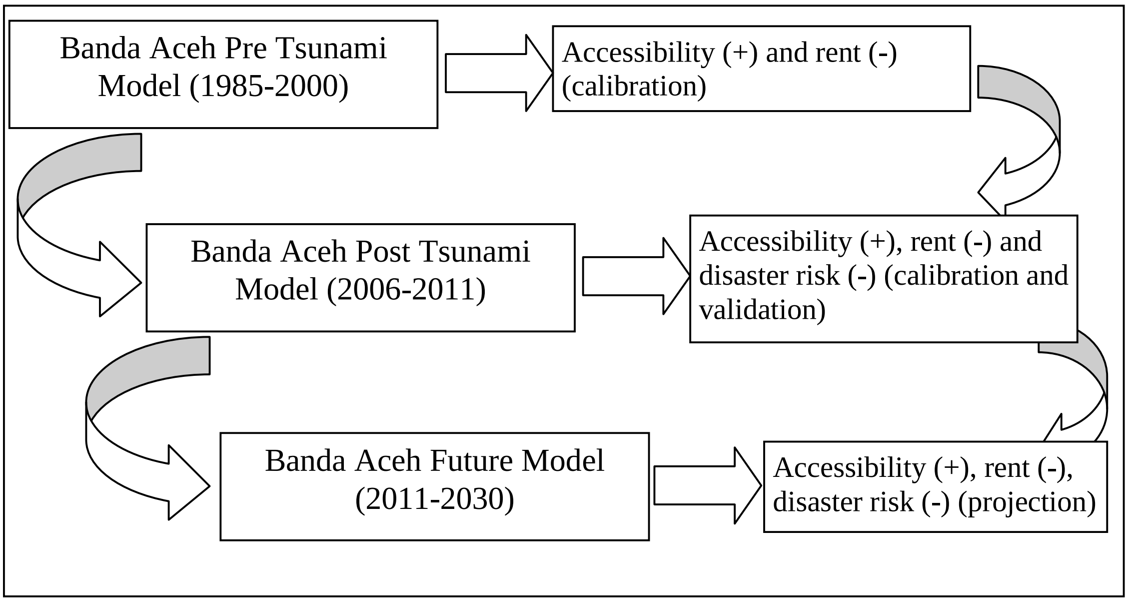


Figure 6.8 : Development of Banda Aceh Future Model 2011-2030

As mentioned earlier in the section 6.2.2, it was hypothesized that the Banda Aceh city residents prefer to avoid the disaster risk after the tragedy 2004. However, several sub-districts in high-risk areas of Banda Aceh city were still attractive to be selected residential areas. There were several factors that lies behind the disaster risk factor, which attract people to reside in the high-risk areas of the city that already discussed in sub section 6.4.3. The other reasons, it might relate to the little awareness people in giving response to the disaster risk issue. A past study, which was conducted in Banda Aceh city concluded that most people, who reside in high-risk areas of the city, had little concern with disaster risk in the context of selecting their residential location (Elvizahara, 2011, Yulianto et al., 2012). Moreover, according to the latest study, most of the respondents revealed that the follow-up information about tsunami post disaster strategies was very little. Seven of ten respondents said that they have never attended and involved in e.g. any program about tsunami preparedness (e.g. what to do and how to survive). Consequently, the respondents were not be able to answer what kind of rational response in facing the possibility of tsunami disaster in the future. 29% of respondents said that they resigned their self to the destiny, which they believe as a part of religious local wisdom in Aceh. Only 18.5% of respondents, whom informed that, they know what should be done if the tsunami strike again in the future (Astuti, 2014). Based on the model results, it was also found that the impact of disaster risk factor was very small and limited.

Furthermore, In Banda Aceh future model, there were several strategies, which were applied in the model to response the behaviour of land use and transport interaction as shown in pre-and post-tsunami model. The strategies selected were directed to reach the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability. As mentioned earlier in the chapter 5, the strategies selected were the combined land use and transport strategies in the framework of sustainability. The land use strategies such as land and property tax were the strategies, which might apply as a response against the behaviour land use as shown in both pre and post tsunami model. According to the result of calibration process and supporting by some past studies in Banda Aceh city, most of people considered the accessibility and rent as the main factors in housing location choice. On the other hand, the Banda Aceh city residents tend to give little attention in disaster risk issue, which actually should be considered for finding where the best location for their residential area.

In the transport side, the poor of public transport and several other transport policies attracted many people to use private vehicles rather than public transport system as explained in chapter 4. Moreover, the data showed that the number of people that used public transport as their transport mode reduced significantly from the year of 2000 to the year of 2011 (see chapter 4). It seems that this trend will continue and it will also potentially increase the carbon emission from urban transport sector in the future. Therefore, it is needed to apply several transport strategies in the future model as a response against the behaviour land use and transport interaction as shown in post tsunami model, which was discussed in the next chapter 7.

Chapter 7
Application of Strategies in Banda Aceh Future MARS Model

7.1 Introduction

This chapter is intended to discuss the implementation of strategies that were already developed as discussed in the previous chapter 5 to be applied in context of Banda Aceh city, which was discussed in the previous chapter 4.

In this research, it is assumed that the planning scenario for Banda Aceh city is 19 years for long term strategic planning of development process 2011-2030. The base year selected in the Banda Aceh MARS model is the year of 2011. The data input in the base year of 2011 is applied in the model to project the land use and transport condition of Banda Aceh city in 2011-2030. After that, the integrated land use and transport strategies developed in chapter 5, which is called as Banda Aceh Integrated Land use and Transport Plan (BILT), is also implemented in the model. Figure 7.1 shows the mechanism of development Banda Aceh MARS future model 2011-2030, which refer to the pre tsunami model and post tsunami model.

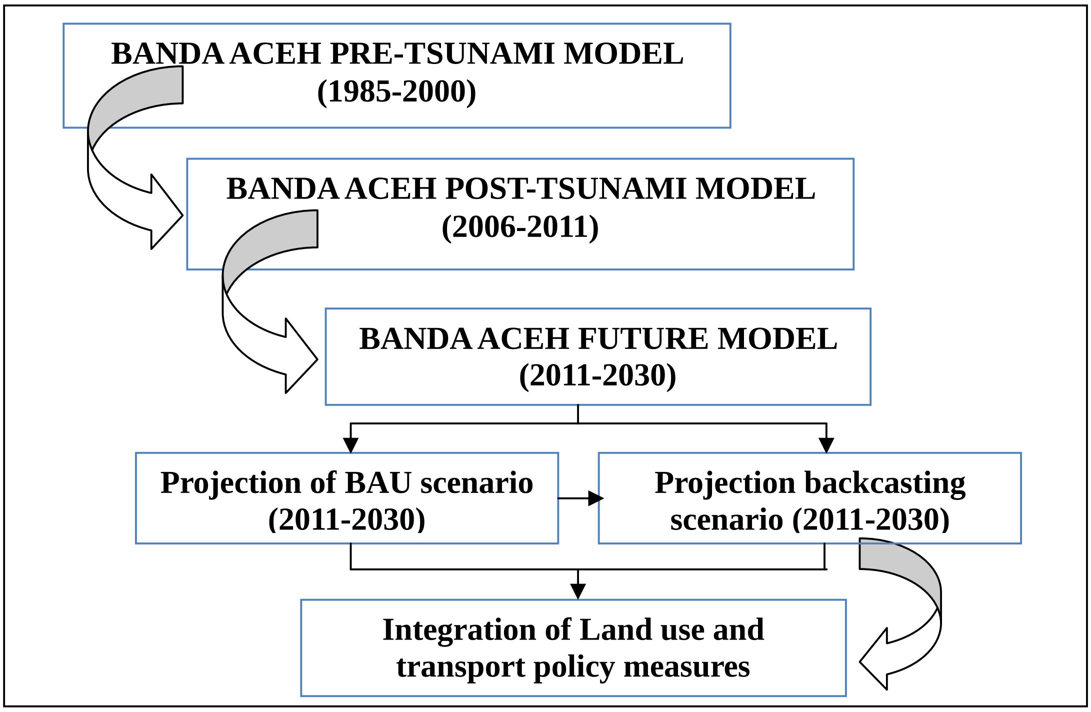


Figure 7.1 : LUTI Model Approach in implementation of BILT Strategies

As can be seen the Figure 7.1, the development of Banda Aceh future model refer to the land use and transport interaction in Banda Aceh pre tsunami model and post tsunami model. In the Banda Aceh future model, several alternative policy measures are applied in order to achieve the objectives of Banda Aceh city in the framework of urban risk reduction and urban transport sustainability.

The projection of resident distributions in the city (e.g. city residents in high-risk and low risk areas) is one of the general indicator to see the future image of the city in the light of the way to reach the city objectives in the framework of urban risk reduction. On the other hand, the changes of modal split as a result of different transport strategies selected is the general indicator selected to see the city future image in the light of the way to reach the urban transport sustainability city objectives. In this context, it should be noted that the further discussion regarding the indicator selected (e.g. fatalities, carbon emission) as a result of the resident distribution and modal split changes will be discussed in the chapter 8.

Therefore, generally, there are two main important issues discussed in this chapter. The first issue is related to the scenario planning of Banda Aceh city in the long term strategic planning (2011-2030), which is used to project future development condition in do nothing scenario. In this context, the trend in the past and in current situation based on pre-and post-tsunami model is used to extrapolate the future image of Banda Aceh city in the next several future years. The second issue is related to the implementation of land use and transport strategies selected as "do something scenario". In this context, it is assumed that "do something scenarios" change the future image in "do nothing scenario" that refer to the target planned based on the main city objectives that want to be achieved. This approach was known as backcasting approach (Robinson, 1982) and later this term was also used in several urban transport studies (Geurs and Van Wee, 2000, Barrella and Amekudzi, 2011).

For that reason, systematically, the discussion in this chapter is started with the explanation of Banda Aceh future development scenario 2011-2030, which is explained in section 7.2. After that, the scenario do something for Banda Aceh 2011-2030 is explained in section 7.3. In this section, the implementation results of land use and transport policy measures are discussed in sub section 7.3.1 and 7.3.2 respectively.

In the land use part (section 7.3.1), the different land use zoning policy measures by limiting the land for development are discussed in this sub section. In this context, there are two land use zoning policies that are discussed. Firstly, the allocation of land availability development in the planned-retreat strategy with strict zoning regulation is discussed in sub section 7.3.1.1. Secondly, the land use zoning in pricing policy is discussed in sub section 7.3.1.2.

In the transport side (7.3.2), the various of transport policy measures is discussed in this section. In this part, there are three transport policy measures that are discussed. Firstly, the implementation of bus rapid transit, which is discussed in sub section 7.3.2.1. Secondly, the implementation of parking scheme is discussed in sub section 7.3.2.2. Lastly, the application of cut fuel subsidy is discussed in sub section 7.3.2.3.

Furthermore, the combination of policy measures, which are integrated in policy packages, are discussed in section 7.4. There are three policies package, which are discussed in sub section 7.4.1, 7.4.2, and 7.4.3. In more detail, the structure of this chapter can be seen in the Figure 7.2 below.

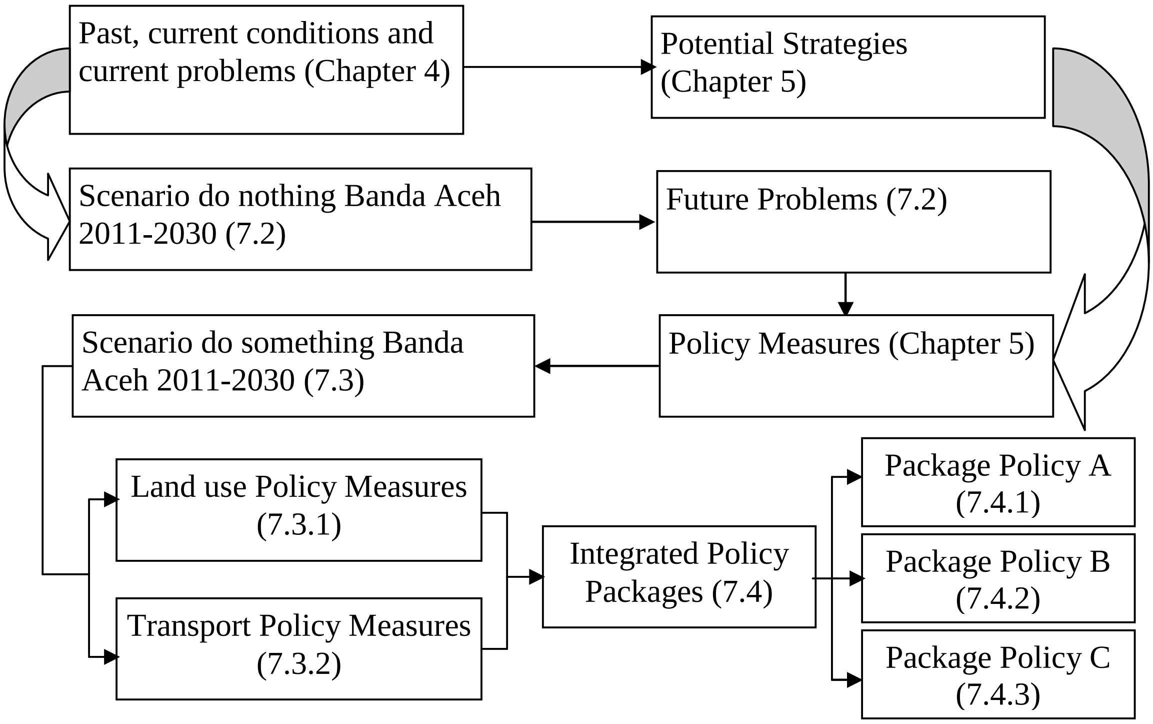
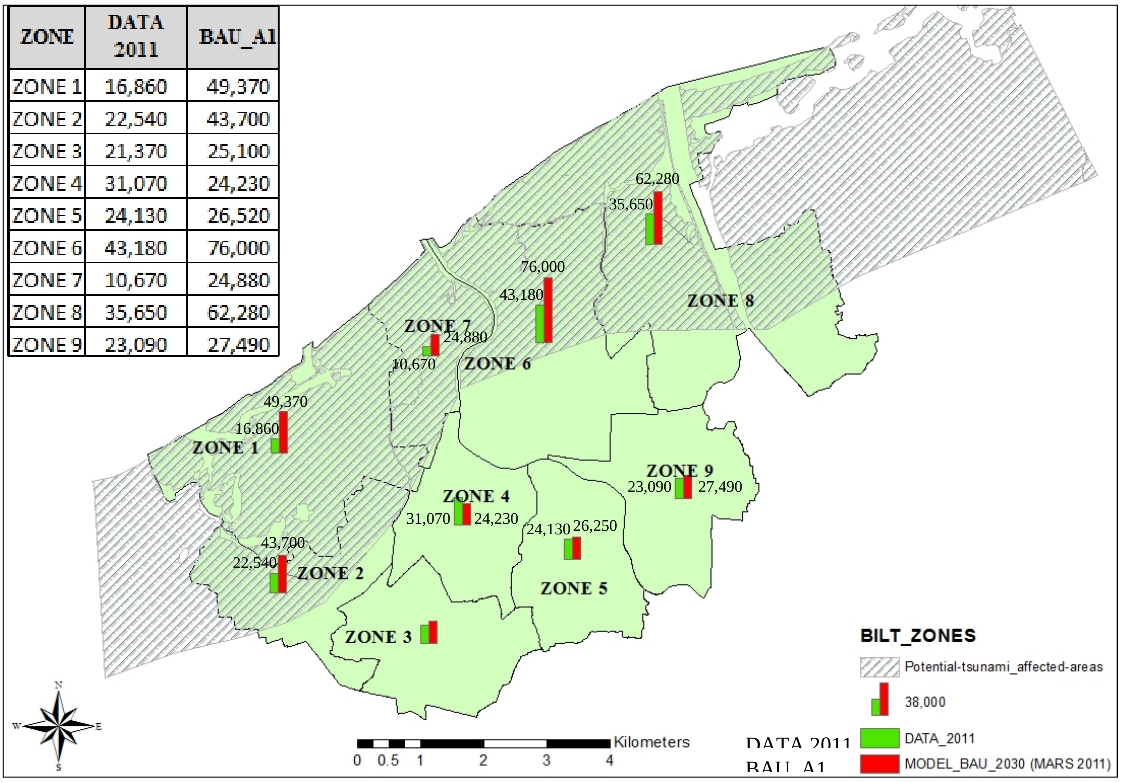


Figure 7.2 : The structure of land use and transport strategies application in Banda Aceh MARS Model

7.2 The results of projective scenario 2011-2030 (BAU)

In this do nothing scenario, there was no land use zoning regulation that applied in high-risk areas of the city. All of the high-risk areas of the Banda Aceh city were allowed to be used as the new promoted development areas for business areas or residential areas. Figure 7.3 below shows the projection of Banda Aceh residents distributions in business as usual scenario for the year of 2030, which was developed in an interactive map using ArcGIS.



ZONE	DATA 2011	BAU_A1
ZONE 1	16,860	49,370
ZONE 2	22,540	43,700
ZONE 3	21,370	25,100
ZONE 4	31,070	24,230
ZONE 5	24,130	26,520
ZONE 6	43,180	76,000
ZONE 7	10,670	24,880
ZONE 8	35,650	62,280
ZONE 9	23,090	27,490

Figure 7.3 : Projection of Banda Aceh residents distribution 2030 in BAU (A1) scenario comparing with census data in 2011

As can be seen in the Figure 7.3, the number of Banda Aceh residents in high-risk areas of the city increased significantly in the next 19 years based on the projection of Banda Aceh MARS model 2011-2030. For instance, the increase of Banda Aceh city residents projected in such as zone 1, zone 2, zone 5, zone 6, zone 7 and zone 8, which are located in high-risk areas, were higher compared to other zones, which are located in low risk areas to the tsunami hazard. In the model, the small impact of disaster risk factor does not give much effect to reduce more people to reside in high-risk areas of the city, which is actually expected. This condition make the high-risk areas of the city still attractive for the Banda Aceh city residents.

In the transport side, the services level of public transport was quite low as explained earlier in chapter 4 and 5 (KEMENHUB, 2012). Moreover, there was also a lack of planning in urban transportation sector such as lack of planning in transport demand management, which already discussed in the previous chapter 4. This situation attracted many people to use private vehicles rather than public transport system to travel in the urban areas. The growth rates for car and motorcycles are 3.73% and 3.09% in average respectively over the period 2011-2030. Based on this condition and situation, it was also important to project the future image of Banda Aceh city in the sector of urban transport regarding the choice of modes of transport used by the city residents. Figure 7.4 below shows the result of modal split projection using Banda Aceh MARS model 2011-2030, which was projected based on the past image (1985-2000) and current image (2006-2011) of Banda Aceh city.

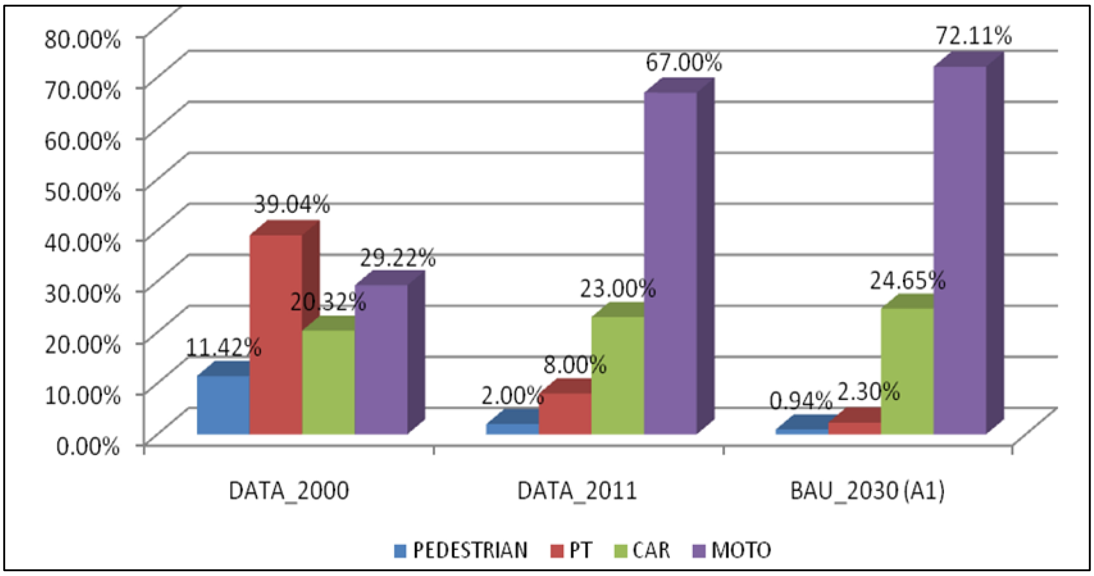


Figure 7.4 : Modal Split projection for the year 2030 in BAU scenario after revision process (A1) (Kamal, 2002, STTD, 2011)

As can be seen in the Figure 7.4, the number of people that use public transport showed the decreasing trend. The number of people that used public transport system decreased more than 31.04% from 39.04% in 2000 to 8% in 2011. It was projected that the number of people that use public transport remained only 2.30% in 2030. It decreased by more than 5% compared to in 2011. The car was not changed much, it increased from 23% (2011) to 24.65% (2030), while for moto, the percentage moto users increased from 67% (2011) to 72.11% (2030). The pedestrian decreased significantly from 2% (2011) to only 0.94% (2030).

7.3 Banda Aceh 2011-2030 backcasting Scenario

The objective of Banda Aceh 2011-2030 backcasting scenario application is to change the image projection of Banda Aceh 2011-2030 in business as usual scenario that was already explained in the previous section 7.2, especially the future problems that might happen in the future based on projective condition, which was already also explained in the previous section 7.2.

There are several policies measures that selected to response the effect of land use and transport plan interaction as explained earlier in chapter 5. For that reasons, in the next sub sections, there are two main policy measures, which are discussed in order to reach the sustainability city objectives in the framework of urban risk reduction and urban transport sustainability. Firstly, it is related to the implementation of land use policy measures (7.3.1). Secondly, it is related to implementation of transport policy measures (7.3.2). The implementation of land use policy measures have an objective to reach the city objectives in the framework of urban risk reduction, while the implementation of transport policy measures are directed to reach the city objectives in the framework of urban transport sustainability. It is expected that both these policies could synergistically work to achieve the city objectives in the framework of sustainable development.

7.3.1 Implementation of Land use policy measures

As explained earlier in chapter 4 and chapter 5, the objectives of land use policy measures were to direct the dynamic urban development process in the future in the framework of urban risk reduction. In this context, the land use policies measures were applied to reduce the potential number of people that reside in high-risk areas of the city in the next future years of Banda Aceh city development process. As can be seen in the explanation of sub section 7.2, it was projected that the number of people that reside in high-risk areas of the city significantly increased in the several next future years based on the projection of Banda Aceh MARS model 2011-2030. As a response to the condition projection in the do nothing scenario, there were two land use measures that were discussed in this sub section. The policies measures selected refer to the planned-retreat strategies as explained in chapter 5, which consist of land use plan with strict zoning plan and land use plan with pricing policy through application of land and property tax. The results of land use measures applied are explained in sub section 7.3.1.1 and 7.3.1.2 respectively.

7.3.1.1 Planned-retreat (law enforcement/strict zoning plan)

There were four types classification of land use zoning plan, which were implemented in this strategy. The land use zoning plan were classified based on the level of risk classifications, which was explained in the previous chapter 4 (see detail classification in e.g. Table 4.3). For instance, In the very high-risk zones (zone 1 and 7 with level of damage 85%-100%), the land availability was totally banned to be used as a new development process of residential areas, while in the high-risk zones (zone 2, 6, and 8 with level of damage 50%-85%), 15% of total areas were still given to be used as new development area. Figure 7.5 below shows the results projection of Banda Aceh MARS model 2011-2030 in planned-retreat strategy by implementing the strict zoning land use plan.

ZONE	BAU_A1	PR1_B1
ZONE 1	49,370	16,860
ZONE 2	43,700	33,880
ZONE 3	25,100	42,810
ZONE 4	24,230	31,020
ZONE 5	26,520	37,690
ZONE 6	76,000	69,310
ZONE 7	24,880	10,670
ZONE 8	62,280	75,360
ZONE 9	27,490	41,980

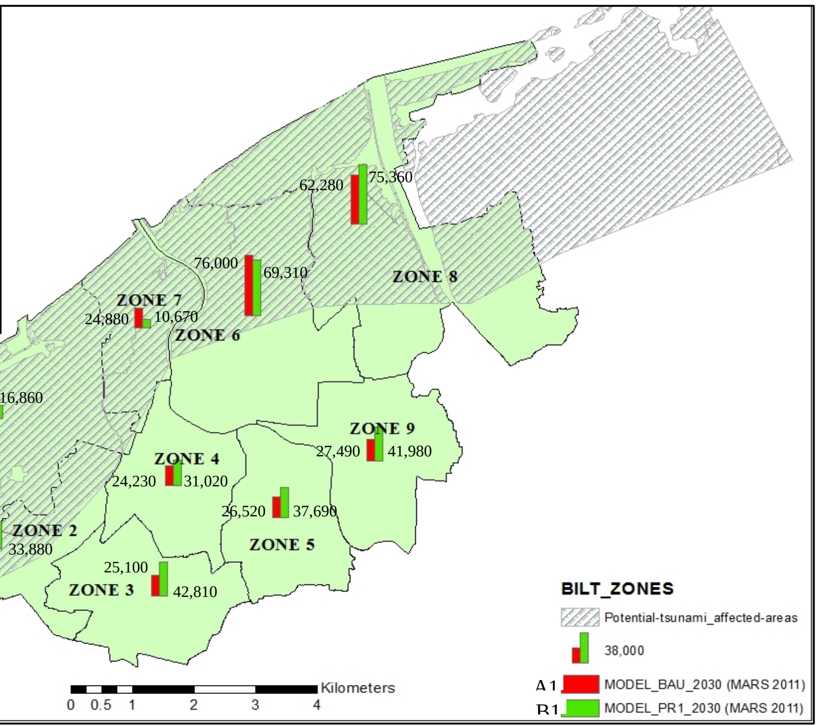


Figure 7.5 : Projection of Banda Aceh residents distribution in planned-retreat strategy with strict zoning plan (2030)

As can be seen in the Figure 7.5, the implementation of land use policy measures by tightly restricting the new development in the high-risk areas of the city significantly reduced the number of city residents in disaster prone areas of the city. For instance, the number of city residents in zone 1 and zone 7 (very high-risk zones) of the city decreased significantly compared to results of the BAU projection scenario. In the same way, the similar trend also could be seen in the high-risk zones such as zone 2,6 and 8 with lesser number of reduction compared to zone 1 and 7.

In the transport side, there was not much difference between the results projection in business as usual scenario (BAU) and in planned-retreat with strict zoning land use plan. Figure 7.6 below shows the results of modal splits for planned retreat strategy with strict land use zoning plan.

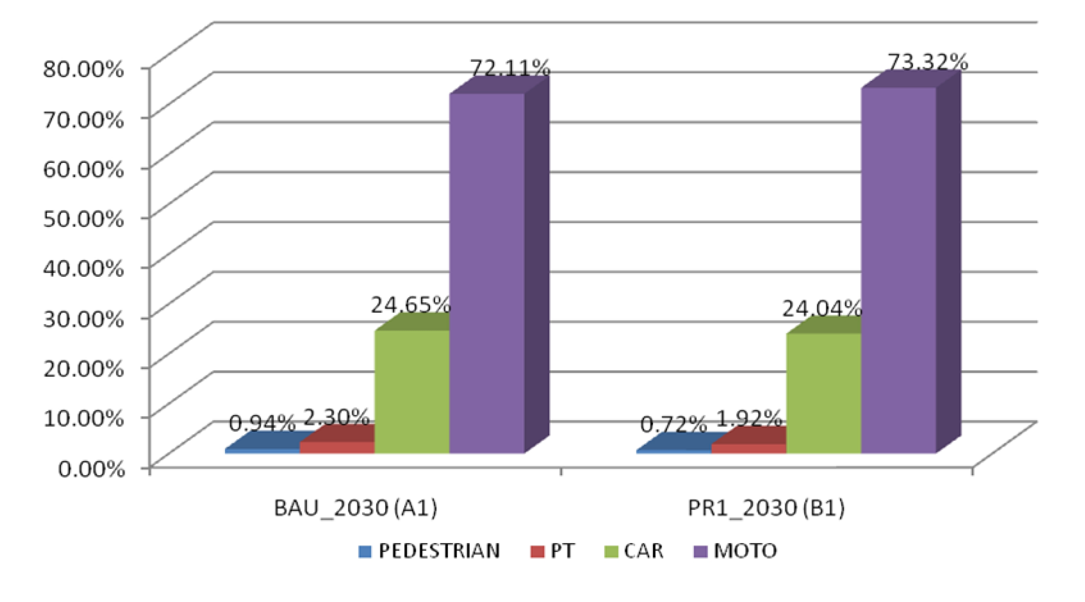


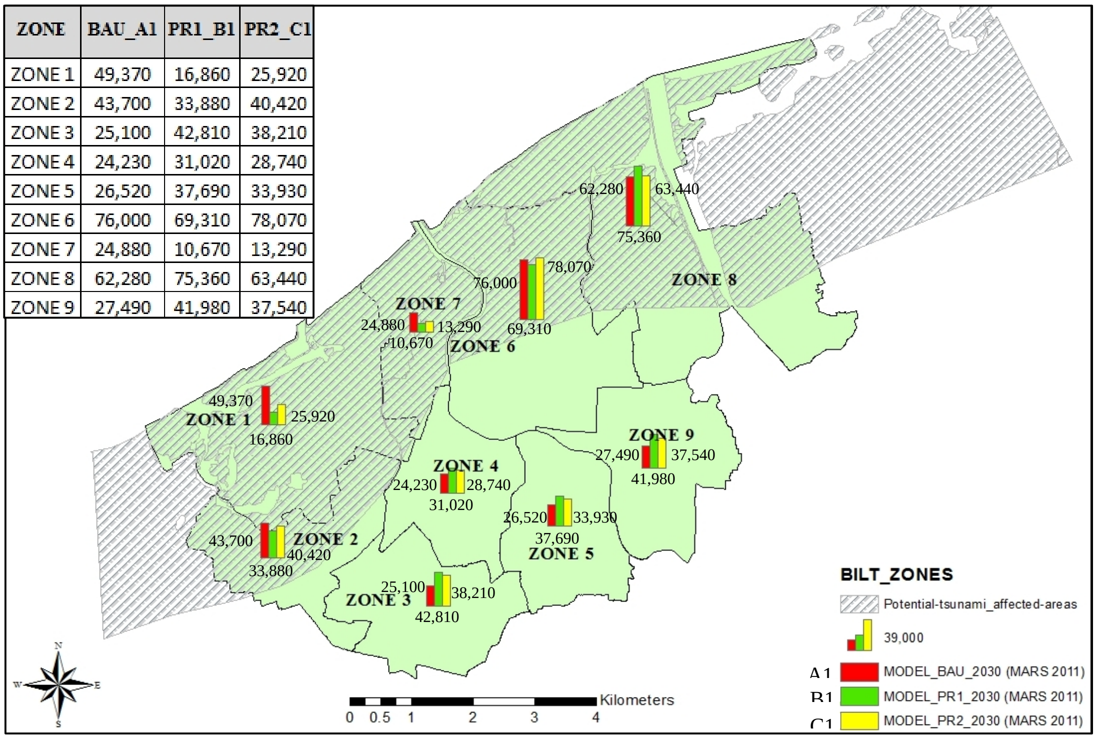
Figure 7.6 : Modal Split projection 2011-2030 in planned-retreat with strict zoning land use plan (2030)

As can be seen in the Figure 7.6, there was very little differences between the modal split projection results in the planned retreat strategy with zoning land use plan and the result in BAU scenario of Banda Aceh MARS model 2011-2030. For instance, the modal split outputs showed that there were 2.30% of people that selected public transport to travel in the urban areas of Banda Aceh city in the year of 2030, whilst there were 1.92% of people that prefer to use public transport system in planned retreat strategy with strict zoning plan.

Similarly, it can be also seen that there were also very little differences between the private vehicle users in the BAU and planned retreat with strict zoning plan land use. The number of motorcyclist and car users in BAU land use plan were 72.11% and 24.65% respectively, whilst there were 73.32% and 24.04% of motorcycles and car users in planned retreat B strategy. From these results, it can be seen that the changes of residents distribution as a result of different land use plan applied in the model also slightly affected the modal split outputs, which also resulted in different result of indicators selected e.g. carbon emissions indicator. The detail of the output further results of indicators can be seen in the next Table 8.1.

7.3.1.2 Planned-retreat (pricing policy)

There are two policies measures that implemented in the planned retreat with pricing policy. Firstly, it is related to the application of different land use zoning plan that has slightly difference in the planned-retreat strategy with strict zoning plan (B). Secondly, it is related to the additional application of land and tax property to direct the city development to the low risk areas of the city. The more detail about the description of these policies measures selected refer to the explanation in the chapter 5. Figure 7.7 below shows the results projection of Banda Aceh MARS model 2011-2030 in planned-retreat strategy C1 by implementing the pricing policy measures, which were discussed earlier in the previous chapter 5.



ZONE	BAU_A1	PR1_B1	PR2_C1
ZONE 1	49,370	16,860	25,920
ZONE 2	43,700	33,880	40,420
ZONE 3	25,100	42,810	38,210
ZONE 4	24,230	31,020	28,740
ZONE 5	26,520	37,690	33,930
ZONE 6	76,000	69,310	78,070
ZONE 7	24,880	10,670	13,290
ZONE 8	62,280	75,360	63,440
ZONE 9	27,490	41,980	37,540

Figure 7.7 : Projection of Banda Aceh MARS model residents distribution in planned retreat strategy with pricing policy (2030)

As can be seen in the Figure 7.7, similar with the previous planned-retreat strategy, the application of this strategy also reduced the number of city residents in disaster prone areas of Banda Aceh city. For instance, the number of city residents in zone 1 and zone 7 of the city decreased significantly compared to results of the BAU projection scenario. However, the number of city residents projection in this strategy in very high-risk zones (e.g. zone 1 and zone 7) were still higher compared to the result projection of planned-retreat with strict zoning plan. This condition was related to the land availability allocation selected in this strategy, which was higher compared to previous planned retreat strategy (PR1). In other words, the more land availability allocation in this strategy attracted more future city residents to reside in high-risk areas of the city compared to the planned-retreat with strict zoning plan.

Similar with the planned retreat strategy with strict zoning plan, this strategy also succeed to direct more urban development to the low risk areas of the city. However, in terms of promoting the new development process to low risk zones of the city, the residents distribution in planned-retreat B with strict zoning plan was still better compared to this strategy. For instance, the resident distributions in zone 3, 5 and 9 in this land use plan were higher compared to the land use plan B with strict zoning plan.

Similar with the previous strategy, in the transport side, there were also not much differences between the results of this strategy application with the BAU (A1) and PR1 (B1). Figure 7.8 below shows the model split projection results of Banda Aceh MARS model in planned retreat strategy with pricing policy, including two previous strategies, that have been discussed earlier for comparison purpose.

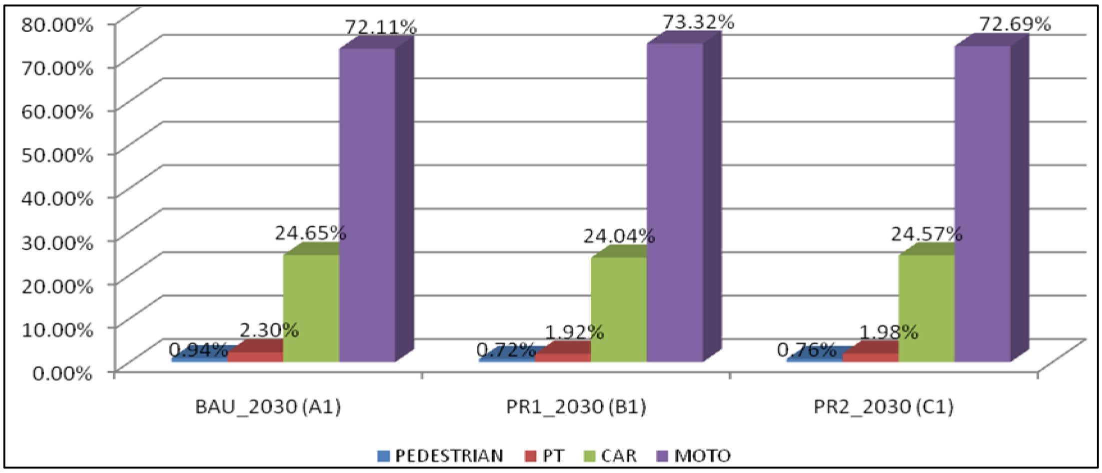


Figure 7.8 : Modal split projection in planned-retreat with pricing policy (2030)

As can be seen in the Figure 7.8, the differences between the three model results of the strategies selected were very small. This condition was related to the different of residents distribution output in different land use plan applied in the model, which slightly affected to the results of modal split output. For Instance, the PT users in BAU (A1) was 2.30%, while for PR1 (B1) and PR2 (B2) were 1.92% and 1.98% respectively. This condition resulted in e.g. the total emission for BAU (A1) was slightly lower compared to the strategy PR1 (B1) and PR2 (B2) (see Table 8.1 for detail)

7.3.1.3 Summary of land use policies measures application

Figure 7.9 below shows the projection of residents distribution in the case study area selected. Figure 7.9(1) shows the projection of residents distribution in BAU land use plan, while Figure 7.9(2) and (3) shows the projection of Banda Aceh resident distributions in the planned-retreat with strict zoning land use plan and pricing policy respectively. The results in strategy PR1 (B1) and PR2 (C1) were compared with BAU strategy A1.

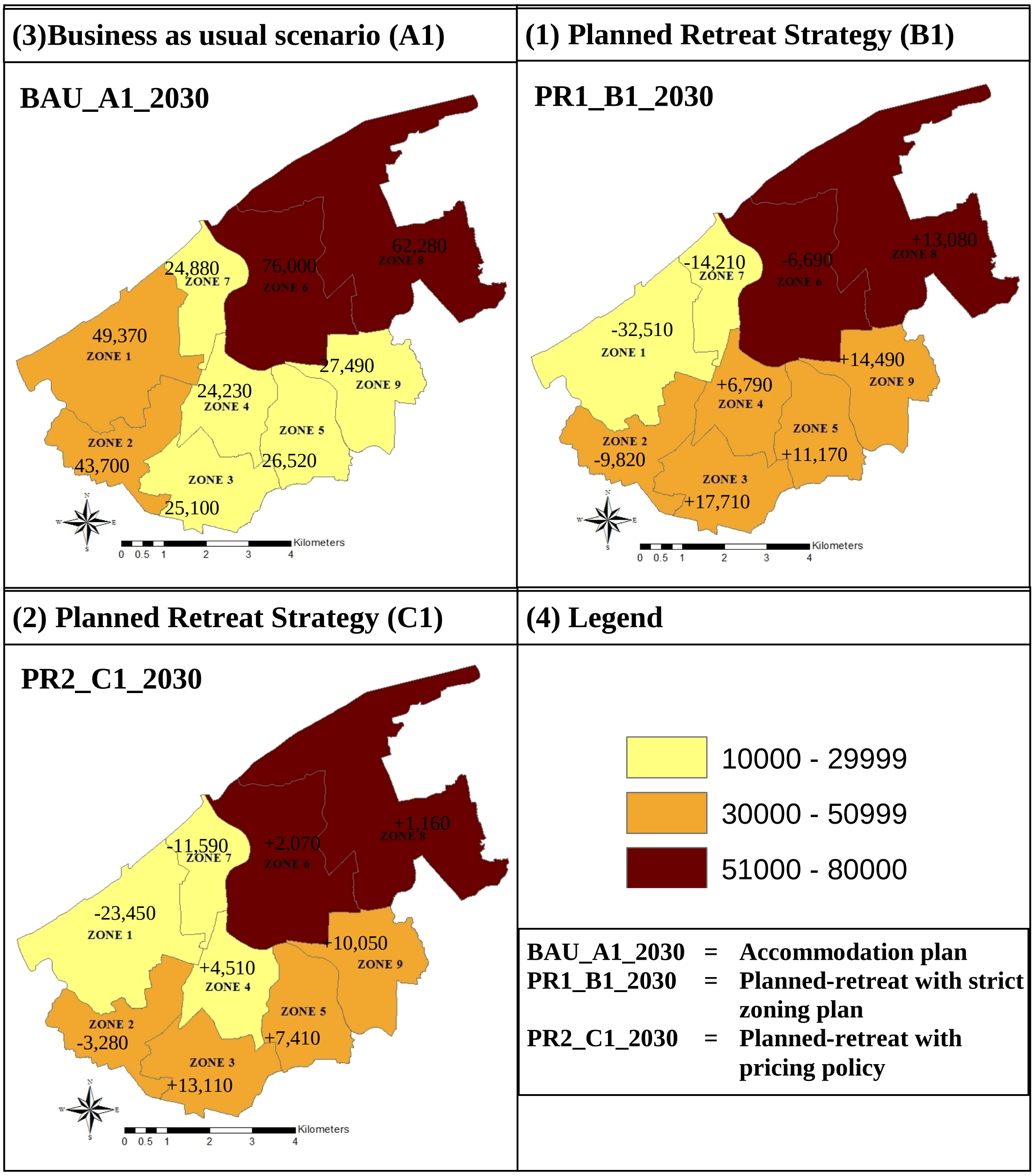


Figure 7.9 : Projection of Banda city residents distribution in 2030 in three land use plan strategies selected using Banda Aceh MARS model 2011-2030

As can be seen in the Figure 7.9, there were three results of residents distribution based on the application of land use strategies selected in the Banda Aceh MARS future model 2011-2030. From Figure 7.9 (1), it can be seen that the selection of accommodation land use plan strategy (BAU) attracted more people to reside in the high-risk areas of the city. The proximity, which shorten the travel distance, and the cheaper land price in the high-risk areas of the city increased the attractiveness of these areas to be used as residential areas. Moreover, the unrestricted land availability for development in these areas allowed the model to allocate more housing units development, which attracted more people to reside in these areas. The cheaper land price, housing rents and the proximity of high-risk zones to the core area of the city increased the attractiveness of these areas, even they are located in disaster risk prone areas to tsunami.

The condition in BAU scenario explained earlier has inspired the author to apply the land use policy measures that could be possible to be applied for minimizing the number of Banda Aceh city residents distributions in high-risk areas of the city. The model outputs showed that the application of strict zoning land use plan strategy in the Banda Aceh MARS model reduced significantly the number of residents distribution in high-risk areas of the city as can be seen in the Figure 7.9 (2). The application of this land use policy measure in the model succeed to direct more city residents distribution to low risk areas of the city. In this case, the application of restricted land use plan in the high-risk zones of the city did not allow the model to allocate the new development process in the high-risk areas of the city, especially in zone 1 and 7, which are located in very high-risk areas to tsunami hazard. Consequently, the number of residents that distributed in these high-risk areas were much lower compared to in BAU scenario as shown in the Figure 7.9 (1).

Furthermore, the application of land and property tax in the second planned-retreat land use plan also reduced significantly the number of city residents that attracted to high-risk areas of the city. The increase of land price and average housing rents as a result of application these policy measures in the Banda Aceh MARS model also succeed to reduce of number of people that reside in high-risk areas of the city as can be seen in the Figure 7.9 (3). In other words, the implementation of this policy measures could be used to direct the dynamic urban development process to low risk areas rather than to high-risk areas of the city. However, it should be noted that the pattern of residents distribution result in the planned-retreat land use plan with strict zoning plan was better compared to in the planned-retreat with pricing policy since the differences land availability allocation that applied in each land use strategy.

7.3.2 Implementation of transport policy measures

As explained earlier in section 7.1 and chapter 5, there were several transport policy measures, which were applied in the model in order to reach the city objectives in the framework of urban transport sustainability. In this context, the main city objective planned to be reached was related to the reduction of carbon emission from urban transport sector. The next several sub sections discussed the result of the transport policy measures application in the model. The discussion was started with the application of the concept of pull strategy and continue with the concept of push strategy.

7.3.2.1 Bus Rapid Transit (A2)

The first transport strategy discussed was the improvement of public transport system. In this strategy, it was assumed that the city authority implement the bus rapid transit system in this city. Furthermore, it was also tested several bus fares reduction scenario that were applied in Banda Aceh MARS Model 2011-2030. The bus fares reductions were categorized into 25%, 50% and 75% reduction. The BRT plan fare was Rp. 4000 that refer to the price plan that implemented in Banda Aceh city and several urban-transport sustainable project in Indonesia as previously explained in chapter 5 (SUTP, 2013c, PP-Walikota, 2013). Figure 7.10 below shows the modal split projection of Banda Aceh MARS model 2011-2030. In this case, the land use plan applied refer to the land use in business as usual scenario, which was already explained in the previous sub section 7.2.

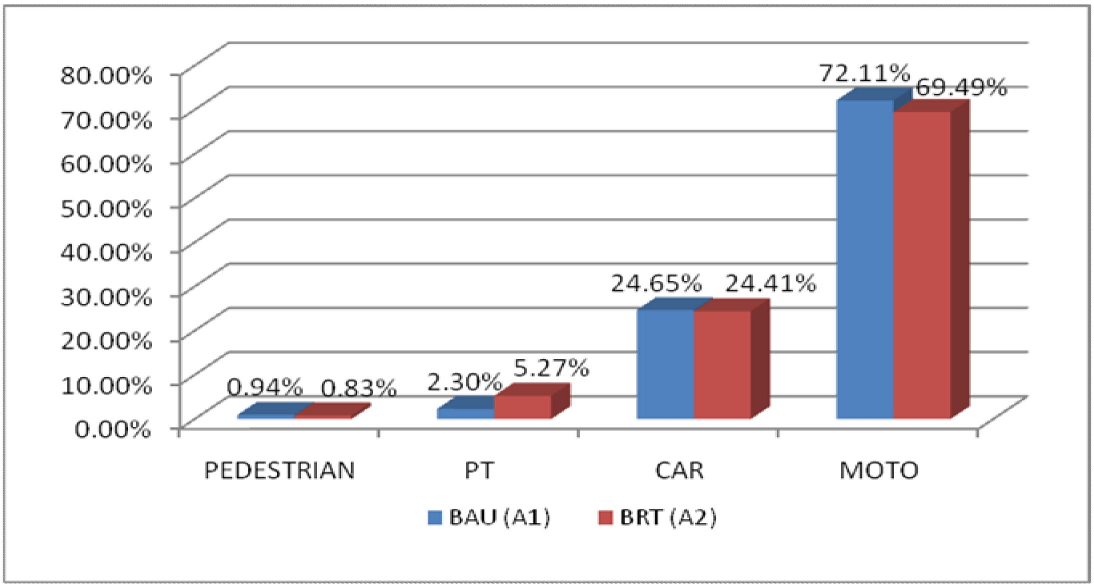


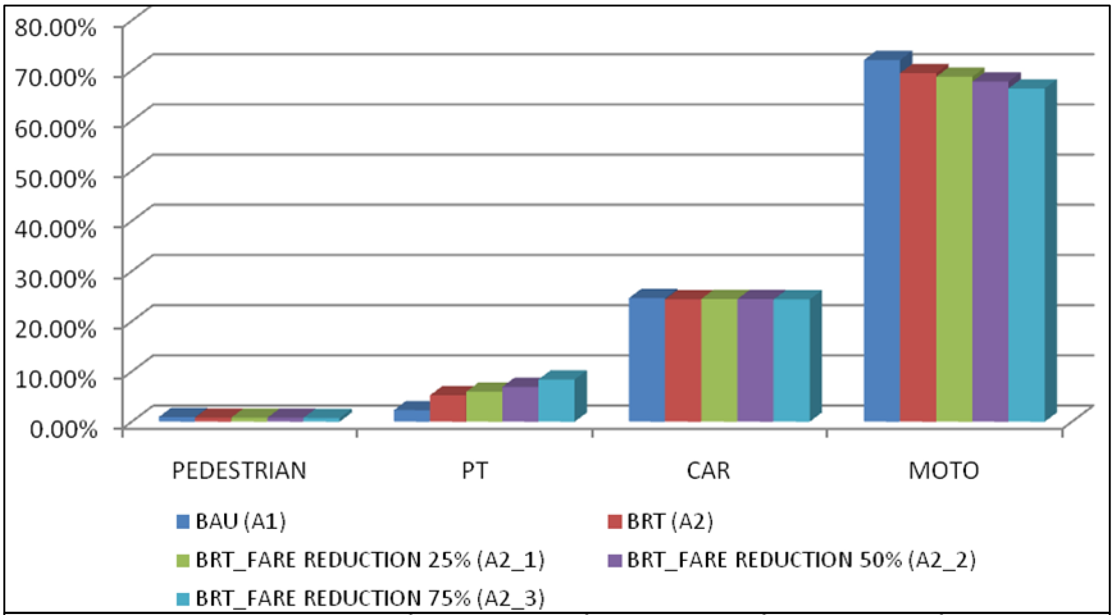
Figure 7.10 : Modal split projection in implementation of bus rapid transit of Banda Aceh MARS model with BRT plan fare = Rp 4000 (2030)

As can be seen in the Figure 7.10, the implementation of Bus Rapid transit attracted more people to use public transport system compared to the results of BAU projection and even with data transport survey in 2011. The percentage of people that selected public transport system increased about by 2.97%, from 2.30% based on do nothing scenario result to 5.27% after the implementation of bus rapid transit policy. Moreover, this number is still lower compared to the data survey in 2011, where the number of people that selected public transport was 8%.

On the other hand, it can be also seen that the number of people that used motorcycle reduced significantly, while the number of people that used car increased slightly. It seems that the implementation of bus rapid transit attracted the motorcycle users to use public transport system. In other words, the improvement several indicators related public transport system in the model such as walking distance and waiting time increased the attractiveness of public transport to be selected as the mode of transport to travel in urban areas of the city. In other words, the implementation of this policy measures reduced the friction of public transport coefficient that makes bus as urban public transport more competitive to private vehicles such as car and motorcycles.

Furthermore, as mentioned earlier, it was also important to investigate the impact of bus fares reduction scheme against the modal split changes. In this context, the friction factor for bus in the model was planned to be decreased in order to attract more people to use public transport system rather than private vehicles through bus fare reduction. In this context, it was assumed that the city authority provide the cheap fares for bus as the main mode of transport in urban areas to promote the concept of urban transport sustainability.

For that reasons, the bus fares reduction that tested in Banda Aceh MARS model were categorized into three types of bus fare reduction, such as 25% (Rp. 1000), 50% (Rp. 2000) and 75% (Rp. 3000) of BRT plan fare as explained earlier. Moreover, it was expected that the implementation of this strategy increases the number of bus passengers compared to the application of BRT plan fare as shown in Figure 7.10. Figure 7.11 shows the results of bus fares reduction implementation in Banda Aceh MARS model future model 2011-2030. The results of bus fares reduction schemes were then compared with the results with the fares for the BRT plan.



	PEDESTRIAN	PT	CAR	MOTO
BAU (A1)	0.94%	2.30%	24.65%	72.11%
BRT (A2)	0.83%	5.27%	24.41%	69.49%
BRT_FARE REDUCTION 25% (A2_1)	0.80%	5.97%	24.46%	68.77%
BRT_FARE REDUCTION 50% (A2_2)	0.78%	6.97%	24.44%	67.81%
BRT_FARE REDUCTION 75% (A2_3)	0.76%	8.43%	24.37%	66.44%

Figure 7.11 : The implementation of various bus fares reduction in bus rapid transit (BRT) policy in Banda Aceh MARS model (2030)

As can be seen in the Figure 7.11 above, the application of bus fares reduction scheme in Banda Aceh MARS future model increased the attractiveness of public transport system. Based on the model results, it can be seen that the reduction of 25% bus fares from Rp. 4000 to Rp. 3000 increased the passenger of BRT by about only 0.7%. Moreover, if the bus fares reduced by 50% from Rp.4000 to Rp. 2000, the BRT passenger increased approximately more than 1.7%%. In addition, if the bus fares reduced by 75% from Rp. 4000 to Rp. 1000, it was projected that the BRT passengers increased about 3.16%.

Furthermore, it can be also seen that the implementation of the BRT policy measures in the model also attracted more private vehicles users to use public transport. The number of cars users reduced by about only 0.24% from 24.65% to 24.41%, while the number of motorcycle users decreased by about 2.62% from 72.11% to 69.49%. In conclusion, it can be seen that the improvement of public transport system could promote the modal shift to public transport system. Moreover, the cheap fares plan selection also played the role to promote the BRT as the main modes of the urban transport system in the city.

7.3.2.2 Parking charge (A3)

There were two type of parking charges that was implemented based on the land use plan scenarios selected in this research. The first parking charge plan refer to the business as usual land use plan, while the second parking charge plan refer to the planned-retreat land use plan as explained earlier in chapter 5. Figure 7.12 below shows the modal split results based on the application of parking charge plan.

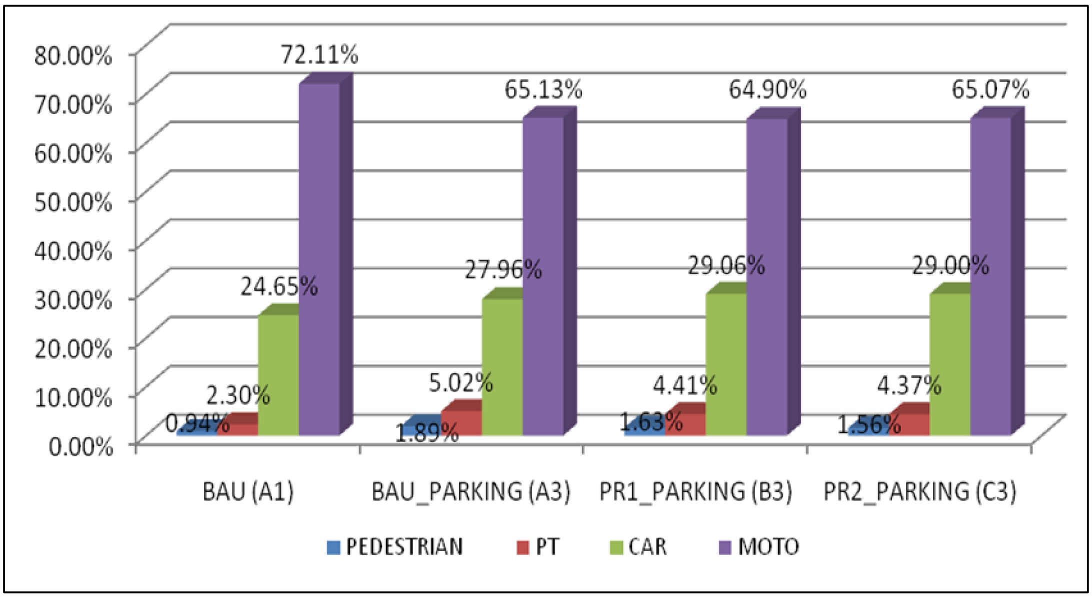


Figure 7.12 : Modal split projection in parking charge scheme (2030)

As can be seen in the Figure 7.12, the application of this policy increased the public transport users in a gradual way. For instance, In the BAU land use plan, where the flat parking charge was flat price for all zones, the number of people that prefer to use public transport system increased by about 2.72%, from 2.30% in BAU scenario to 5.02% in this policy. Moreover, in the planned-retreat land use plan, where the parking charge was applied using different price plan between high-risk and low risk areas, the number of people that prefer to select the public transport system increased by about 2% after this policy measures was applied in the model. In other words, the application of parking charge in BAU land use plan pushed more people to use existing public transport system compared to the implementation of parking charge in the planned retreat land use plan. This condition was related to the expensive parking charge that applied flat in all zones of BAU land use plan, while in the planned-retreat plan, the expensive parking charge was only applied in the high-risk zones of the city.

7.3.2.3 Cut Fuel Subsidy (A4)

The last transport policy measures selected was the cut fuel subsidy. Similar with the concept in parking charge, In the transport demand management strategy, this policy measures was classified as the “push concept” strategy that applied to push people for using public transport system in order to discourage the use of private vehicles by increasing the transport cost of private vehicles from fuel price factor. In other words, the objectives of this policy measures was to reduce the attractiveness of private vehicles to be used as the modes of transport in urban areas (Broaddus et al., 2009). In the model, the application of this policy was intended to increase the friction factor of private vehicles. Figure 7.13 below shows the model results of Banda Aceh MARS model 2011-2030 for modal split projection in the application of cut fuel subsidy policy.

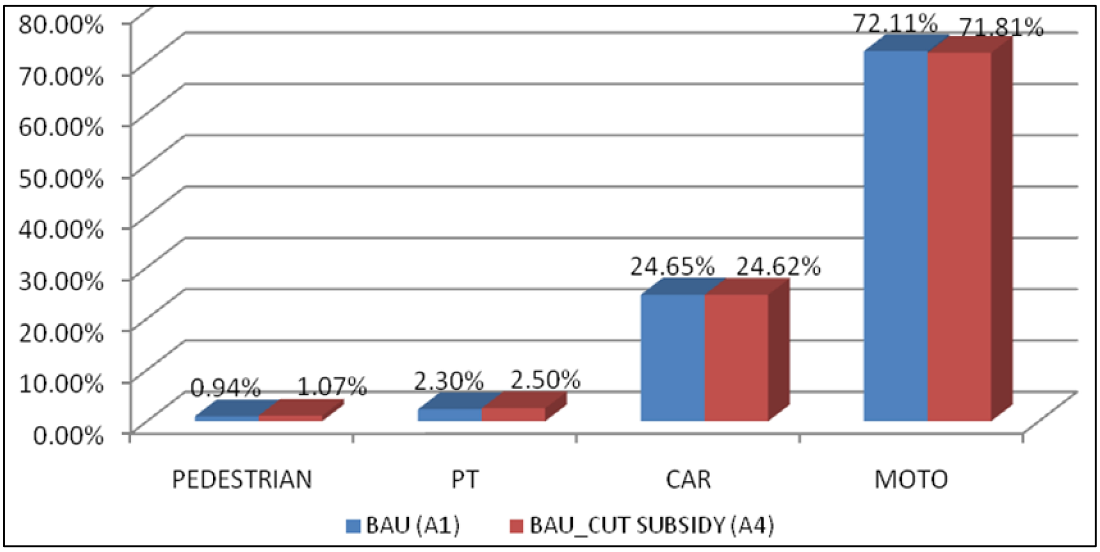


Figure 7.13 : Modal split projection in cut fuel subsidy policy (2030)

As can be seen in the Figure 7.13 above, the implementation of this policy measures decreased the number of people that prefer to use private vehicles. The number of people that use car very slightly decreased by about only 0.03% from 24.65% in BAU scenario to 24.62% after this strategy was implemented. However, the number of motorcyclist increased by about 0.3% after this strategy was applied. The cheaper cost of motorcycle due to lower fuel consumption per-km relative to car attracted car users to shift motorcycles. Moreover, This policy measures also slightly pushed people to use public transport system. However, the increase of existing passengers of public transport system after the implementation of this policy measures was very low (0.2%).

7.3.2.4 Summary of transport policy measures selected

Figure 7.14 below shows the results of Banda Aceh MARS future model for all of transport measures selected in this research.

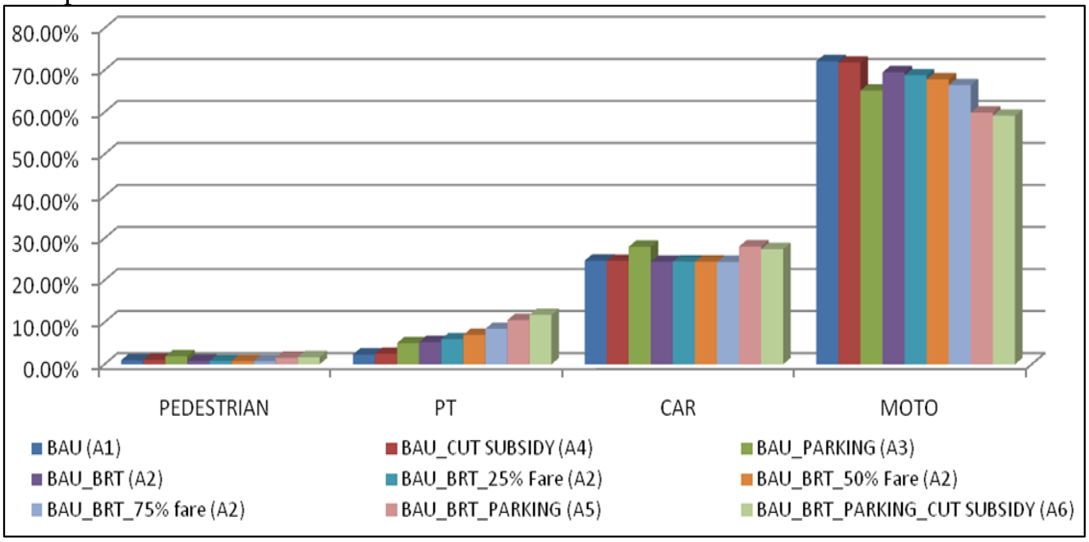


Figure 7.14 : Modal split projection in transport policy measures (2030)

As can be seen in the Figure 7.14, the policy measures that had the lowest impact was cut fuel subsidy (A4) and followed by the parking charge (A3) compared to BAU (A1). Moreover, it can be also seen that the effect of parking policy gives relatively better results compared to cut subsidy policy. Generally, In the aspect of time component, both policies do not significantly affect the time elements of the car and motorcycle modes. On the other hand, in the aspect of cost component, the parking policy (A3) results is relatively better compared to cut fuel subsidy policy (A4). It could be understood that why the parking policy result is better compared to cut fuel subsidy since in the parking policy (A3), the parking price is increased ten times (10x) compared to the BAU (A1). On the other hand, in the cut subsidy policy (A4), the fuel price is increased by about only two times (2x) more expensive compared to in the BAU (A1). For instance, as for costs the parking charges in A3 can increase the time equivalent friction factor in the BAU from 6 minutes to 41 while the fuel subsidy cut in A4 only increases it to 11 minutes for car (see Figure 6 Appendix 1). For motorcycle a typical friction factor increase from 10 to 80 minutes for increased parking charges in A3 and from 10 to 16 minutes for cut fuel subsidy in A4. These much higher increases in the friction factors in A3, compared to A4, account for the marked difference in mode split changes.

In the reality, this situation might relate to the poor and low service level of public transport system. The private vehicles users were reluctant to move to public transport system because the low level service of PT, even the cost of private vehicles was already tried to be increased through application of cut fuel subsidy and parking charge.

Furthermore, it can be also seen that the introduction of BRT (A2) had better impact to promote the use of public transport system in the city compared to the two the cut fuel subsidy (A4) and parking (A3). In addition, the cheap bus fares also played roles in attracting more people to use public transport system.

7.4 Application of integrated policies packages

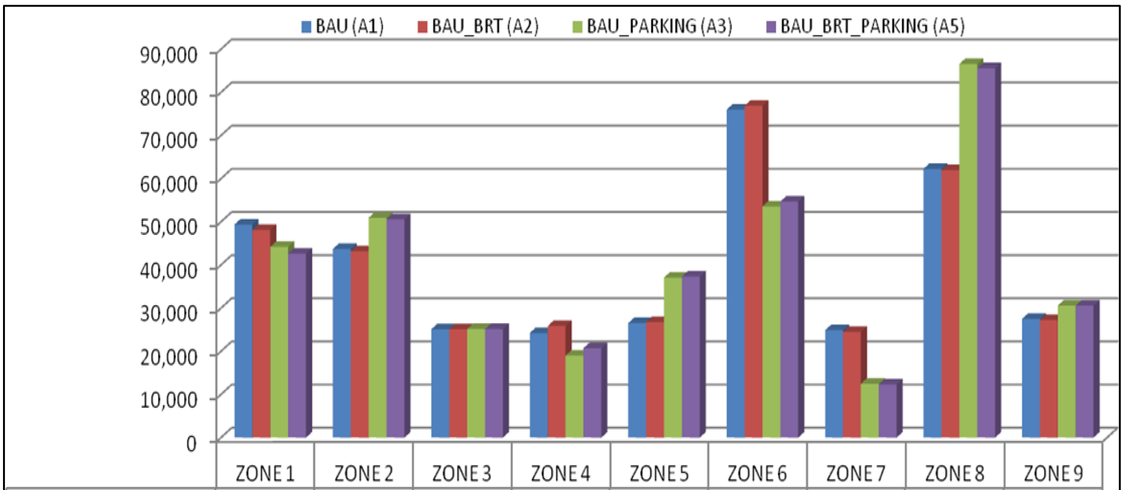
This sub section discussed the application of land use plan with the combined transport measures. It was expected that the application of combined transport policy measures in each land use plan selected could give better results compared previous transport policy measures, which were already tested separately. For that reasons, the discussion in this section was distinguished into three part as mentioned in section 7.1. The first part discussed about the integrated packages of transport policy measures that applied in business as usual land use plan (7.4.1). The second part discussed about the integrated of packages of transport policy measures that applied in planned-retreat land use plan with strict zoning plan (7.4.2) and pricing policy (7.4.3).

7.4.1 Business as usual land use plan and combined transport policy measures

There were two transport policy measures that were tested in this study. In the first package, the implementation of bus rapid transit (BRT) as part of the improvement of public transport system in the case study area selected was combined with the parking charge. In this case, the pull and push concept are applied simultaneously in order to promote the modal shift from private vehicles to convenient urban public transport system.

Furthermore, the introduction of BRT increases the attractiveness of urban public transport system, while the application of parking charge reduces the attractiveness of private vehicles to be used as main the main modes of transport in urban areas. In the second package, the application of cut fuel subsidy was integrated into combination of the BRT with parking charge policy in order to increase more transport cost by private vehicles. It was expected that this combination could increase more private vehicles users to shift to public transport.

Figure 7.15 below shows the residents distribution results of Banda Aceh MARS model 2011-2030 in application of combination of BRT and parking charge in business as usual land use plan, including the BRT and parking charge only policy for comparison purpose.



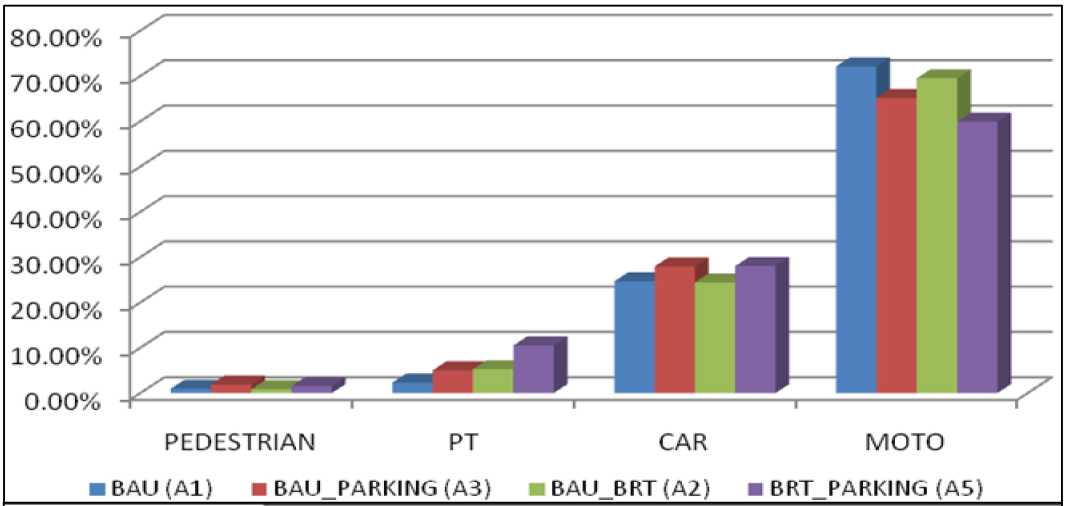
	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU (A1)	49,370	43,700	25,100	24,230	26,520	76,000	24,880	62,280	27,490
BAU_BRT (A2)	48,090	43,190	25,100	25,850	26,730	76,880	24,490	61,980	27,250
BAU_PARKING (A3)	44,170	50,950	25,140	19,010	37,080	53,560	12,480	86,580	30,590
BAU_BRT_PARKING (A5)	42,640	50,580	25,140	20,720	37,320	54,700	12,320	85,580	30,570

Figure 7.15 : Residents distribution projection in BAU land use plan with combined BRT and parking charge (2030)

As can be seen in the Figure 7.15, the implementation of the combination of this policy measures gave slight impact on the residents distribution in the case study areas selected. For instance, it can be seen in zone 1 regarding how the residents changes in the dynamic process of model simulation. At the first place, there were no significance changes after the implementation of BRT plan since the BRT plan was applied in all zones of the city. In other words, the reduction of friction factor for public transport increased the accessibility for public transport that attracted more people to use public transport system, but it gave only small effect on resident distributions.

However, the implementation of parking charge increased the residents number in zone 5, 8 and 9, which relatively have lower risk to tsunami compared to very high-risk zones (e.g. zone 1 and 7) or compared to zone 6, which is located next to zone 8 for instance. In this case, the application of this policy increased the attractiveness of zone these zones relative to zone 1 and 7 or zone 6. In the case of zone 6, the different land price between zone 6 and 8 might push the increase of the attractiveness zone 8 compared to zone 6 when the parking charge policy was applied in the model. Consequently, this condition attract more people to reside in zone 8 rather than zone 6, which is located closer to zone 1 and 7. Furthermore, the combination of BRT and parking charge gave only the small changes of residents number compared to results in the parking charge policy.

In the transport side, the application of this combined policy measures also gave significant impact on the modal split changes. Figure 7.16 below shows the results of modal split projection Banda Aceh MARS model 2011-2030 in BAU land use plan with combination of the BRT and parking charge policy.

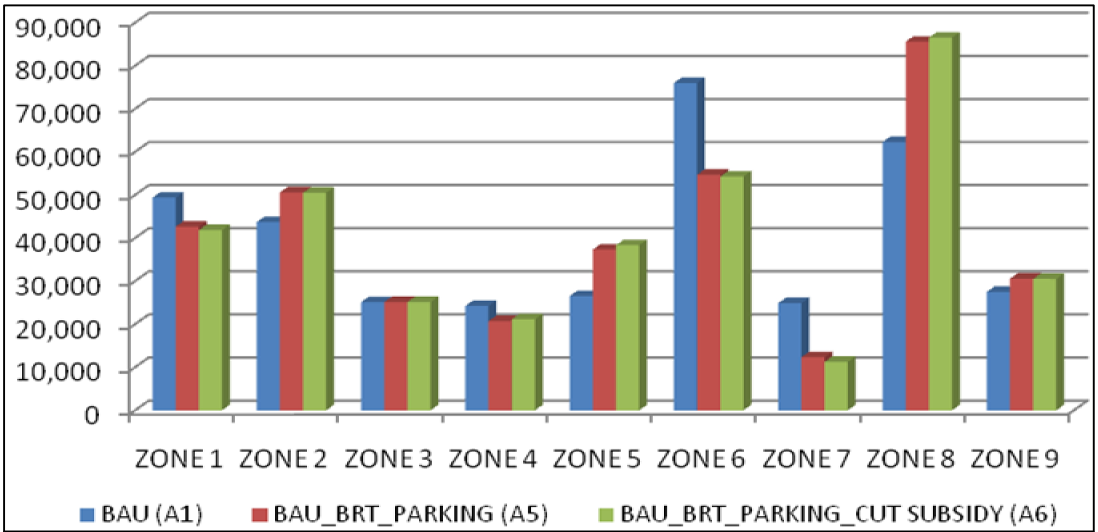


	PEDESTRIAN	PT	CAR	MOTO
BAU (A1)	0.94%	2.30%	24.65%	72.11%
BAU_PARKING (A3)	1.89%	5.02%	27.96%	65.13%
BAU_BRT (A2)	0.83%	5.27%	24.41%	69.49%
BRT_PARKING (A5)	1.53%	10.51%	28.04%	59.91%

Figure 7.16 : Modal split projection in BAU land use plan with combined BRT and parking charge (2030)

As can be seen in the Figure 7.16, the implementation of this combined policy measures increased significantly the number of people that used public transport system compared to in BAU scenario. Moreover, the application of parking charge for supporting the BRT performance increased the passenger BRT almost two times compared to only the BRT implementation policy. Moreover, the implementation of parking and BRT strategy simultaneously (A5) significantly increased the cost components for car and moto and reduced the PT friction factor, which result in reducing the domination of PT friction factor compared to only parking policy (A3) or only BRT (A2). Consequently, the policy A5 push more people to use public transport rather than policy A2 or A3.

In this context, it can be seen that the application of combination BRT and parking charge was quite effective to promote modal shift from private vehicles to public transport system based on the projection of model results. The expensive parking charge pushed the people to find the other alternative of cheap and convenient transport mode. At the same time, the improvement of public transport system through BRT policy measure increased the attractiveness of public transport system that pulled more people to use this mode of transport in the city. Figure 7.17 below shows the residents distribution results of Banda Aceh MARS model 2011-2030 in application of combination of the BRT, parking charge plus with the cut fuel subsidy in business as usual land use plan strategy.



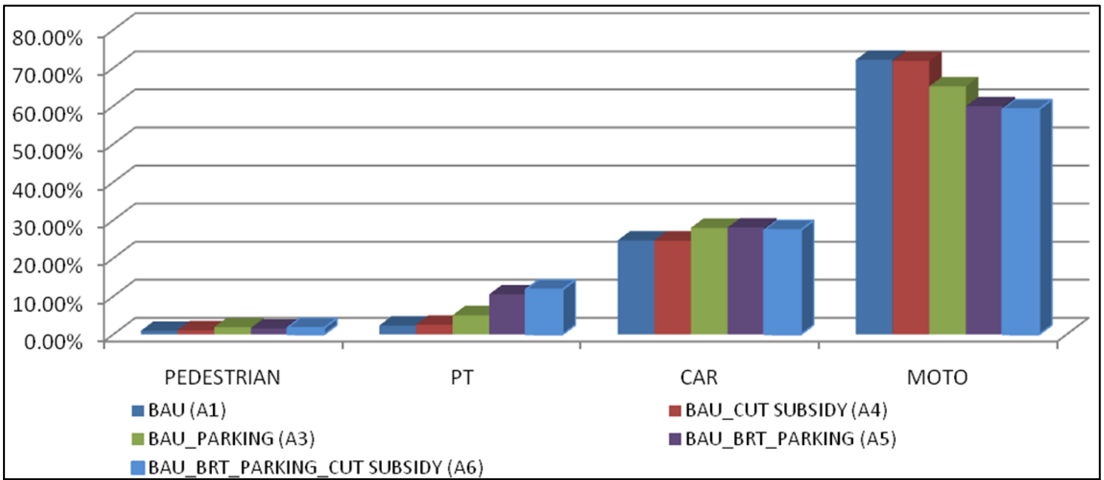
	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU (A1)	49,370	43,700	25,100	24,230	26,520	76,000	24,880	62,280	27,490
BAU_BRT_PARKING (A5)	42,640	50,580	25,140	20,720	37,320	54,700	12,320	85,580	30,570
BAU_BRT_PARKING_CUT SUBSIDY (A6)	41,830	50,510	25,140	21,140	38,350	54,280	11,260	86,530	30,520

Figure 7.17 : Residents distribution projection in BAU land use plan with combined BRT, parking charge and cut fuel subsidy (2030)

As can be seen in the Figure 7.17, the implementation of this policy package gave small impact on the residents distribution by comparing with previous policies package using combination BRT and parking. However, the implementation of this policy measures reduced significantly the number of residents in certain zones such as zone 1 by comparing with the model results in BAU scenario. Moreover, it can be also seen that there was also a zone that has more population after the implementation of this policy.

In these cases, it seems that the increase of transport cost for private vehicles as a result of the application of this policy in the model influenced the residential choice areas in the case study area selected. For instance, the zone 5, which is located in the core area of the city, was look more attractive to be selected as a residential areas since this zone has shorter travel distance compared to the zone 1. Moreover, it should be also noted that the level of risk in the zone 5 was also lower compared to in the zone 1. In summary, the implementation of combined push and pull strategy in this alternative policy measure gave the positive contribution to reduce the number of residents in high-risk areas according to the model result.

In the transport side, the application of this combined policy measures also give significant impact on the modal split changes with better results in the context promoting public transport system compared to the previous policy measures mentioned earlier. Figure 7.18 below shows the results of modal split projection Banda Aceh MARS model in BAU land use plan with combination BRT, parking charge and cut fuel subsidy policy implementation.



	PEDESTRIAN	PT	CAR	MOTO
BAU (A1)	0.94%	2.30%	24.65%	72.11%
BAU_CUT SUBSIDY (A4)	1.07%	2.50%	24.62%	71.81%
BAU_PARKING (A3)	1.89%	5.02%	27.96%	65.13%
BAU_BRT_PARKING (A5)	1.53%	10.51%	28.04%	59.91%
BAU_BRT_PARKING_CUT SUBSIDY (A6)	1.70%	11.75%	27.40%	59.15%

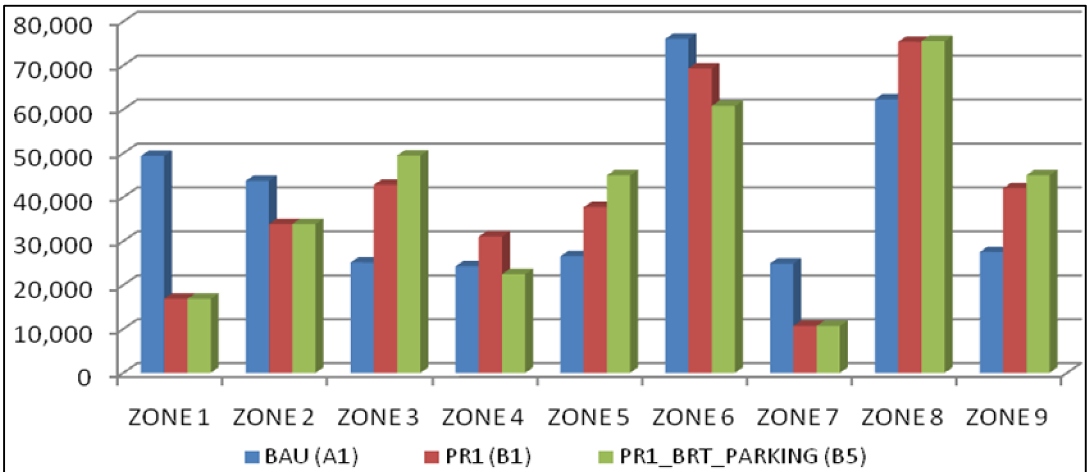
Figure 7.18 : Modal split projection in BAU land use plan with combined BRT, parking charge and cut fuel subsidy (2030)

In the Figure 7.18 above, the additional of cut fuel subsidy after the combination of BRT and parking charge increased significantly the public transport users from 10.51% to 11.75% based on the model projection. Moreover, the number of motorcycles users reduced from 59.91% to 59.15% (0.76%), while the number of car users decreased from 28.04% to 27.40% (0.64%). However, there was not much changes for pedestrian, but it slightly increased from 1.53% to 1.70% after the implementation of this policy. From this picture, it can be seen that the implementation of this combined policy measures attracted more private vehicle users to shift to public transport system.

7.4.2 Planned-retreat (strict zoning plan) and combined transport policy measures

Similar with the policy measures integrated packages in BAU land use scenario, there were two transport policy measures packages that were tested in this policy package. Firstly, the implementation of bus rapid transit (BRT) was combined with the parking charge to be applied in this planned-retreat land use policy. Secondly, the cut fuel policy was also introduced after the combined policies measures mentioned earlier to be applied in the same land use policy.

Figure 7.19 below shows the results of modal split projection for Banda Aceh MARS model in planned-retreat land use (strict zoning plan) with combination of the BRT and parking charge, including the results of BAU and planned-retreat with no transport policies measures applied for comparison purpose.



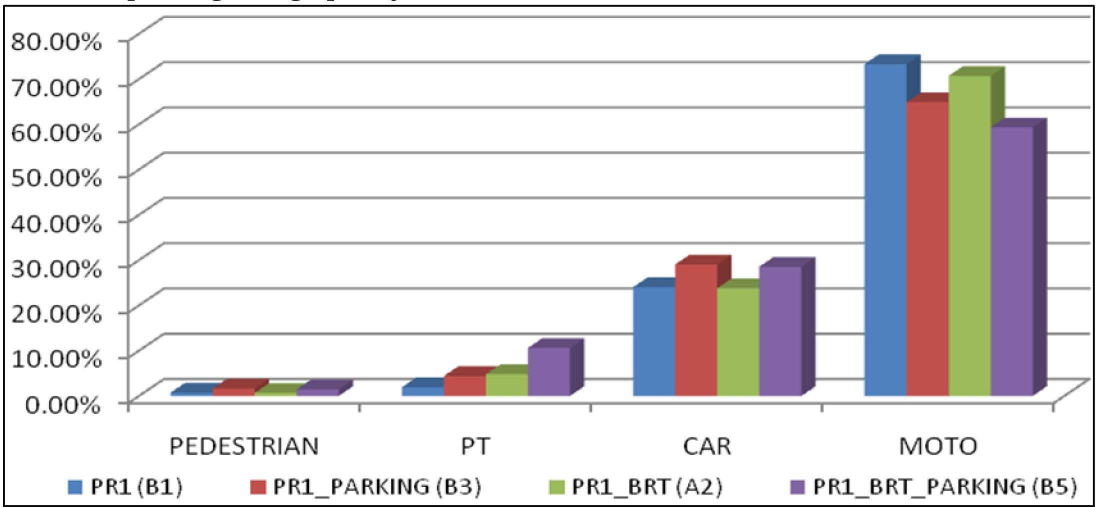
	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU (A1)	49,370	43,700	25,100	24,230	26,520	76,000	24,880	62,280	27,490
PR1 (B1)	16,860	33,880	42,810	31,020	37,690	69,310	10,670	75,360	41,980
PR1_BRT_PARKING (B5)	16,860	33,880	49,480	22,460	44,960	60,750	10,670	75,520	44,990

Figure 7.19 : Residents distribution in planned-retreat strategy (strict zoning land use plan) with combined BRT and parking charge (2030)

As can be seen in the Figure 7.19, the implementation of strict land use zoning in the high-risk areas of the city directed the urban dynamic development process to the low risk areas of the city. Moreover, the implementation of transport policies measures attracted more people to reside in the core area of the city. For instance, it can be seen that the number of residents in zone 6 reduced after the combined BRT and parking was applied in the model. On the other hand, the number residents in zone 5, which was planned as the new second core area in the long term city strategic plan increased after this policy package was applied. The different parking charge applied in these zones reduced the attractiveness of zone 6 relative to zone 5, which was planned as the new promoted development area. In addition, in this case, the increase of friction factor for private vehicles increased the attractiveness of the areas that located near to the centre of activities.

Furthermore, in the transport side, the application of this combined policy measures also gave significant impact on the modal split changes with better results in the context promoting public transport system and discouraging the use of private vehicles compared to the previous policy measures of planned-retreat without transport policies measures applied.

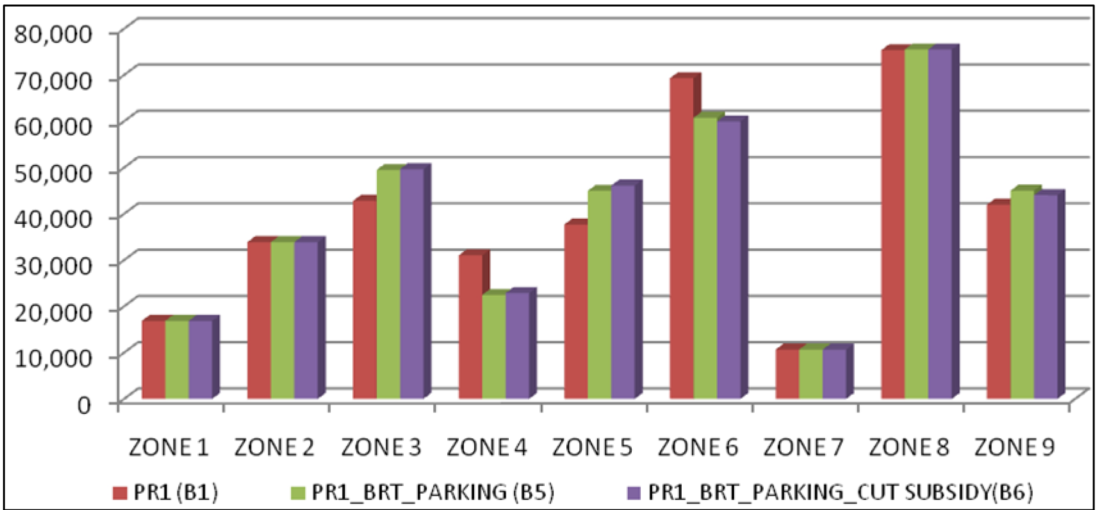
Figure 7.20 below shows the results of modal split projection Banda Aceh MARS future model in planned-retreat using strict land use plan with combination of the BRT and parking charge policy.



	PEDESTRIAN	PT	CAR	MOTO
PR1 (B1)	0.72%	1.92%	24.04%	73.32%
PR1_PARKING (B3)	1.63%	4.41%	29.06%	64.90%
PR1_BRT (A2)	0.67%	4.83%	23.81%	70.70%
PR1_BRT_PARKING (B5)	1.48%	10.62%	28.57%	59.34%

Figure 7.20 : Modal split projection in planned-retreat strategy (strict zoning land use plan) with the combined BRT and parking charge (2030)

As can be seen in the Figure 7.20, the application of this package policy did not only direct the city development process to high-risk areas of the city, but also it promoted the use of public transport system as soon as the concept of pull and push in transport demand management strategy were applied in the model. The combination of the BRT and parking charges pushed the private vehicles to use public transport system. In the model, the application of this policy package increased the friction factor for private vehicles and at the same time, it also decreased the friction factor for public transport. Consequently, the implementation of this policy measures in the model attracted more people to use public transport system and discouraging the use of private vehicles. Moreover, Figure 7.21 below shows the residents distribution results of the model in application of combination of the BRT, parking charge plus with the cut fuel subsidy in planned-retreat with strict land use zoning plan.

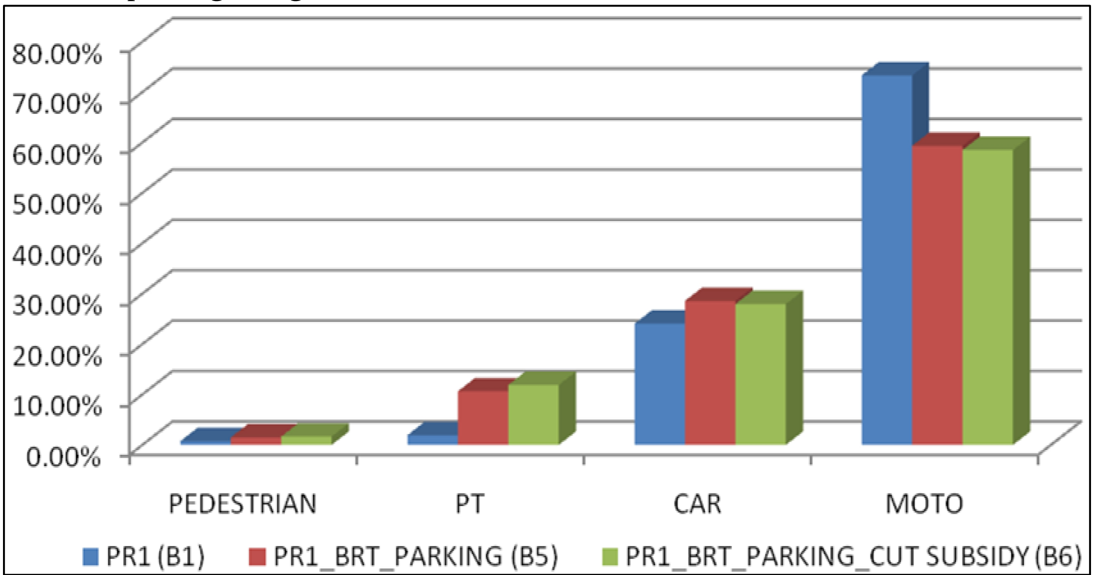


	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
PR1 (B1)	16,860	33,880	42,810	31,020	37,690	69,310	10,670	75,360	41,980
PR1_BRT_PARKING (B5)	16,860	33,880	49,480	22,460	44,960	60,750	10,670	75,520	44,990
PR1_BRT_PARKING_CUT SUBSIDY(B6)	16,860	33,880	49,650	22,870	46,120	59,970	10,660	75,520	44,030

Figure 7.21 : Residents distribution in planned-retreat (strict zoning land use plan) with combined BRT, parking charge and cut fuel subsidy (2030)

As can be seen in the Figure 7.21, there were not much differences between the results of the packages of policies with addition cut fuel policy and without the application of this policy in the context of the residents distribution projection. However, it should be noted that the implementation of this policy gave small reduction of residents number in zone 2 and 8. The application of this policy in the model increased the transport cost for private vehicles in all zones. Consequently, it reduced the number of residents in the zones that had the longer travel distances. In this context, it can be seen, the application of the cut subsidy policy measures, which increased the transport cost regarding travel distance, reduced the number of city residents that are located far away from the core area of the city.

In the transport side, the addition of the cut fuel subsidy policy in this policy packages also gave better results in the context promoting public transport system compared to the previous policy measures with only the BRT and parking charges. Figure 7.22 below shows the results of modal split projection model in strict zoning land use plan with the integration of the cut fuel subsidy policy into combined the BRT and parking charge.



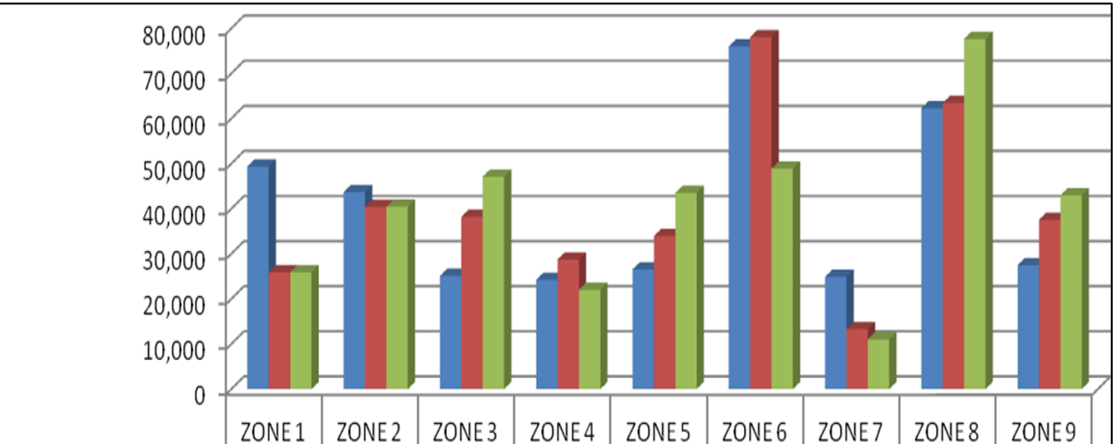
	PEDESTRIAN	PT	CAR	MOTO
PR1 (B1)	0.72%	1.92%	24.04%	73.32%
PR1_BRT_PARKING (B5)	1.48%	10.62%	28.57%	59.34%
PR1_BRT_PARKING_CUT SUBSIDY (B6)	1.65%	11.90%	27.95%	58.51%

Figure 7.22 : Modal split projection in planned-retreat strategy (strict zoning land use plan) with combination of BRT, parking charge and cut fuel subsidy policy (2030)

As can be seen in the Figure 7.22, the application this policy packages succeed to attract more people to use public transport system rather than private vehicles as the main mode of transport in the case study area selected. Similar like in BAU land use plan, the combination of parking charge and cut fuel subsidy increased significantly the friction factor for private vehicles in the model that decreased the number projection of car and motorcycles users. Moreover, the improvement of bus level of services in the model reduced the friction factor for public transport that increased the number of public transport users. It can be also seen that the most people that were attracted to public transport came from motorcycles users. In other words, in the reality, the increase of transport cost could push the motorcycle users to use public transport system as a result of combined policy measures selected.

7.4.3 Planned-retreat (pricing policy) and combined transport policy measures

Similar with the previous policy measures integrated packages in the BAU land use scenario and planned-retreat with strict zoning plan land use, there were also two transport policy measures packages that were tested in this policy package. The policies measures tested consists of the application of the combined bus rapid transit (BRT) with parking charge and the combined these two policies measures with introduction of cut fuel subsidy policy. Figure 7.23 below shows the results of modal split projection in planned-retreat land use (pricing policy) with combination of the BRT and parking charge, including the results of BAU and planned-retreat without transport policies measures applied for comparison purpose.



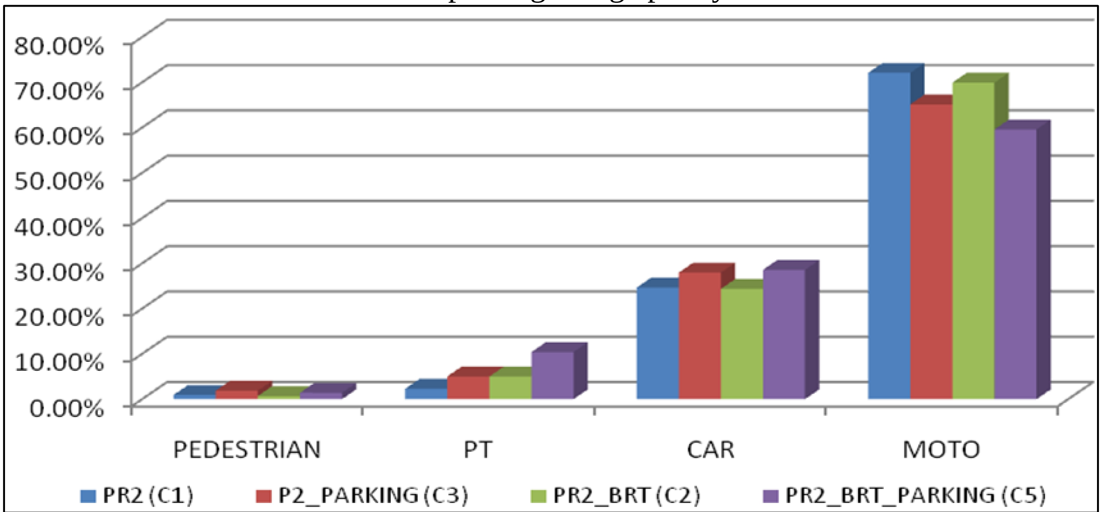
	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU (A1)	49,370	43,700	25,100	24,230	26,520	76,000	24,880	62,280	27,490
PR2 (C1)	25,920	40,420	38,210	28,740	33,930	78,070	13,290	63,440	37,540
PR2_BRT_PARKING (C5)	25,910	40,440	47,110	22,040	43,500	48,890	11,020	77,670	42,970

BAU (A1) PR2 (C1) PR2_BRT_PARKING (C5)

Figure 7.23 : Residents distribution in planned-retreat strategy (pricing policy) with combination of BRT and parking charge policy (2030)

As can be seen in the Figure 7.23, the application of this policies packages decreased significantly number of residents in high-risk zones of the city for directing the urban development process to low risk zones in order to reach the city sustainability city objective in the framework of urban risk reduction by comparing with the model results in BAU land use plan. In the model, the increase of land and property tax in the high-risk zones of the city reduced the attractiveness these areas. Moreover, the implementation of this the combined BRT and parking charge also increased the number of residents in certain zones and reduced the number of residents in the other zones. For instance, it was projected that the number of city residents in low risk zones such as zone 3, 5 and 9 increased, while the number of city residents in high-risk zone such as zone 1 and 7 decreased. The implementation of the combined BRT and parking charges increased the relative attractiveness low-risk zones relative to high-risk zones that attracted more people to reside in low-risk areas of the city. In the Banda Aceh medium-strategic planning, the zone 5 would be planned as the new primary area for the new promoted development areas in Banda Aceh city long term strategic planning (RTRW, 2009).

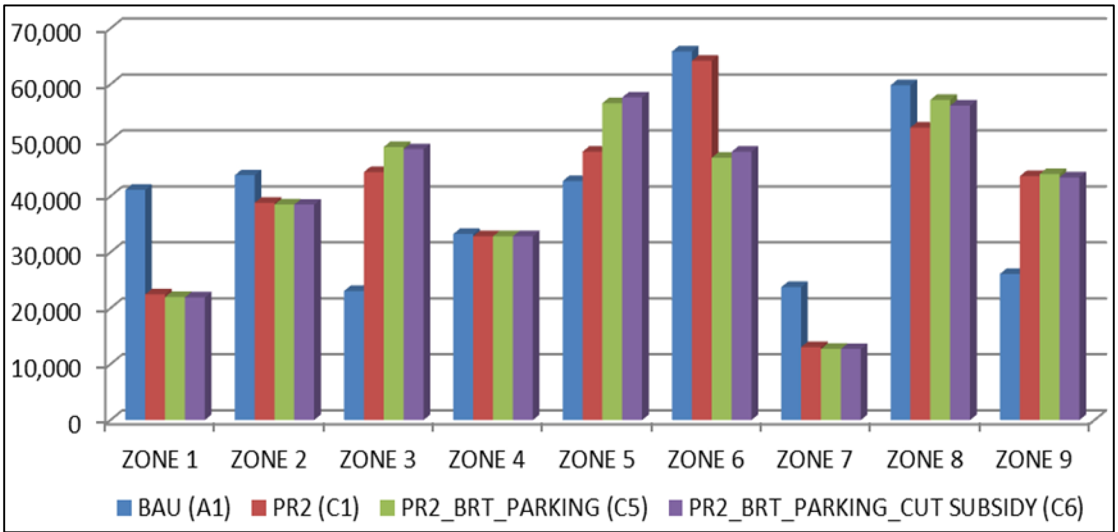
Furthermore, in the transport part, the application of this combined policy measures also attracted more people to use public transport system and discouraging the use of private vehicles compared to the previous policy measures of planned-retreat retreat strategy that applied in do nothing transport policy measures selected. Figure 7.24 below shows the results of modal split projection in planned-retreat (pricing policy) with combination of the BRT and parking charge policy.



	PEDESTRIAN	PT	CAR	MOTO
PR2 (C1)	0.94%	2.30%	24.65%	72.11%
P2_PARKING (C3)	1.89%	5.02%	27.96%	65.13%
PR2_BRT (C2)	0.70%	5.00%	24.36%	69.94%
PR2_BRT_PARKING (C5)	1.41%	10.41%	28.58%	59.60%

Figure 7.24 : Modal split projection in planned-retreat strategy (pricing policy) with the combined BRT and parking charge (2030)

As can be seen in the Figure 7.24 above, the application this policy packages increased the attractiveness of public transport system to be used as the main mode of transport in the case study area selected and at the same time it also reduced the attractiveness of private vehicles. The application of parking charge increased the friction factor for both car and motorcycles in the model. On the other hand, the improvement of bus level services in the model reduced the friction factor for public transport system. This condition increased the number of public transport passenger on the one hand, and it also reduced the number of car and motorcycles users on the other hand. Moreover, Figure 7.25 below shows the model results of residents distribution in the application of combination of BRT, parking charge plus with cut fuel subsidy in planned-retreat with pricing policy.

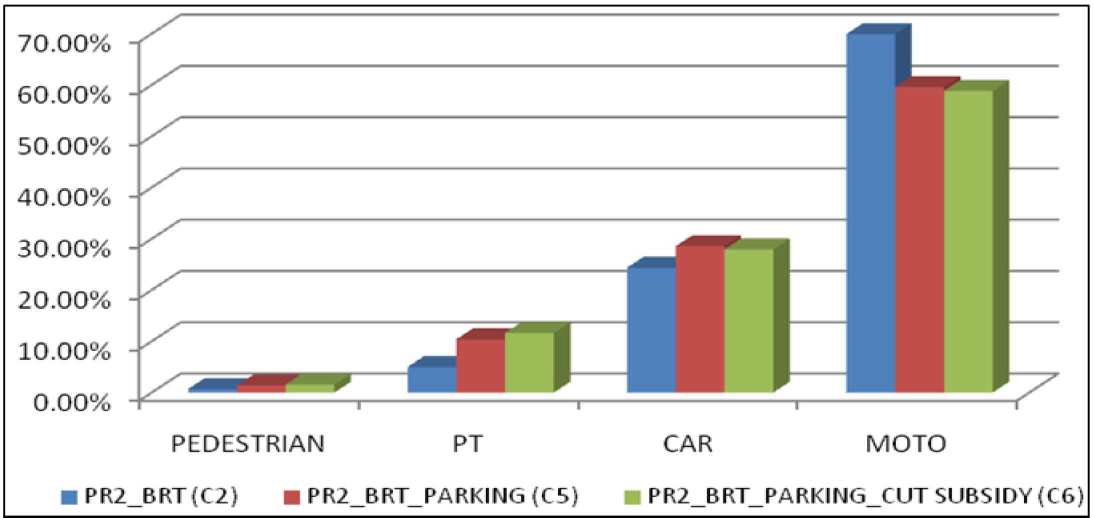


	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU (A1)	41,132	43,748	23,061	33,250	42,724	65,852	23,766	59,826	26,125
PR2 (C1)	22,470	38,830	44,325	32,851	47,970	64,201	13,049	52,260	43,602
PR2_BRT_PARKING (C5)	21,978	38,510	48,804	32,845	56,642	46,871	12,710	57,222	43,978
PR2_BRT_PARKING_CUT SUBSIDY (C6)	21,933	38,494	48,412	32,851	57,661	47,948	12,703	56,176	43,382

Figure 7.25 : Residents distribution in planned-retreat strategy (pricing policy) with combination of BRT, parking charge and cut fuel subsidy policy (2030)

As can be seen in the Figure 7.25, the additional of cut fuel subsidy application did not give significant impact on the residents distributions in the planned-retreat with pricing policy. Similar with the planned-retreat strategy in strict zoning land use plan, the application of this policy package in the model increased the transport cost for private vehicles in all zones that affected all city residents. In other words, the increase of friction factor for private vehicles were similar in all zones after this policy was implemented in the model.

In the transport part, the addition of the cut fuel subsidy policy in this policy packages also gave a positive contribution in the context promoting public transport system compared to the previous policy measures with only the BRT and parking charges. Figure 7.26 below shows the results of modal split projection Banda Aceh MARS model in planned-retreat land use plan with combination of the BRT, parking charge and cut fuel subsidy.



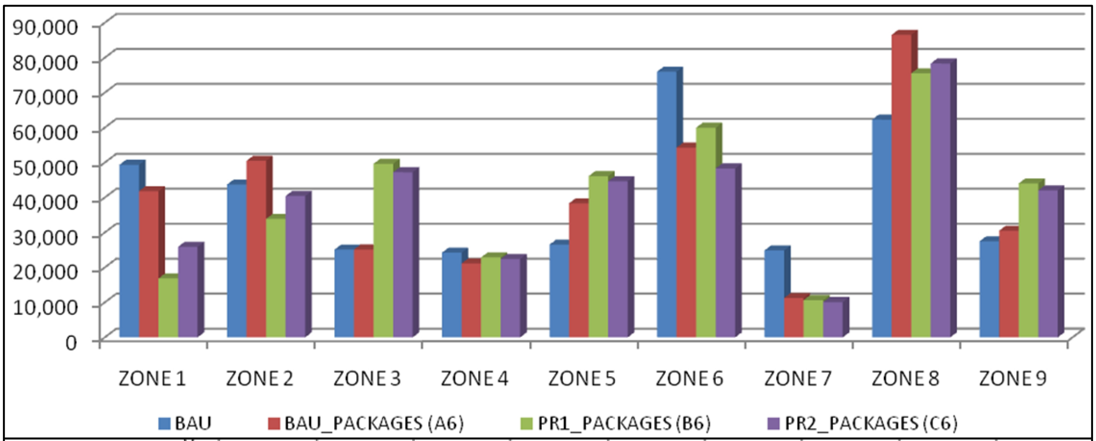
	PEDESTRIAN	PT	CAR	MOTO
PR2_BRT (C2)	0.70%	5.00%	24.36%	69.94%
PR2_BRT_PARKING (C5)	1.41%	10.41%	28.58%	59.60%
PR2_BRT_PARKING_CUT SUBSIDY (C6)	1.57%	11.66%	27.92%	58.85%

Figure 7.26 : Modal split projection in planned-retreat strategy (pricing policy) with combination of the BRT, parking charge and cut fuel subsidy policy (2030)

As can be seen in the Figure 7.26, the application this policy packages attracted more people to use public transport system rather than private vehicles as the main mode of transport in the case study area selected. Similar like in the second policy packages using application strict zoning land use plan, the combination of parking charge and cut fuel subsidy increased significantly the friction factor for private vehicles in the model that decreased the number projection of car and motorcycles users. This condition pushed the private vehicles users to shift to public transport system. In conclusion, the application of this policy package could be also applied to promote the urban development process in the framework of urban risk reduction and urban transport sustainability.

7.4.4 Summary of integrated policy packages application

Figure 7.27 below shows the results of integrated policy package in the Banda Aceh MARS future model for residents distribution, including the results in BAU scenario land use plan for comparison purpose.



	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8	ZONE 9
BAU	49,370	43,700	25,100	24,230	26,520	76,000	24,880	62,280	27,490
BAU_PACKAGES (A6)	41,830	50,510	25,140	21,140	38,350	54,280	11,260	86,530	30,520
PR1_PACKAGES (B6)	16,860	33,880	49,650	22,870	46,120	59,970	10,660	75,520	44,030
PR2_PACKAGES (C6)	25,910	40,440	47,240	22,440	44,670	48,340	10,110	78,350	42,060

Figure 7.27 : Model projections for residents distribution in the application of all policy packages (2030)

As can be seen in the Figure 7.27, the application of integrated policies packages positively contributed to direct the urban development process in the framework of urban risk reduction. There were three policy packages application results, which can be seen in the figure, to prove that the integrated policy packages selected had positively contribution in achieving the sustainability city agenda. Firstly, the application of transport policy measures in the A6 reduced the number of city residents in high-risk areas of the city as can be seen in the zone 1 (BAU packages). Secondly, the application of strict zoning land use plan in the high-risk areas of the city (B6) also reduced significantly the number of city residents that reside in high-risk areas of the city as can be seen in the zone 1,2,6, and 7 (PR1 packages). Thirdly, the application of pricing policy through tax and property tax (C6) also gave the better results to direct the city development to the low-risk areas of the city such as shown in zone 3, 5 and 9 (PR2 packages). From this figure, it can be concluded that combination of land use and transport plan plays the main role in achieving the city sustainability objectives in the framework of urban risk reduction.

On the other hand, the application of integrated policy packages also gave positive contributions in directing the sustainability city objectives in the framework of urban transport sustainability. The application of “pull” and “push” concept strategy in Banda Aceh MARS future model succeed promote modal shift from private vehicles to public transport system. Figure 7.28 below shows the results of modal split projection of Banda Aceh MARS future model for integrated policy packages in BAU land use plan, including several transport measures application for comparison purposes.

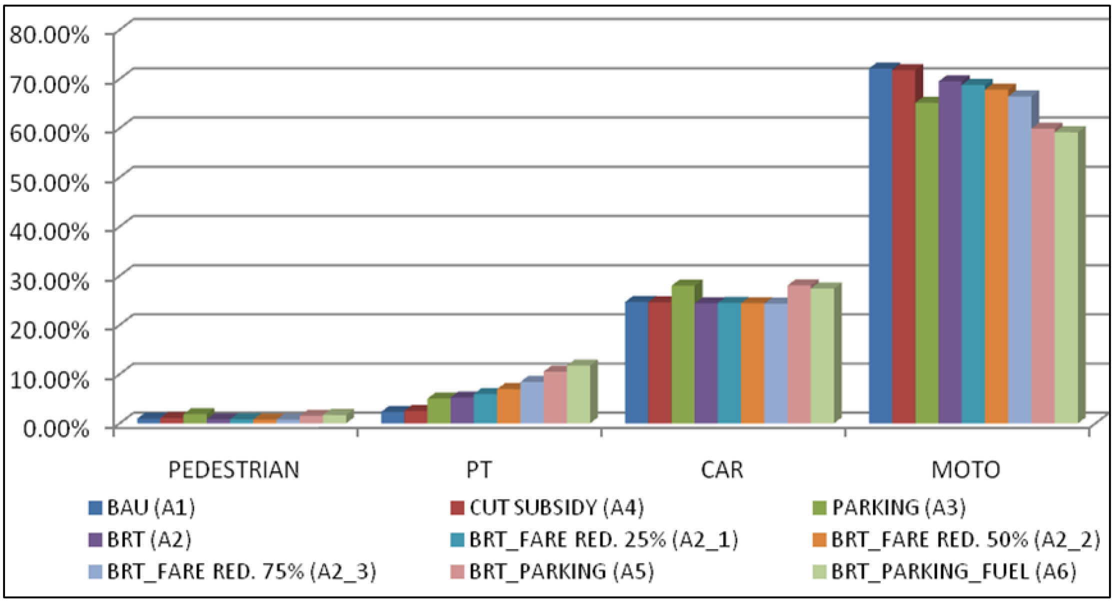


Figure 7.28 : Model projections for modal split in the application of policy packages in BAU land use plan (2030)

As can be seen in the Figure 7.28, the application of integrated policy packages in the Banda Aceh MARS future model succeed to promote the public transport system (the BRT) as the main mode of transport in the case study area selected based on the model projection. The application of the combined BRT and parking charges as the implementation concept of “pull” and “push” concept increased the attractiveness of public transport system and reduced the attractiveness of private vehicles in the model. The complete of integrated policy packages, which consist of combination of the BRT, parking charges, and cut fuel subsidy, gave the best results compared to the others in the context of promoting public transport system. In the model, the application of this policy increased the friction factor for private vehicles such for car and motorcycles to the highest level compared to other policy measures selected in this study. This condition attracted the city residents to select the public transport mode that modelled in Banda Aceh MARS future model. Furthermore, the various of bus fare scenarios in the integrated package policy were also tested to investigate the effect of this factor in changes modal split. The model results showed that the bus fares reduction increased more the attractiveness of public transport system. In the model, the reduction of bus fare reduced the fiction factor public transport mode that attracted more city residents in the case study area selected to use this mode of transport rather than private vehicles. It could be seen in the results of bus fares reduction simulation, which consist three fares reduction scheme, namely 25% (Rp. 3000), 50% (Rp. 2000) and 75% (Rp. 1000). From this picture, it can be seen that the public transport fares also played the main role in promoting public transport as the main mode in urban transportation in order to reach the city sustainability agenda.

Furthermore, the Figure 7.29 shows the results of modal split projection for different land use plan strategies selected, including the BAU results for comparison purpose.

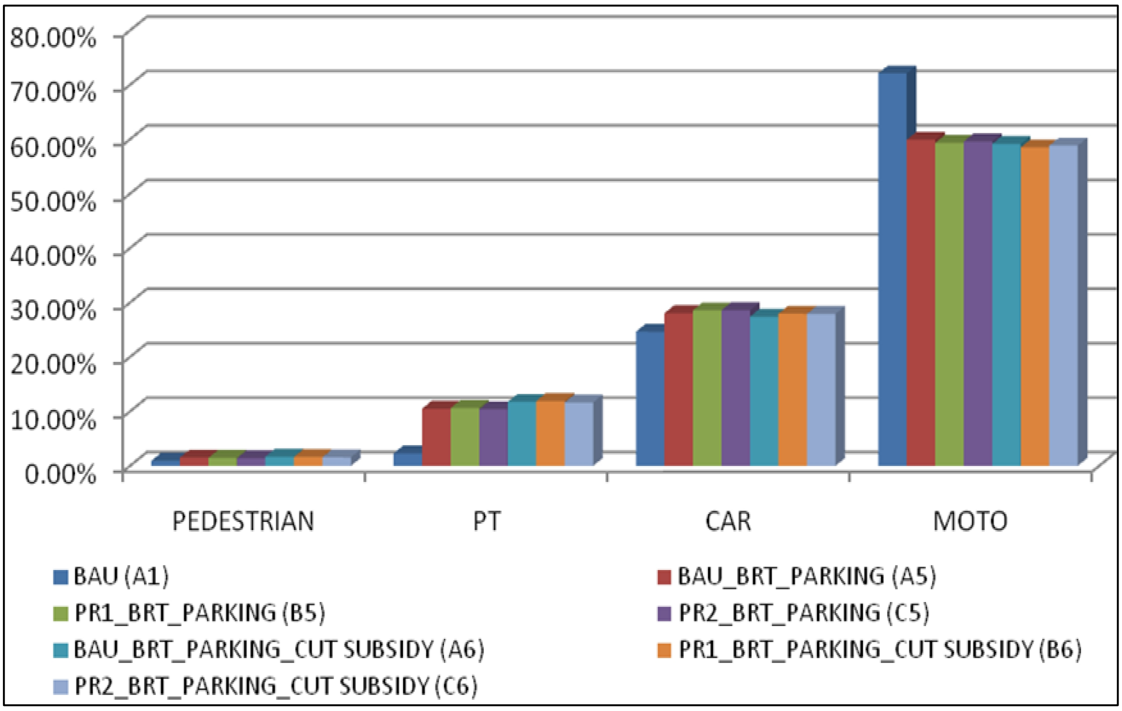


Figure 7.29 : Model projections for modal split in the application of policy packages in three land use plan scenarios selected (2030)

As can be seen in the Figure 7.29, the different application of integrated package policies resulted in different result modal split changes. This condition occurred because the implementation of planned-retreat land use plan changed the residents distribution that contributed to the modal split outputs. Moreover, the different application of parking charge in business as usual land use plan and planned retreat also resulted in different modal split outputs. The application of parking charge in business as usual land use plan, which was applied in all zones, pushed more people to shift to public transport rather than in the planned-retreat plan, which was only applied in several zones in the core areas of the city. In addition, the application of cut fuel subsidy in the combined policy package also positively contributed for pushing people to use public transport and simultaneously discouraging the use of private vehicles.

7.5 Model results and the reality

How accurate and precise the LUTI model can do the future projection of urban evolution ? This is a typical question that normally possible appear regarding linking the model outputs with the condition in the reality, both in academic and practical issues. According to the results of model calibrated in this study, it can be seen that the model has the ability to represent the condition in the reality in the past condition of Banda Aceh city.

In the Banda Aceh future model, the implementation of BRT in the model reduced the 30% of travel time by public transport, which significantly increased the number of people that used public transport in the city (e.g. comparison results of policy A1 vs A6). In the reality, the significant travel time reduction (e.g. 50%) of public transport after BRT program in the several American cities significantly increased the BRT ridership. For example, in the Pittsburgh city, the BRT program implemented increased the BRT ridership about 80%-100% (Wright and Fjellstrom, 2003). However, there is still left a question, whether the combined transport policies selected could increase more the mode share of public transport e.g. more than 10% (e.g. Model projection below 10%, from 2.30% in A1 to 11.75% in A6) in the case study area?. The next question is that how accurate and precise the projection of model results could be believed ?. As known that there are many uncertainty factors in the future that are involved in the reality condition.

In this context, the experience of BRT program implemented in other cities can be used as the comparison purposes. For instance, the BRT implementation in Bogota city increased the PT mode shares from 64% to 70% in the six years period of time (1999-2005) (Pindiprolu et al., 2006). Moreover, in the case study area selected, the past study, which was previously discussed in the chapter 4, showed that there were 39.04% of city residents that preferred to use public transport in the last two decades before the tsunami tragedy (Kamal, 2002).

From on that point, there is a possibility that the model results can be used as an scientific approach to project the future image of the case study area selected. In the real practice, it is expected that the implementation of combined transport policy measures (e.g. A6) may bring the future condition better. However, it is needed more effort to reach the similar condition as it was before the tsunami tragedy in the way to promote the public transport system as a main option of urban transport system for Banda Aceh residents.

Chapter 8
Strategies Evaluation in the Framework of Sustainability

8.1 Introduction

This chapter presents the evaluation and assessment of all the alternative policy measures previously discussed in chapter 7. Moreover, as discussed earlier in chapter 3, there were two possible approaches that can be used in evaluating the strategies to be selected, the first is multi-criteria analysis (MCA) and cost benefit analysis (CBA) is the second. In this context, the application of the multi-criteria analysis approach using analytical hierarchy processes is one of the alternatives that can be used to evaluate the possible alternative policy measures in the framework of sustainable development. However, it should be noted that the application of the framework assessment using MCA cannot be shown at this stage because of the research limitation in this study[9]. In this context, it is expected that the next application of the framework assessment using the approach of multi-criteria analysis can be recommended for further studies following this research for promoting the application of land use and transport strategies in the framework of urban risk reduction and urban transport sustainability, especially in the context of developing cities in developing countries.

For these reasons, the discussion of the strategies for evaluation in this chapter focuses on the results from the model without involving the weighting process (simple CBA approach). The indicators selected in the evaluation process refer to the city objectives in the case study area selected. Moreover, the systematic discussion in this chapter has been classified into three main sections, which consist of the framework assessment, indicators selected and the discussion of results for finding the best strategies in the framework of urban risk reduction and urban transport sustainability. In this context, the framework assessment of strategies for evaluation is discussed in section 8.2, while the parts of indicators selected and

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[9] The limitation issues are related to the limitations of time and finance for this research (e.g. weighting process from expert through forum group discussion to evaluate the strategies selected).

strategies evaluation in the framework of sustainability are discussed in section 8.2 and 8.3 respectively.

8.2 Framework Assessment

Figure 8.1 below shows the framework assessment used, which consists of several systematic steps that were used to evaluate the strategies selected, which refer to the indicators selected (refer details in chapter 3). As discussed earlier, the selection of the indicators was fitted with the sustainable development concept in the framework of urban risk reduction and urban transport sustainability.

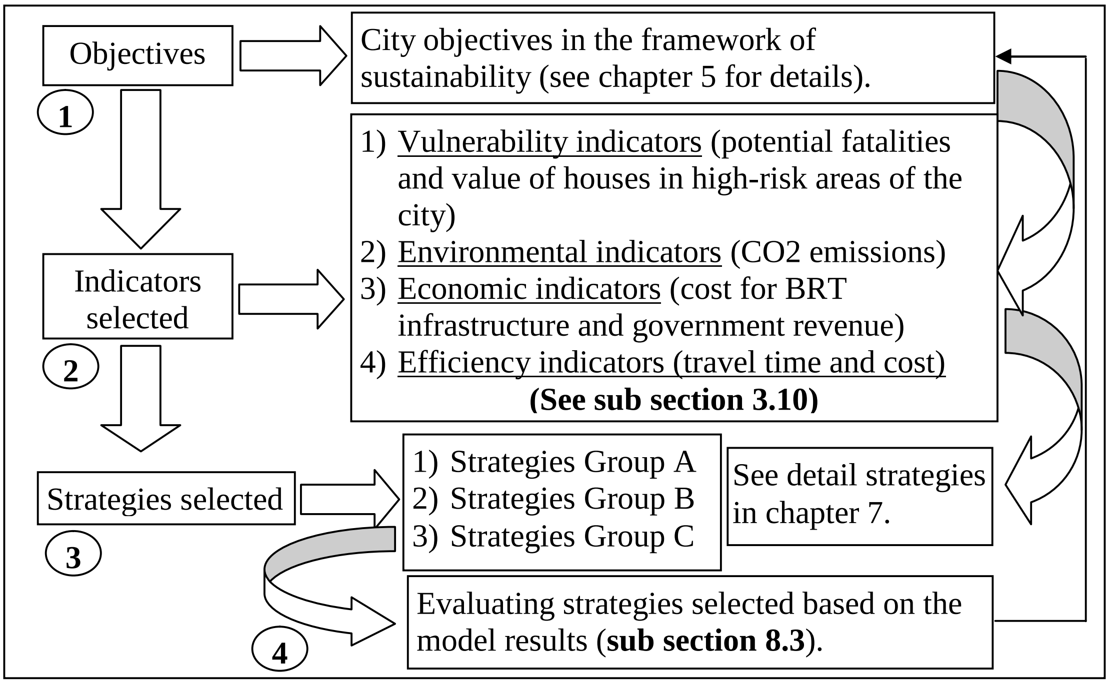

Figure 8.1 : Logical steps in selecting strategies for evaluation processes for achieving the sustainable city objectives

The indicators selected were categorized into four further main indicators as follows.

1) Vulnerability indicators, which consist of (A) potential fatalities, and (B) value of housing loss indicators.

2) Environmental indicator (C), which only consist of CO_2 emission indicator.

3) Economic indicators, which consist of costs and revenues. The costs consist of (D) cost of BRT infrastructure, (E) BRT operational and maintenance costs and (F) fuel subsidy. The revenue consists of (G) fuel, (H) parking, (I) BRT fares, (J) land taxes, and (K) NPV revenue indicators.

4) Efficiency indicators, which consist of PT (Public Transport) travel cost (L) and time (M), private car travel cost (N) and time (O), and motorcycle travel cost (P) and time (Q).

8.3 Strategies for evaluation

As discussed previously in the sub section 8.2, there were 18 (eighteen) combined alternative policy measures selected, which were evaluated using 4 (four) sets indicators selected in the process of strategies evaluation (see the previous Figure 8.1). All of the alternative policy measures selected were classified into three types of land use plan selected, which were fitted to the Banda Aceh sustainable city agenda (BAPPEDA, 2014).

In this discussion, three type land use plan selected consist of (1) business usual land use plan A, (2) planned-retreat with strict zoning land use plan B, (3) planned-retreat land use plan C with pricing policy. In the first type of land use plan A, the alternative policy measures consist of the application of land use and transport plan in accommodation land use strategy (BAU) ranging from alternative policy measures A1 to A6. In the second type of land use plan B, the alternative policy measures consist of the application of land use and transport plan using the application of planned-retreat with strict zoning land use plan B, ranging from alternative policy measures B1 to B6. Lastly, in the third type of land use plan C, the alternative policy measures consist of the application of land use and transport plan in planned-retreat land use plan C with using application pricing policy, ranging from alternative policies measures C1 to C6.

No	Indicators selected	Land Use Plan A (BAU with accommodation strategy)						Land Use Plan B (Planned-retreat 1)						Land Use Plan C (Planned-retreat 2)					
		A1 (BAU)	A2 (BRT)	A3 (Parking) (P)	A4 (Cut Subsidy) (CS)	A5 (BRT_P)	A6 (BRT_P_CS)	B1 (BAU)	B2 (BRT)	B3 (Parking) (P)	B4 (Cut Subsidy) (CS)	B5 (BRT_P)	B6 (BRT_P_CS)	C1 (BAU)	C2 (BRT)	C3 (Parking) (P)	C4 (Cut Subsidy) (CS)	C5 (BRT_P)	C6 (BRT_P_CS)
1	**Vulnerability**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**
A	Fatalities (2030)	39,496	35,336	38,472	35,336	34,112	33,464	13,488	13,488	13,488	13,488	13,488	13,489	20,736	20,728	20,736	20,728	20,728	20,728
B	Housing value (2030)	8315	8161	8269	7833	7779	7724	5265	5263	5267	4970	4997	4983	5693	5711	5691	5221	5219	5196
2	**Environment**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**
C	Emission (tonnes)	**105,700**	**98,840**	**105,200**	**102,200**	**93,510**	**86,820**	**107,700**	**99,930**	**106,100**	**103,100**	**93,890**	**87,210**	**107,600**	**99,850**	**106,500**	**102,800**	**94,460**	**87,710**
3	**Economic (in billion rupiah)**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**	**NPV**
D	Infrastructure cost	0	481	0	0	481	481	0	481	0	0	481	481	0	481	0	0	481	481
E	BRT O & M	0	785	0	0	1,218	1,334	0	776	0	0	1,209	1,324	0	500	0	0	1,211	1,327
F	Fuel Subsidy	3,041	2,801	3,071	0	2,676	0	3,053	2,809	3,084	0	2,688	0	3,056	2,812	3,089	0	2,694	0
G	Fuel revenue	0	240	0	113	365	538	0	244	-31	117	365	538	0	244	-33	118	362	536
H	Parking revenue	26	24	202	26	173	171	26	24	204	27	175	173	26	24	203	26	173	171
I	BRT fare revenue	0	508	0	0	773	846	0	498	0	0	769	843	0	500	0	0	769	843
J	NPV (2011-2030) (revenue-cost)	-3,015	-3,294	-2,899	139	-3,065	-260	-3,027	-3,300	-2,911	143	-3,069	-252	-3,030	-3,025	-2,920	144	-3,081	-257
K	Land tax	0	0	0	0	0	0	0	0	0	0	0	0	14.52	14.55	14.48	13.17	13.11	12.90
4	**Efficiency**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**	**2030**
L	Cost (Bus fare)(Rp)	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
M	Travel time (PT) (Average) (min)	44.34	30.61	45.42	43.82	31.98	31.98	44.16	30.67	44.88	44.14	31.45	31.41	44.07	30.41	45.40	43.81	31.89	31.88
N	Cost car (per km)	589	590	3,978	835	3,985	4,454	595	595	4,014	841	4,020	4,489	593	593	3,998	839	4,003	4,475
O	Travel time (car) (Average) (min) *****	10.19	10.19	11.36	9.83	11.38	10.87	10.09	10.08	11.31	9.72	11.33	10.83	10.12	10.12	11.32	9.75	11.35	10.84
P	Cost moto (per km)	347	347	2,534	438	2,530	2,782	347	347	2,534	438	2,530	2,782	348	348	2,509	438	2,506	2,753
Q	Travel time (moto) (Average) (min)	8.81	8.82	10.29	8.34	10.33	9.74	8.59	8.82	10.29	8.13	10.33	9.74	8.74	8.75	10.30	8.30	10.35	9.76
R	Trip Dist(Car) km//trip	3.00	3.00	3.54	2.82	3.54	3.31	2.95	2.95	3.50	2.77	3.51	3.28	2.96	2.96	3.52	2.79	3.52	3.29
S	Trip Dist. (Moto) km/trip	2.66	2.66	3.30	2.48	3.32	3.07	2.56	2.56	3.34	2.40	3.35	3.12	2.65	2.66	3.35	2.49	3.37	3.12

Table 8.1 : Results for all alternative policy measures A1-C6 (all units in economic indicators in billions Indonesian rupiah)

8.3.1 Business as usual land use plan A

As can be seen in Table 8.1 above, there were various results from the alternative transport policy measures implementation with the BAU land use plan A ranging from A1-A6. For instance, first, it can be seen that the alternative transport policy measures using application of “push strategy” with the implementation of fuel subsidy cut (A4) and parking charges (A3) resulted in very slight changes regarding residents distribution in high-risk areas of the city compared to policy A1 (see indicator potential fatalities for detail). In this case, the policy A4 produced a slightly better performance compared to policy A3 in term of reducing the attractiveness of high-risk areas in the city.

Moreover, the application of the “pull strategy” through application of the BRT (A2) policy also attracted more people to move to low-risk areas of the city. Similar results were also produced by alternative policies A5 and A6. From these results, it can be seen that the application of “pull strategy”, including combined “push” and “pull” strategy gave better results compared to the application of “push only” strategy. In this case, it can be seen that the increase of PT accessibility through the provision of a better and more convenient public transport system attracted more people to reside in other lower-risk areas rather than in the high-risk areas of the city, which are closer to the core area of the city such as zone 1.

In the aspect of environment, the implementation of “push strategy” through policy measures A3 and A4 slightly decreased the carbon emission compared to A1. On the other hand, the implementation of a “pull strategy” through policy A2 resulted in a bigger decreased in total carbon emission compared to A3 and A4.

Moreover, the combination of both “push” and “pull” strategy applications (A5 and A6) produced lower carbon emissions compared to the other policies (A1, A2, A3 and A4). In the model, the mode split changes (see Figure 7.18 for detail) of combined policy measure A6 significantly reduced carbon emissions. According to Figure 7.18, the significant shift from private vehicles (e.g. motor bikes 72.11% in A1, 59.15% in A6 and cars 24.65% in A1 rising to 27.04% in A6) with BRT system increase, from 2.3% in A1 to 11.75% in A6, could result in a reduction of 17.86% in carbon emissions. Moreover, it could also result in a fuel consumption saving of 15.50%. These results were in line with the assessment approach in other past studies (e.g. BRT projects in the CDM of the Kyoto Protocol), where the projection of potential CO_2 emission reduction in several developing cities of developing countries could result in reductions between 16% and 65% from their baseline scenario plans (Vincent et al., 2011).

Moreover, the local government also needs to consider the economic aspects regarding the budget allocation for developing the BRT infrastructure. In this case, the calculation was done using the BRT infrastructure cost calculator (ITDP, 2013) (see appendix A). The general calculation in Table 8.1 shows that the local city authority will need to allocate more than 481 billion rupiah to develop the BRT infrastructure, including the road infrastructure maintenance cost from 2011 to 2030 (see Appendix H for detail). In return, the development of this infrastructure may increase the attractiveness of the public transport system to be used as the main mode of transport for people in the city. Moreover, according to the TransMilenio experience in Bogota, the cost for fuel was almost 25% of their total BRT operational costs (ITDP, 2007). In this case, the fuel for the BRT was also included in the BRT operating and maintenance costs, which can be seen in Appendix A4 and the summary of costs and government revenue can be seen in the previous Table 8.1.

The application of A6 could result in lower fuel consumption that will result in a lower budget allocation for fuel subsidy. In this alternative policy measure, the fuel subsidy allocation can be reduced. In this case, the government can get fuel revenue savings of more than 50 billion rupiah per year (e.g. A6) that can be used to subsidize the BRT public transport system (see Appendix H.6).

On the other hand, the local city authority may also get additional revenue from the parking sector. The implementation of parking charges could significantly increase government revenue compared to policy A1 from 3 to 19 billion per year (see Appendix D). In addition, it should be noted that the fuel subsidy cut plays the main role in increasing the government revenue to subsidize the implementation of a sustainable urban transport system by implementing the BRT system (see NPV results Table 8.1). However, based on the latest NPV results, the local government will still need to subsidize the BRT system in order to cover the BRT operational and infrastructure costs. In this case, the BRT revenue should be increased more in order to cover the operational and maintenance costs.

Furthermore, the use of BRT (e.g. A2) can also increase the efficiency of people in their journey activities in the city. The implementation of the BRT public transport system could significantly reduce travel times from about 44 minutes to only about 30 minutes on average (see Appendix E.4). However, travel times using private vehicles were still faster compared to public transport (see Table 8.1). In addition, the application of combined transport policy measures (A5 or A6) made the cost for using private vehicles (cars) per km slightly more expensive than using public transport (see Appendix E.1).

All in all, from the BAU land use plan strategy, it can be seen that the A6 policy measure was better on vulnerability (lower fatalities and higher housing values), environment, economic (NPV, except compared with A4) compared to the other policies selected. On the other hand, this policy is not popular with the private motor vehicle users because the travel costs with this policy are more expensive compared to the other policies, due to the objective to decrease the number of city residents using cars/motorcycles. Therefore, in the aspect urban risk reduction and urban transport sustainability objectives, this policy can be considered as the best strategy in the land use group plan A (see column land use plan A in Table 8.1).

8.3.2 Planned-retreat with strict zoning land use plan B

As can be seen in the Table 8.1, similar to the previous results in the BAU land use plan, there were also various results from the implementation of the alternative transport policy measures with the group land use plan B (B1-B6). However, it can be seen that there were no significant changes that affected the vulnerability indicators after the various transport policy measures were applied (e.g. see fatalities indicator).

The implementation of a strict zoning land use plan in this model that banned any new future developments in the very high-risk areas of the city, which might reduce the value of housing damage (viz. see details of value of damage) compared to the BAU land use plan. In other words, the application of this policy in the model keep constant the population and housing distribution in the very high-risk areas of the city In addition, the implementation of strict zoning land use plans stopped future development in the high-risk areas of the city to help the city to achieve the sustainable city objective in the framework of urban risk reduction compared to the BAU land use plan.

In the aspect of environment, the implementation of a “push strategy” through application of policy measures B3 and B4 also slightly decreased carbon emissions in the city. However, the total carbon emissions produced in this land use strategy (B1=107,700 tonnes) was slightly higher compared to the total carbon emissions produced in the BAU land use plan (e.g. A1=105,700 tonnes). In other words, the implementation of strict land use zoning plans resulted in different residential distributions that slightly changed the total carbon emissions produced in this strategy compared to that with the BAU land use plan.

On the other hand, the implementation of "pull strategy" through the application of policy B2 produced lower carbon emissions compared to policy measures B3 and B4. Moreover, the combination of "push" and "pull" strategy applications through policies B5 and B6 resulted in much lower carbon emissions compared to the three transport policies mentioned earlier (B2, B3 and B4).

The overall results showed that application of the combined policy measure (B6) could reduce carbon emissions more than 19% and the application of this policy measure could save the city fuel consumption more than 16% compared to a "do nothing" transport policy in policy measure B1. Similarly, like in the BAU land use plan, the implementation of combined policy measures (B5 or B6) in this planned-retreat land use strategy also have potential to be applied in the case study area selected in order to reach the target of carbon emission reductions from the urban transport sector. However, it should be noted that the application of this combined strategy has implications for the economic aspects, where the government should develop the BRT infrastructure. In this case, the city authority needs to allocate more than 481 billion rupiah to develop the BRT infrastructure using the same calculation as that with the BAU land use plan.

The application of the BRT strategy through alternative policy measure B2 could save about 5.46% from the budget for fuel. Moreover, the combination of the BRT and parking policy measures (B5) could also save much more fuel as it resulted in a much lower budget allocation for fuel subsidy (8.45%). Moreover, If the local government apply the complete package policy B6, the fuel subsidy allocation for Banda Aceh city can be eliminated. In this case, the government might get additional revenue of more than 54 billion rupiah per year. The potential NPV total result from all the economic indicators considered was 538 billion rupiah from 2011-2030 (see Appendix H.12 for details).

All in all, with land use plan B, all of the policies selected showed better performance in the vulnerability indicators (i.e. fatalities and housing values) compared to those with BAU land use plan A or C. The policy B6 had better performance in the aspect of environment (see total emissions produced) compared to other policies in this land use plan (B1-B6).

8.3.3 Planned-retreat land use plan C with pricing policy

As can be seen in Table 8.1, similar to the previous results from the BAU and the planned-retreat land use planning B, there were also various results from the implementation of the alternative transport policy measures in the planned-retreat land use planning C with pricing policies (C1-C6). The implementation of transport policy measures through e.g. the application of a "push strategy" with a cut in fuel subsidy (C4) and increased parking charges (C3) resulted in very slight changes regarding residents distribution in high-risk areas of the city compared to the do nothing transport policy measures in C1, which were considered not significant. Moreover, in this case, all of the policies in this land use plan significantly produced better performance compared to all the policies in the BAU land use plan A in the context of reducing people and housing distribution in the very high-risk areas of the city (refer the vulnerability indicator).

In the aspect of environment, similar to the two previous types of land use planning mentioned earlier (Land use planning A and B), the implementation of a "push strategy" through application of policies C3 (106,500 tonnes) and C4 (102,800 tonnes) also slightly decreased the carbon emissions in the city compared to the alternative policy C1 (107,600 tonnes), which was used as the base policy measure for this type of land use planning.

On the other aspect, the implementation of a "pull strategy" through application of policy C2 (99,850 tonnes) produced lower carbon emission compared to policy measures C3, C4 and C1 as mentioned earlier. Moreover, the combination of "push" and "pull" strategy application through alternative policies C5 (94,460 tonnes) and C6 (87,710 tonnes) resulted in much lower carbon emissions compared to all alternative transport policies in this type of land use group. The results showed that the application of combined policy C6 can reduce more than 18% of carbon emissions and the application of this policy measure can save the city fuel consumption more than 15% compared to the “do nothing” transport policy in the alternative transport policy measure C1.

Similar to the application of transport policy measures in the planned-retreat land use plan B, the implementation of combined policy measures (C5 or C6) in this planned-retreat land use strategy also have potential to be applied in the case study area selected in order to reach the national Indonesian action plan in the context of carbon emission reduction, especially from the urban transport sector. However, it should also be noted that the application of this combined strategy has implications for the government budget, where the government must improve the public transport system in the city through developing the BRT infrastructure. In this case, the city authority needs to spend more than 481 billion rupiah to develop the BRT infrastructure (the same calculation also applies for the BAU {A} and for the planned-retreat B).

However, the application of the BRT strategy through the alternative policy measure C2 could save about 5.46 % from the budget for fuel and this would increase to 7.94 % if the C5 strategy is applied in the model. Moreover, if the city government applies the complete policy in C6, the fuel subsidy allocation for Banda Aceh city can be eliminated. In this case, the government might save more than 54 billion per year. Furthermore, the potential NPV total resulting from all the economic indicators considered was about -257 billion rupiah (see Appendix H.18). In this case, the BRT revenue should be increased more in order to cover the BRT operations and maintenance costs.

All in all, from the land use plan C, all of the policies selected showed better performance in the aspect of vulnerability indicators (i.e. potentially lower fatalities and housing damage losses) compared to all the policies selected in the BAU land use plan. On the other hand, the performance of all policies selected in this land use plan C were not better compared to all of the policies in the land use plan B strategy (land use plan C). However, in the aspect of economic indicator, the application of land tax policy in this land use plan C could increase the government revenue, which might be used to support the urban risk reduction program. Moreover, the policy C6 had better performance in the aspects of environment (see lower total emissions produced) compared to other policies in the same type of land use plan. However, in the economic aspect, the government should still allocate the budget to subsidize the BRT (e.g. C2, C5, C6).

8.3.4 Comparison of three land use plans (A6, B6 and C6)

As can be seen in Table 8.1, the implementation of policy measures A6, B6 and C6 with three different land use plans resulted in three different results. For the vulnerability indicator, the application of planned-retreat land use plans with policy measures B6 and C6 significantly reduced the number of residents in high-risk areas of the city (e.g. zone 1). From the table above, it can be seen that the reduction of residents after strict land use zoning plan application in policy measure B6 reduced the fatalities in the high-risk areas selected (e.g. very high-risk zone 1) by more than 59%, while the implementation of pricing policies (increasing land tax) with policy measure C6 decreased the potential fatalities by about 38% compared to policy measure A6. Moreover, the implementation of these two alternative policy measures reduced the potential loss from housing damage by considering the return period of a similar tragedy as occurred in 2004. The implementation of land use policies through alternative policies B6 and C6 can save the budget for the post disaster era by more than 30% compared to a BAU strategy (A6) (see Appendix G for details).

For the environmental aspect, the results from policy measure A6 showed better performance compared to the alternative policy measures B6 and C6. The different parking policy measures applied in the BAU and the planned-retreat land use plans resulted in different total carbon emissions produced since the application of a flat parking charge performed better than the application of the partial parking charges that were applied with the planned retreat land use plans.

Moreover, differences in the land use plan strategy implementation also contributed to the projected increase in carbon emissions in Banda Aceh city. Similarly with carbon emission indicators, the projected fuel consumption for the three policy measures selected was also reduced significantly compared to other policy measures in each type of land use plans. In this context, it can be seen that the alternative BAU (A) land use plans performed better compared to the planned-retreat land use plans (B and C) in the context of environmental indicators (see the environment indicator for emission result in the Table 8.1).

In the economic aspect, there were no differences regarding the allocation of costs for developing the BRT infrastructure in all of the three policy measures selected.

On the other hand, the implementation of cut subsidy policy measure in the three policy measures selected can increase the government fiscal space, which can be used for other important sectors (e.g. health and education). In other words, the application of these three policy measures can significantly increase the government revenue from the oil and gas sector by not subsidizing the price of domestic fuel at the pump station. However, it should be noted that, the implementation of policy measures B6 and C6 gave slightly more government revenue compared to policy measure A6 because the city fuel consumption in B6 and C6 was slightly higher compared to the fuel consumption for A6. On the other hand, alternative policy measures B6 gave slightly more revenue (in million rupiah) for the government from the parking sector and policy C6 gave additional revenue from the land tax (see Appendix H for details). In this context, there is a trade-off that needs to be considered regarding these two indicators selected, which can be fitted with the sustainable city objectives and refer to the weighting process in the MCA analysis approach, which can be done in a further study.

Moreover, in terms of efficiency indicators, there were no differences in the results from the three alternative policy measures. The application of BRT in all policy measures selected reduced significantly the travel time for public transport in the city. From the point of view of city residents, the improvement of the public transport system through the BRT as an alternative mode of transport provided by the government for city residents for making trips in the urban areas more efficient, especially from the aspects of cost and time. From the perspective of stakeholders, this is one of the smart alternatives to implement the concept of urban transport sustainability. From the political perspective, the possibility of turmoil, which could happen, could be reduced if the government implemented the policy of cutting the fuel subsidy after the government has provided convenient public transport in and around the city.

8.4 Summary of strategies evaluation

Based on the results from the discussions, it can be seen that the combination of push and pull strategies through the application of combined BRT, parking charges, and cuts to the fuel subsidy showed the best performance amongst the other alternatives selected for each group land use plan selected. When the BAU land use plan was selected, policy measure A6 had the best performance amongst the other policy measures selected in the first group strategy. Similarly, with the planned-retreat land use plan the policy measures B6 and C6 showed the best performance for the land use plan groups two and three respectively.

However, from all the policy measures tested, the policy measure B6 showed relative better performance compared to the other policy measures tested in this study, especially in the aspect of urban risk reduction (i.e. fatalities and housing values), referring to the vulnerability indicator. In other words, the application of strict zoning land use plans in this policy measure in very high-risk zones of the city succeeded in significantly reducing the potential number of city residents living in high-risk zones of the city in the future. In the aspect of disaster risk reduction budget allocation, the implementation of policy B6 can save the government post disaster budget about 40.08% compared to the BAU land use plan as shown in Appendix G.5. The application of policy A6 with a BAU land use plan might result in a potential housing loss of about 7.7 trillion rupiah, while the potential housing loss with planned-retreat land use plan B was only 4.98 trillion (B6) rupiah using the assumption of a tragedy similar to that in December 2004.

Furthermore, in the context of urban risk reduction, policy measure B6 is only one of the potential solutions for helping Banda Aceh to reach sustainable city objectives. Policy measures A6 and C6 are two other potential alternative solutions that can be applied in the case study area. Nevertheless, it should be noted that implementation of A6 has the potential to attract more people to reside in high-risk areas of the city compared to policy measure C6. Consequently, in this case, policy measure C6 is an alternative that can be applied after policy measure B6.

There are two positive things that can be learned from policy measure B6 and C6. Firstly, the land use application of these policies provide the new insight in promoting the concept of urban risk reduction through application of land use zoning plans and property taxes. Based on the model results, the land and property tax regulation should be reformed in Indonesia to direct the sustainable city agenda on the right track of urban risk reduction objectives since many Indonesian cities are located in disaster prone areas.

Moreover, the two policy measures (A6 and C6) are two alternative options that might be possible to be applied if the government cannot apply the very strict zoning land use policy as applied in the policy measure B6 because of several issues such as e.g. land acquisition and property rights. In this case, the model results showed that the land and property tax regulations are alternative potential measures that can also be applied to reduce the attractiveness of high-risk areas of the city in order to reduce vulnerability of the city to potential disasters from natural hazards. On the other hand, if the government continues the accommodation land use policy, the evacuation preparedness alternative strategy should be selected as the main priority government program to minimize the negative impact of the potential for destruction from natural hazards by considering the return period of a similar magnitude tsunami in the context of Banda Aceh.

Furthermore, the application of the combined transport policy (e.g. policy A6) gave the best performance compared to the others. In the fuel consumption indicator, the application of combined transport policy measure A6 can increase the government revenue by more than 54 billion rupiah per year as a result of reduction in fuel consumption. In the final year of simulation, it was projected that 287.6 billion rupiah could be saved as a result of fuel consumption reduction from 157,400 (A1) to 133,000 (A6) kilolitre according to the results from the model. In this case, the government can save Rp. 2.356 per liter of fuel both for petrol and diesel (see Appendix C). According to the real data for fuel consumption for Banda Aceh in 2011, the fuel consumption for Banda Aceh city was 14.45% of total fuel consumption for the Province of Aceh. In fact, this percentage was only 0.29% of national fuel consumption (PERTAMINA, 2012). However, the local government should be aware that this fuel consumption might significantly increase in future years in the do nothing scenario. In addition, the application of parking charges (e.g. A6) could also add government revenue about 13 billion rupiah in 2011 and it could increase to more than 24 billion rupiah in 2030) (Appendix H.6).

Based on the explanations above, it can be seen that the application of combined transport policy measures is one of the alternative solutions that can be used to promote new policies to shift budget allocation from a fuel subsidy to an urban-transport infrastructure subsidy. In fact, the fuel subsidy in the national budget not only burdens the budget revenue and expenditure, but it also directs urban transport activities to an unsustainable condition. The high fuel subsidy for urban transportation providing cheap fuel, attracts more city residents to use private vehicles rather than the public transport system. This condition increases the carbon emissions and fuel consumption in the city that increases the fuel subsidy year by year. In this context, it can be seen that the fuel subsidy policy is not a good policy to be continued in Indonesian cities in the framework of urban transport sustainability. Moreover, it should be also noted that the cut fuel subsidy policy is not to be implemented to eliminate the importance of subsidy items in the government national budget, but it is selected to shift the fuel subsidy budget to subsidise public transport systems in order to reduce fuel consumption without decreasing the level of mobility in urban areas.

On the other hand, the local city government should also consider the other important aspect to provide a convenient public transport system before the cut fuel subsidy policy is implemented in order to provide a better travel choice for city residents. Based on the model result, the BRT fare might give revenue about more than 88 billion rupiah per year on average (A6), which can be used to support the BRT operational costs. Therefore, it is also important to consider the BRT operating costs and the maintenance costs for BRT and its infrastructure. The detailed result of this calculation can be seen in appendix H.1.

Furthermore, according to the result of the NPV calculations, the cut fuel subsidy plays a dominant role in increasing the government revenue. From the NPV results, it can be seen that it was only the alternative cut fuel subsidy (A4) that resulted in a positive value for the NPV compared with the other policies such as BAU (A1), BRT (A2) and parking (A3), which had negative values since the fuel subsidy policy was not applied in these three strategies. For instance, with policy measure A2, the government needs to allocate about 328 billion per year (2011-2030) to cover the costs of BRT implementation. Moreover, the combined BRT and parking plus cut subsidy (e.g. policy A6) results in reducing the government subsidy from 3.015 trillion to only 260 billion rupiah or about 15 billion per year. In this case, the use of public transport as the main mode for urban transport should be promoted more to attract more people to use the system in order to create more revenue, which could be used to cover the operational and maintenance costs. On the other hand, this would also reduce the use of fossil fuel.

Based on the discussion above, there are two important things to be considered in the context of government budget allocation, which should be managed based on strategies selected in the light of a sustainable urban vision. First, it relates to government efforts to reduce the use of fossil fuel to promote sustainability. Second, the government efforts for allocating budgets to promote the sustainability concept through e.g. the BRT strategy, need huge funds to be invested, in the right way to reach the city sustainability objectives.

From the model results, it can be seen that the subsidy item in the local government budget can be reduced significantly if the combined pull and push transport policy measures are implemented in the case study area selected. In this context, the item subsidy is not planned to be eliminated, but it is planned to be shifted from the column of fuel subsidy to the column of investment in the urban public transport system. In this case, the government revenue from saving fuel could not only be used to support a sustainable urban transport program, but also it could be used to support the urban risk reduction program e.g. through a 1% budget allocation from the national or local budget (Hadi, 2013).

For the aspect of urban risk reduction, the projection of total loss might reach more than 8 trillion rupiah if a similar tsunami tragedy in 2004 occurred during the period 2011-2030. The total value of housing loss can be compared in reality to the tsunami tragedy in 2004 (BRR, 2005). In a general view on a macroscopic scale, it can be seen that the application of combined land use and transport policy measures positively contribute to help Banda Aceh to reach the sustainability objectives. In reality, they can help Banda Aceh to promote the implementation of their green city concept development, which has just recently been planned (BAPPEDA, 2014). All in all, according to the results of this study, there are three potential options of combined land use and transport strategies that can be implemented in the case study area selected in order to reach the sustainability city agenda.

1) Land use plan A with combined transport A6. In this combined land use and transport strategy, the city authority should provide more budget allocation for an urban risk reduction program, especially for pre-disaster (e.g. better building regulations, early warning systems, tsunami drilling) and for post disaster efforts (e.g. the costs for rehabilitation and reconstruction after a disaster) as a result of more people and potentially more housing development in high-risk areas of the city in the future.

2) Land use plan B with combined transport B6. In this combined land use and transport strategy, the city authority could make a lower budget allocation for an

urban risk reduction program compared to the strategy with land use plan A since new potential developments in high-risk areas are strictly prohibited. The government budget plan in this strategy for the urban risk reduction program should focus on the pre disaster components rather than on post disaster efforts.

3) Land use plan C with combined transport C6. The city authority could also make a lower budget allocation for urban risk reduction programs since the projection of housing distribution in high-risk areas of the city is reduced significantly after the implementation of a new land use plan in this strategy. The budget plan for urban risk reduction in this strategy should still focus on both pre and post disaster programs since there will still be restricted areas, which can to be used as new development areas with this strategy.

However, it should be noted that the summary of the three points above is the researcher’s opinion, based on an inductive process using equal weights for all indicators selected. The further question is, which one is the best package of land use and transport policies that should be selected by stakeholders or policy makers in order to reach the sustainable city agenda in the framework of urban risk reduction and urban transport sustainability?. In this context, the stakeholders in decision making process need to forecast a description of the future image of the city in order to select the best strategy based on their sustainability city objectives.

The multi-criteria analysis approach can be selected as an alternative approach to select the best strategies that fit with the objective of a sustainable city using a weighting process, which can be conducted through a discussion group forum. In this context, it is important to conduct this process in order to avoid the self-interest of the researcher in giving policy advice to the stakeholders. As we know there are limitations to the model which might contribute to errors because other factors, which are not considered in the model, are simply ignored in the analysis process (Whyte, 2013).

Therefore, the stakeholders should also be given a logic process for thinking to make decisions not just quoting the results of scientific evidence to convince them and to claim what the best policies are. It should be understood that there is no perfect model, but that a model can be used as a scientific approach for finding the best solution, which may be acceptable to the public.

Furthermore, in reality, this issue is very important to be discussed because it has become an up-to-date issue with the United Nations program related to the issue of disaster resilience in the world. Two thousand cities worldwide have enrolled in this program. The UN has suggested that high-risk cities should integrate the important aspect of disaster risk management into their long term strategic planning in order to promote the concept of urban risk reduction (Mwendwa, 2014). However, it should be noted that the combined concept plan developed in the framework of urban risk reduction and urban transport sustainability make this research one step further ahead compared to the UN disaster resilience program.

Chapter 9
Summary, Conclusions and Recommendations

9.1 Summary

There are two important issues that can be summarized in this study. The first one is related to the summary of the methodology (9.1.1), which explains how the objectives of the study are met/answered. The second one is related to the summary of results (9.1.2), which give several answers to the various research questions set out previously in chapter 1.

9.1.1 Summary of the methodology

The summary of the methodology, which explains the way the objectives of all the research questions (research questions 1-5 in chapter 1) were reached, is as follows:

1) Problems and objectives of the research were identified. Then, a literature review was carried out to understand the concept of sustainable urban development for a certain group of high-risk cities, which are located in disaster prone areas. It was found that there has not been integration between the concepts of urban risk reduction and of urban transport sustainability. As a result, there is a gap in planning to find land use and transport strategies in the framework of sustainability since there has been no comprehensive efforts to consider these two aspects simultaneously. For this reason, we need to fill this gap by helping the group of high-risk cities to reach their future city visions in the framework of sustainability. This is the way that was selected in order to answer the question "what do we need to do" regarding how to reach the long term city strategic vision in the framework of urban risk reduction and urban transport sustainability (**research question 1**).

2) A development concept plan of land use and transport strategies was developed in order to put the new issue of sustainability in the framework of urban risk reduction and urban transport sustainability. The concept plan developed has an objective to fill the gap between the issues of urban risk reduction and urban transport sustainability in isolation, which have not been considered academically as an integrated concept. This is the way that was selected to put the issue of

sustainability into the framework of urban risk reduction with urban transport sustainability (**research question 2**).

3) Then, the city of Banda Aceh, which is located in a tsunami disaster-prone area, then was selected as a case study area. After that, a concept plan was developed and applied in the case study area selected (to be fitted with the characteristics of the case study area) with several possible alternative land use scenarios in the framework of urban risk reduction and transport strategies in the framework of urban transport sustainability. This task was conducted to show how to interpret the concept of urban risk reduction and urban transport sustainability into land use and transport strategies in order to reach the sustainability city agenda in the case study area selected (**research question 3**).

4) Several possible alternative land use and transport policy measures were tested in the MARS LUTI model. However, there are no LUTI models that consider the aspect of disaster risk in their sub land use models. Therefore, the MARS model, which was originally developed for Vienna city, was modified to be applied for Banda Aceh. The MARS model developed for Banda Aceh city consists of a pre (1985-2000) and a post-tsunami model (2006-2011). In the post-tsunami model, an original component was the addition of the disaster risk factor in the sub-land-use model of the Banda Aceh MARS model. It was found that the expected sign for the coefficient of disaster risk factor was as assumed. Therefore, this factor was taking forward in the Banda Aceh future model as explained in chapter 7, previously. This approach was selected to explain how to apply the prospective strategies in a modified LUTI model, which can be applied in the context of a high-risk city. (**research question 4**).

5) Then, eighteen (18) combined land use and transport policy measures were tested in the future model. The policies measures tested were classified into three (3) group of land use plan, which consist of BAU A (accommodation), planned-retreat B (strict zoning plan), and planned-retreat C (pricing policy). The transport policies tested in the land use plan selected consists of (1) BAU, (2) BRT, (3) parking, (4) cut fuel subsidy, (5) BRT and Parking, (6) BRT, parking and cut fuel subsidy. Therefore, all of the policy measures tested consist of A1-A6 (land use plan A), B1-B6 (land use plan B), and C1-C6 (land use plan C) (research question 5). The model results for all policy measures tested then were

evaluated using a framework assessment, which refer to the indicators selected in the framework of urban risk reduction and urban transport sustainability. The indicator selected in the framework of urban risk reduction was (1) vulnerability indicator, while the indicators selected in the framework of urban transport sustainability were (2) environment, (3) economic and (4) efficiency indicators. This was the last method selected in the way to find the several possible policies measures that should be implemented to reach the high-risk city objectives in the framework of sustainability **(research question 5)**.

9.1.2 Summary of the results

Figure 9.1. explain the final results of this study according to the evaluation results.

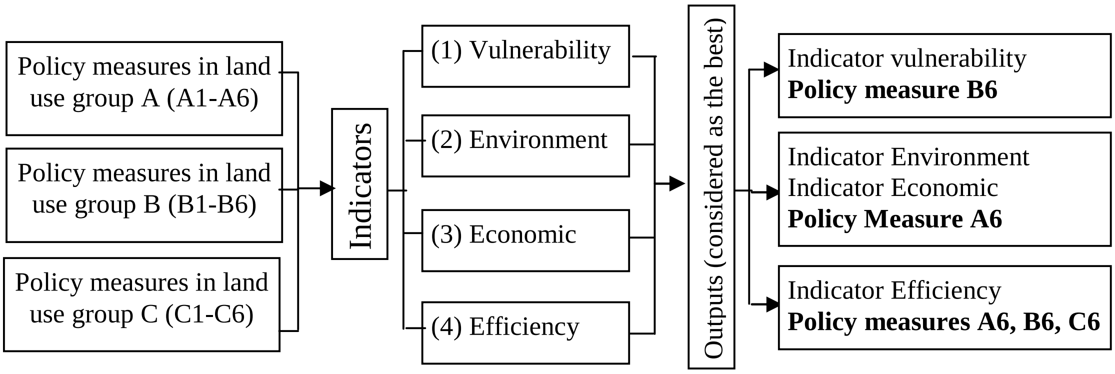

Figure 9.1 : The results summary of land use and transport policy selected in the framework of urban risk reduction and urban transport sustainability

From the Figure 9.1, there are two important issues, which can be summarized regarding the performance of policy measures selected to reach the sustainability objectives. Firstly, from the aspect of urban risk reduction (see the vulnerability indicator in the Table 8.1), the application of strict land use regulation with planned retreat B shows the best performance compared to the other two land use strategies (BAU land use plan A and land use plan C). In this case, it can be seen that the land use policy measures applied play the main role in reducing the number of people resident in the high-risk areas.

Secondly, from the aspect of urban transport sustainability, the results (see Table 8.1 for the environment indicator) showed that the combination of push and pull strategies through the application of the BRT, the parking and the cut fuel subsidy policies produced the best performance with the three groups of land use plans (A6, B6, C6). Moreover, alternative policy measure A6 showed slightly better performance compared to B6 and C6 since the land use strategies applied in policy B6 and C6 make population distribution more decentralized.

In addition, there are no significant differences with the efficiency indicator between policy measure A6 compared to B6 or C6 (see the efficiency indicator in Table 8.1). However, it should be noted that the application of policy measures e.g. A6, B6 and C6 increase the transport cost of private vehicles, which means that car and motorcycle users will not be happy with these policy measures since the objective of these strategies is to push more people to use public transport rather than private vehicles.

9.2 Conclusions

The conclusions from this research have two aspects. The first aspect is related to the policy measures part. The first aspect is related to the policy measures part (sub section 9.2.1). The second aspect is related to the modelling part (sub section 9.2.2). The policy part covers the results from the implementation of policy measures in the model. On the other hand, the modelling part covers the conclusion from the modelling aspect, including the limitation of the model to deal with complex problems in the real world.

9.2.1 Conclusions in the policy part

The conclusions from the policy part are categorized into the land use and the transport policy. Therefore, the discussion of the policy conclusion section is divided into the effect of land use policy (9.2.1.1) and transport policy measures (9.2.1.2), and finally, including the conclusion from the alternative policies packages that were applied in the model (9.2.1.3).

9.2.1.1 Effect of land use policy measures application

According to the model results, the implementation of the two land use policy measures selected (PR1_B1-B6) and PR2_C1-C6) made a significant contribution to reducing the population in the high-risk areas of the city, which positively reduced the vulnerability of the city to potential tsunami disasters in the future. In this context, there are several contributions from the alternative land use policy measures selected, which are summarised as follows :

1) The performance of the strict zoning land use plan (i.e. B6) is significantly better compared to the pricing policy (i.e. C6). Moreover, the performance of these two strategies are considered better compared to the strategy in the BAU (i.e. A6) by considering the vulnerability indicator. This result is related to the condition, where the application of strict zoning land use plan stops the possibility of people choosing to live in the high-risk areas of the city because the high-risk areas are totally banned for future development. This could reduce the potential future population in the high-risk areas of the city by more than 65% (A1 vs B1 in 2030). However, the application of this policy could result in several potential problems such as land acquisition and property rights that have to be faced by the authority during the rehabilitation and reconstruction process. This was previously faced by the local authority for Banda Aceh city as explained earlier in Chapter 4 (sub section 4.2.2).

2) The application of the land pricing policy in the planned retreat plan C (e.g. C6) can provide an "alternative different approach" regarding the land use policy approach selected to discourage people from living in the high-risk areas of the city while still respecting the aspect of land and property rights after the disaster occurred. In this policy, the city authority will intervene in the market prices for housing and rent through reform of the land and property tax in order to reduce the attractiveness of the high-risk areas of the city. This could reduce the number of people in the high-risk areas of the city in the future by about 48% (A1 vs C1), but this is still lower than the result from B6, which was about 66% (A1 Vs B1). So, this alternative policy measure C1 can be presented as "a more moderate solution" to deal with the complex problems that occur post-disaster, if policy measures with strict zoning land use plan cannot be implemented. Therefore, the application of pricing policy is one potential alternative that can be implemented in an Indonesian city in order to reach the sustainable city objectives.

3) From a broader perspective, the implementation of land use policy measures can also help the city to reach the sustainable city objective in the general indicators as explained in chapter 3 previously (e.g. fatalities, economics, environment, and future generations). For instance, the application of a strict zoning land use plan or of a pricing policy (e.g. land tax) as shown in the model results in significantly lowering the population in the high-risk areas of the city (see points 1 and 2), which would reduce the potential number of fatalities in the future. From the

economic perspective, the application of these policies can also reduce the potential economic losses in the future from damage to housing and government assets, which are planned to be built in high-risk areas of the city (vulnerability indicator in Table 8.1). From the perspective of environment, the reduction of demand to reside in the high-risk areas of the city provides more land that can be used for green space areas. From the aspect of land use regulation in the framework of urban risk reduction, the green space areas can be used as buffer areas (natural barriers) that have the objective of reducing the level of the tsunami destructive force before it reaches the housing areas in the city. From the aspect of future generations, the application of these policy measures can save many people from living in the high-risk areas of the city in the future.

9.2.1.2 Effect of the application of the transport policy measures

Based on the model results, several of transport policy measures also gave good potential results in directing the future development of Banda Aceh in the framework of urban transport sustainability (see Table 8.1 for details).

1) The application of the “push only transport strategy” through cuts in the fuel subsidy (A4) showed better results than the BAU scenario (A1) by discouraging city residents from using their private vehicles, which could save more than 3.24% per year from fuel consumption in the city as compared to A1.

2) The application of the “pull only transport strategy” through public transport improvement (BRT) (A2) showed better results compared to “the BAU scenario (A1). It could save fuel consumption by about 6.23% per year compared to policy A1. However, the performance of this policy measure is not as good as the combination of both push and pull transport strategies (e.g. A6).

3) The combination of the “push and pull transport strategy” through combining BRT, parking and cutting the fuel subsidy (e.g. A5 and A6) gave much better results compared to the “push only” or the “pull only” strategies. This transport strategy discourages people from using private vehicles on the one hand and attracts people to use the public transport system on the other hand. For instance, the application of policy A6 could reduce more than 17% of carbon emissions and it could also save fuel consumption by more than 15% compared to A1. Moreover, the government could get more than 50 billion rupiah in revenue every year. In this case, the reduction of the government burden for fuel subsidy budget

can increase the national fiscal space in order to increase the budget allocation for other important sectors such as the development of public transport, infrastructure, health or education.

9.2.1.3 Comparison of the three integrated policies packages

There are several issues that can be raised regarding the application of the best three alternative policy measures in three different land use plans, which consist of alternative policy measures A6, B6 and C6 as follows :

1) According to the model results (Table 8.1), it can be seen that there is a trade-off between the results of A6 compared to B6 or C6 in the context of directing strategies to reach the sustainable city objectives. For instance, on the one hand, in the aspect of vulnerability reduction, the application of policy measures B6 and C6 had much better performance compared to A6 since there was no land use policies that applied in this alternative policy measure. The policy measures B6 and C6 could reduce the population in the high-risk areas of the city by about 60% and 38% respectively in 2030 compared to A6. On the other hand, the performance results of indicator in the aspect of carbon emission for policy measures A6 (86,820 tonnes in 2030) was slightly better compared to B6 (87,210 tonnes in 2030) or C6 (87,710 tonnes in 2030).
2) According to the explanation in point 1 above, the city authorities might choose land use plan A (accommodation) if the stakeholders think that the aspect of accessibility is more important compared to the aspect of vulnerability to disaster risk. However, it should be noted that in this case, the government should apply other disaster mitigation strategies (e.g. evacuation routes or escape buildings as part of emergency preparedness and response) in the combined land use strategy A since the high-risk areas of the city could be used as residential areas in this strategy.
3) The application of the planned-retreat land use plan through alternative policy measure B6 (strict land use regulation) might also be selected by the city authority if the vulnerability aspect is given at the top priority for the sustainable city objectives. On the other hand, the alternative combined land use and transport policies in strategic land use plan C can also be applied as “another win-win solution alternative” (for the vulnerability indicator) if the city authority has

problems with land acquisition and property rights as the Banda Aceh city authority had after the tsunami in 2004 (See chapter 4 for detail).

9.2.2 Conclusions in modelling part

In the modelling part, several issues were raised that can be concluded as follows :

1) The application of the MARS model for a high-risk city can present new insights about how to apply alternative policy measures in the LUTI model, which can be used to show quick model results for the decision making process. Moreover, the model application can be used in a plan or blue print for long term city spatial planning for promoting the concepts of sustainability in reality.

2) According to the results from the model calibration, the pre-tsunami model was calibrated and validated well in showing the behaviour of land use and transport interactions before the tsunami, which was represented by the good correlation between the model results and the census data as discussed in Chapter 6.

3) The results from the post tsunami modelling did not produce a result as good as that from the pre-tsunami model. However, it should be noted that the results from calibration of the post tsunami model also showed that the disaster risk factor, which was added in the sub land use model of the MARS model, had the correct sign as expected, which assumed reducing the attractiveness of the high-risk areas relative to the other zones. Nevertheless, the disaster risk factor only gave a small effect, not a really significant change, due to supply side constraints. This result represents the real condition in the case study area selected, where the demand for new development in the high-risk areas of the city was still very high from 2006 to 2011 that can be seen in the quantitative data from that time (see sub section 6.3 and 6.4).

4) The crash development approach during the rehabilitation and reconstruction process in reality needs to be considered, where a market led approach is not applicable during the emergency response phase. In this context, the limitations of the model to deal with this issue, especially the difficulties faced in the process of calibrating the model for post-tsunami reconstruction should be taken into account. Thus, the current modelling tools may need to add new modules in order to improve the model performance in such a situation. These new modules could have an alternative development scenario for the first few years post-disaster

where the market based approach is not applicable before reverting to normal conditions where the development process goes back to a market based approach.

9.3 Recommendations for further studies

This sub-section is split into recommendations for further study concerning policy (9.3.1) and for those concerning modelling (9.3.2).

9.3.1 Recommendations from the policy aspect

There are two potential recommendations in the academic aspect, which can be raised in the context of policy aspect for further study of this research as follows :

1) The other alternatives of land use and transport policy measures can be proposed to provide more alternative results of modelling outputs in the further study. For instance, in the reality, the prospective policy measures proposed in the further research can be adopted from several urban land use-transport interaction plan in the framework sustainability, which is fitted with the case study selected in the future (e.g. urban growth boundary, financial incentives for disaster risk reduction in the part of land use sub model and the other types of combination of push and pull transport strategies in the part of transport sub model).
2) All of the indicators selected in the evaluation process of strategies selected were based on subjective selection by the researcher with reference to the national and local action plans for the city of Banda Aceh. In reality, a further research is needed to develop local or national indicators, which can be accepted by policy makers/stakeholders or political authority (government institution).

9.3.2 Recommendations from the modelling aspect

The two recommendations for further study made in the context of the modelling aspects of this research are as follows :

1) From the modelling aspect of land use and transport interaction, the ability of the MARS model to deal with post-disaster condition, where the process of development was not conducted in normal condition need to be considered. This aspect of modelling could be a topic for further research.
2) In the context of the case study, a comprehensive land use and transport survey, which could be done in Banda Aceh in the future, could improve the quantitative

aspects of the Banda Aceh MARS model. In this case, the application of the Banda Aceh MARS model could be used in government planning to support a periodic land use and transport survey that can enhance the capability of the model to provide more accurate and precise results.

3) Moreover, the undertaking of a stated preference survey in the future could explain more clearly why the disaster risk factor only gave a very small reduction to the attractiveness of the high-risk areas of the city. The variable disaster risk did not give a significant effect due to supply side constraints such as e.g. limited choice of locations for planned development of residential areas during the rehabilitation and reconstruction process after the tsunami. In this context, the survey results could explain the minimal effect of disaster risk in the post tsunami model, which may be due to the lack of choices at that time or it may indeed be the case in reality.

4) In the context of Indonesia, another important point is that it is interesting to represent income group in the model in order to explore more the performance of fuel subsidy application, which may be applied in different way for higher (not subsidised) and lower income groups (subsidised).

9.4 Recommendation for policy makers

There are several rational reasons, why the further application of the concept plan developed in this Banda Aceh MARS model has potential to be implemented in other case studies, especially with other Indonesian cities, these are as follows:

1) All of the local government has several action plans in the local, national, and global context (e.g. their priority programs) in the framework of urban risk reduction and urban transport sustainability, which need a reliable forecasting model using scientific approach for finding the best alternative evidence-based policies, in order to reach the sustainability city agenda.

2) The further development of this research in the aspect modelling and policy could help the government to start their planning process in the right way using evidence based policy approach, especially in the aspect of land use and transport interaction.

3) The comprehensive approach of multi-criteria analysis can be proposed as a further research by involving the policy makers in order to understand how their vision regarding e.g. the to treat small annual risk versus longer term climate change with more regular lower level flooding versus much less frequent but more severe of tsunami for instance.

9.4.1 Example of recommendation for policy makers

There are several examples for further application of this research (e.g. using the concept and strategies developed, including the model) to be used in various future local government or international programs to find ways to reach city objectives in the framework of urban risk reduction and urban transport sustainability, such as:

1) From the aspect of urban transport sustainability, the concept developed in this research could be used to involve Banda Aceh city in the international program of promoting the concept of urban transport sustainability (e.g. 100 cities engaged in sustainable urban mobility planning to reduce greenhouse gas emissions). For instance, Banda Aceh is one of the cities that involved in the program “MobiliseYour City Program as part of Sustainable Urban Mobility program under Cooperation for Urban Mobility in the developing World (CODATU) in January 2016. Banda Aceh was among the first cities to join the international platform to promote sustainable urban mobility planning in this program.

2) In the aspect of urban risk reduction program, it is also potential for Banda Aceh city to be involved in the program e.g. 100 resilient cities by the Rockefeller foundation as part of global coalition program in order to promote the concept of resilient cities (https://www.rockefellerfoundation.org/our-work/initiatives/100-resilient-cities/). In November 2015, the urban risk reduction part of this research also presented in the International workshop on the development of disaster resilience, which was conducted on Campus of ITB Indonesia with cooperation with Huddersfield University UK, supported by researcher links program (cooperation between British Council and Newton Fund).

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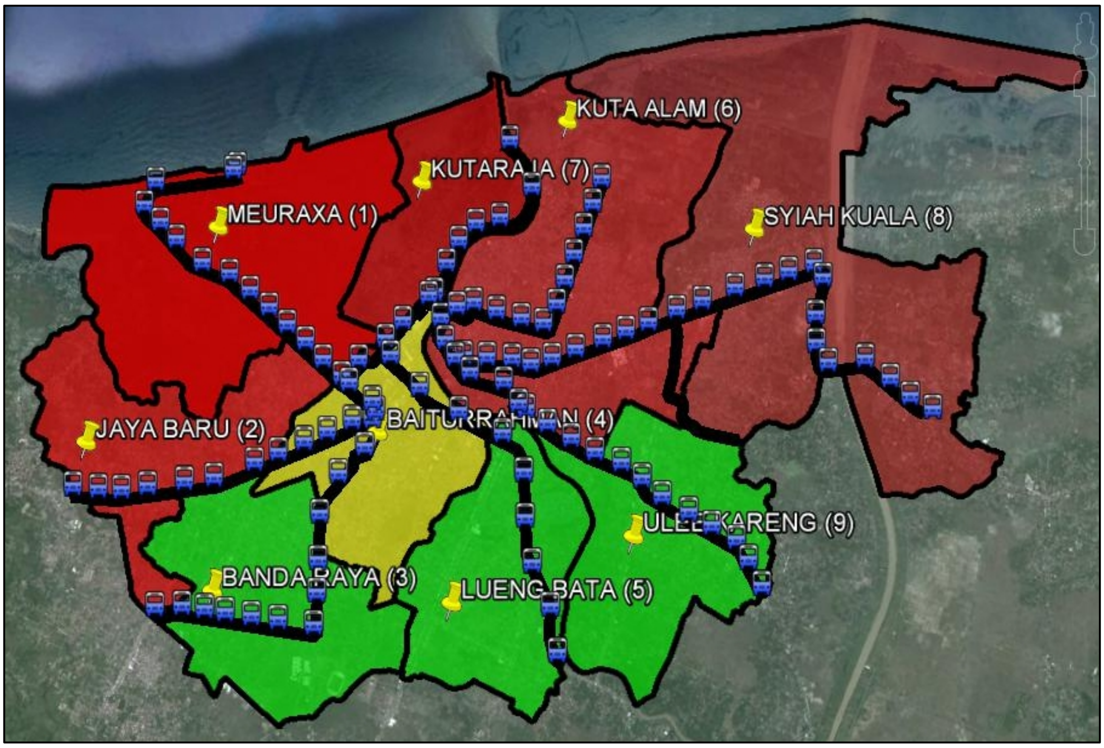
Appendices

Appendix A Public Transport Improvement

Appendix A.1 below shows the BRT planning in Banda Aceh city that used in this research as a strategy to improve the public transport condition (DISHUB, 2008). In the practice, the bus stop distance planned may be in the 300 to 1000 m (Wright, 2002, ITDP, 2013b).



Appendix A.1 BRT planning in the case study area selected

Appendix A.2 shows the total cost for bus stop development in the case study area selected based on data from department of transportation in Banda Aceh city (DISHUB, 2012) .

No	Works items in bus stop development	Price (Rupiah) (IDR)
A.	Structure Works	83,698,471.85
B.	Architecture Works	35,315,763.30
C.	Electrical Works	2,436,000.00
D.	Total before tax	121,450,235.15
E.	PPN 10% (Tax)	12,145,023.52
F.	Total after tax	133,595,200.00

Appendix A.2 Total cost for building bus stop infrastructure

Furthermore, In current practice, the capital cost for BRT may be in the range US $ 1-10 million per km. In this study, it was assumed to use the minimum cost BRT infrastructures to fit with the local government budget. From the Jakarta case study, it was found that the TransJakarta implementation in 2001 used the fund allocations from the government routine development budget. In this context, it is expected that the concept can be adopted in the developing cities of developing countries due to low cost reason compared to other mass transit option that may cost much more expensive. In fact, the BRT cost is only around US$400,000-US$2 million (Wright and Fjellstrom, 2003). The data mentioned in Appendix A.1 and Appendix A.2 were used later in BRT infrastructure cost calculator in the Appendix A.3.

The number of bus stop selected refer to the bus stop distance mentioned earlier (ITDP, 2013b) and the estimation of bus stop cost refer to the real data in the case study area selected rather than the estimation bus stop cost in BRT calculator that cost more expensive (DISHUB, 2012, ITDP, 2013a). The number of bus stop and the distance of busway kilometre were selected based on the real condition in the case study area selected using software Google Earth. The road networks that use as the bus lanes refer to the data provided in ARCGIS and the data from department of transport (DISHUB, 2008). The formula used to calculate several item in calculating the cost for BRT infrastructure are shown below.

$$No\ of\ bus\ stop = \sum_{Zone\ 1-9} Number\ \ bus\ stops$$ **Eq. Appendix 1**

$$Cost of\ busstop = \sum Cost((Structure + Architecture + electricity) + tax))$$ **Eq. Appendix 2**

Moreover, several others calculations are provided in the BRT infrastructure calculator that provided in the CD (e.g. the formula used in the BRT calculator) of this research. The BRT calculator was developed by The Institute for Transportation and Development Policy (ITDP, 2013a). The detail calculation of BRT infrastructure cost estimation can be seen in Appendix A.3. Based on the estimation results, the total cost obtained for BRT infrastructure was $1,072,208.92 or if it is converted to Indonesia rupiah, the total equal to Rp. 10,722,089,246. This result was conformed with the capital cost in the BRT guidelines (ITDP, 2013b).

BRT Infrastructure Cost Calculator					1$ = Rp. 10,000.-	
Input number of busway kilometres	33.0					
Item	**Cost/unit**	**Units**	**Reference info.**	**Quantity requested**	**Cost (US$)**	**Cost (IDR)**
Busway construction / roadway reconfiguration			**No. of km.**	**Enter no. of km of each type**		
Use existing asphalt on busway / new concrete at stations	150,000	US$ per kilometre	33.0	33.0	$4,950,000	Rp. 49,500,000,000
Busway colouration			**No. of km.**	**Enter no. of km of each type**		
Busway with fully colourised lanes	50,000	US$ per kilometre	33.0	33.0	$1,650,000	Rp. 16,500,000,000
Station construction			**No. of stations**	**Enter no. of stations of each type**		
RAB DISHUB KOTA BANDA ACEH (Stations)	303,468,700	Rupiah per station		113.0	$3,429,196	Rp. 34,291,963,100
Number of Bus	2,162,857,143			100.0	$21,628,571	Rp. 216,285,714,286
Maps and information			**No. of stations**	**Enter no. of stations or kiosks**		
Maps at stations	3,000	US$ per station	66	113.0	$339,000	Rp. 3,390,000,000
Fare collection readers			**No. of stations**	**Enter no. of stations w/ each type**		
Coin-based system (2 readers per station)	1,500	US$ per station	66	113.0	$169,500	Rp. 1,695,000,000
				Sub-total	$32,166,267.74	Rp. 321,662,677,386
10% contingency		US$			$3,216,626.77	Rp .32,166,267,739
Total cost projection in the range US$400,000 – US$2 million (Module 3a : Mass Transit Options) (Wright and Fjellstrom, 2003)					**$35,382,894.51**	**353,828,945,124**
Cost per kilometre (including planning costs)					**$1,072,208.92**	**10,722,089,246**

Appendix A.3 : Total cost estimation for building the BRT Infrastructure for BRT initial investment (ITDP, 2013a)

Appendix B Fuel Consumption

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Assumption used $dollar	9,036	9,100	10,399	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500	10,500
Premium/liter	4500	4,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Solar/liter	4500	4,500	5,500	5,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
Fuel/barrel (us$)	112	110	108	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106

Economic fuel price before alpha & tax	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Premium/liter	6,340	6,296	7,064	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001
Solar/liter	6,340	6,296	7,064	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001	7,001
Economic fuel (alpha_10%)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Premium/liter	6,974	6,926	7,771	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701
Solar/liter	6,974	6,926	7,771	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701	7,701

Economic fuel (tax_15%)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Premium/liter	8,020	7,965	8,936	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856
Solar/liter	8,020	7,965	8,936	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856	8,856
Fuel Subsidy per liter	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Premium/liter	3,520	3,465	2,436	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356
Solar/liter	3,520	3,465	3,436	3,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356	2,356

Appendix B.1 : Assumption used to calculate fuel subsidy and government revenue from fuel saving as a result of alternative transport policy measures (SETKAB, 2013, Aswicahyono et al., 2011, ESDM, 2013)

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Appendix C Efficiency

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT bus																				
A1	504	503	503	503	502	501	501	500	500	500	499	499	499	499	499	499	499	499	499	499
A4	503	503	503	503	503	502	501	501	500	500	501	502	502	503	504	504	505	506	506	507
A3	504	502	499	496	494	492	491	490	488	486	484	482	480	478	476	474	473	471	470	469
A2	492	492	492	492	492	492	491	491	491	491	491	492	492	493	493	494	494	495	495	495
A5	492	491	488	486	484	482	481	481	480	478	476	474	472	471	469	468	466	465	465	464
A6	492	491	488	485	483	482	481	480	479	478	476	474	472	470	469	467	466	465	464	463
Car																				
A1	586	583	613	604	597	591	586	580	576	571	565	560	555	551	547	544	542	539	537	535
A4	762	762	796	788	786	783	781	780	778	777	776	775	774	774	774	776	778	780	782	785
A3	3,552	3,542	3,590	3,571	3,556	3,542	3,529	3,518	3,507	3,497	3,486	3,475	3,465	3,456	3,450	3,442	3,436	3,431	3,427	3,425
A2	586	583	612	603	597	591	585	580	575	571	565	560	555	551	547	544	541	539	537	535
A5	3,550	3,540	3,588	3,568	3,554	3,540	3,527	3,516	3,505	3,495	3,484	3,473	3,463	3,454	3,448	3,444	3,437	3,433	3,430	3,428
A6	3,850	3,845	3,895	3,878	3,870	3,862	3,854	3,849	3,844	3,839	3,834	3,830	3,826	3,823	3,824	3,827	3,828	3,830	3,834	3,839
Moto																				
A1	293	291	300	297	294	292	289	287	285	284	282	280	278	276	275	274	273	272	272	271
A4	355	354	365	362	361	360	359	359	358	358	357	357	357	357	357	358	359	360	361	362
A3	2,006	1,999	2,012	1,997	1,985	1,974	1,965	1,957	1,950	1,942	1,933	1,925	1,917	1,910	1,904	1,899	1,895	1,891	1,888	1,887
A2	292	291	300	296	294	292	289	287	285	284	282	280	278	277	275	274	273	273	272	272
A5	2,003	1,996	2,009	1,994	1,983	1,973	1,964	1,957	1,950	1,943	1,935	1,927	1,919	1,912	1,907	1,902	1,898	1,895	1,892	1,890
A6	2,129	2,125	2,141	2,128	2,120	2,113	2,108	2,103	2,099	2,095	2,091	2,086	2,082	2,078	2,076	2,075	2,074	2,074	2,074	2,076

Appendix C.1 Projection of travel cost (peak) by mode of transport per km in BAU land use plan A (in Indonesia Rupiah)

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YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT bus																				
B1	504	503	503	502	502	501	500	498	497	496	495	495	494	494	492	490	487	484	483	482
B4	503	503	502	502	502	501	500	499	498	497	497	497	496	495	493	491	488	486	484	483
B3	504	503	502	500	498	496	494	492	489	486	483	481	479	476	475	474	474	475	476	478
B2	492	492	492	492	491	491	490	489	488	487	487	486	486	486	484	482	480	478	476	475
B5	492	492	490	489	487	486	484	482	480	478	475	473	471	469	468	466	467	468	469	471
B6	492	491	490	489	487	486	484	482	480	477	475	473	471	469	467	466	467	468	469	471
Car																				
B1	586	583	613	604	598	592	586	581	576	572	567	562	557	552	549	546	543	541	539	537
B4	762	762	796	789	786	784	782	781	779	778	777	776	776	775	776	778	780	782	785	788
B3	3,552	3,543	3,592	3,574	3,560	3,547	3,535	3,524	3,514	3,504	3,494	3,484	3,474	3,466	3,459	3,452	3,447	3,444	3,442	3,442
B2	586	583	613	604	598	592	586	581	576	572	566	561	557	552	549	546	543	541	539	537
B5	3,550	3,541	3,590	3,572	3,558	3,545	3,533	3,522	3,512	3,502	3,492	3,482	3,472	3,464	3,459	3,454	3,449	3,446	3,445	3,445
B6	3,850	3,846	3,897	3,881	3,874	3,867	3,860	3,855	3,851	3,847	3,843	3,840	3,837	3,835	3,836	3,839	3,841	3,845	3,851	3,858
Moto																				
B1	293	291	301	297	295	293	291	289	287	285	284	282	280	279	278	277	276	276	275	275
B4	355	354	366	363	362	361	360	360	359	359	359	359	359	359	359	360	361	362	363	364
B3	2,006	2,002	2,018	2,008	1,999	1,992	1,984	1,976	1,968	1,961	1,953	1,945	1,938	1,932	1,928	1,926	1,927	1,929	1,933	1,937
B2	292	291	301	297	295	293	291	289	287	285	284	282	280	279	278	277	276	276	275	275
B5	2,003	1,998	2,015	2,005	1,997	1,990	1,983	1,975	1,968	1,961	1,953	1,946	1,939	1,934	1,930	1,928	1,928	1,930	1,934	1,938
B6	2,129	2,127	2,147	2,138	2,134	2,130	2,125	2,121	2,117	2,112	2,108	2,104	2,101	2,098	2,097	2,098	2,102	2,106	2,113	2,120

Appendix C.2 : Projection of travel cost (peak) by mode of transport per km in planned-retreat land use plan B (in Indonesia Rupiah)

YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT Bus																				
C1	504	503	503	503	502	502	501	499	498	497	497	496	496	495	495	495	495	494	494	494
C4	503	503	503	503	503	502	501	500	499	498	498	498	498	498	498	498	498	498	498	498
C3	504	503	501	499	497	496	494	493	490	488	486	484	482	480	478	476	474	473	472	471
C2	492	492	492	492	492	492	491	490	489	488	488	488	488	488	488	488	488	488	488	488
C5	492	491	489	488	487	486	485	483	482	480	478	476	474	472	471	469	468	467	466	465
C6	492	491	489	488	487	486	485	483	481	479	477	476	474	472	470	469	468	466	465	464
Car																				
C1	586	583	613	604	597	591	586	580	575	571	565	560	555	551	547	544	541	539	537	535
C4	762	762	796	788	786	783	781	780	778	777	776	775	774	773	774	776	778	780	782	785
C3	3,552	3,541	3,589	3,569	3,554	3,539	3,526	3,514	3,503	3,492	3,480	3,469	3,459	3,449	3,443	3,436	3,429	3,425	3,422	3,421
C2	586	583	612	603	597	591	585	580	575	570	565	560	555	550	547	544	541	539	537	535
C5	3,550	3,539	3,587	3,567	3,552	3,537	3,524	3,512	3,501	3,490	3,478	3,467	3,457	3,448	3,442	3,438	3,431	3,427	3,425	3,424
C6	3,850	3,844	3,894	3,877	3,868	3,859	3,852	3,845	3,840	3,834	3,830	3,825	3,821	3,818	3,819	3,822	3,823	3,826	3,831	3,836
Moto																				
C1	293	291	301	297	295	292	290	288	286	284	282	280	279	277	276	275	274	273	273	273
C4	355	354	366	362	361	361	360	359	358	358	358	357	357	357	357	358	359	360	361	362
C3	2,006	2,000	2,015	2,003	1,995	1,987	1,979	1,971	1,962	1,954	1,945	1,937	1,928	1,921	1,915	1,910	1,906	1,904	1,902	1,902
C2	292	291	300	297	294	292	290	288	286	284	282	280	279	277	276	275	274	273	273	273
C5	2,003	1,996	2,012	2,001	1,993	1,985	1,977	1,970	1,962	1,954	1,946	1,938	1,930	1,923	1,917	1,912	1,908	1,906	1,905	1,905
C6	2,129	2,125	2,143	2,134	2,129	2,125	2,120	2,116	2,111	2,106	2,101	2,096	2,092	2,087	2,085	2,084	2,083	2,084	2,086	2,088

Appendix C.3 : Projection of travel cost (peak) by mode of transport per km in planned-retreat land use plan C (in Indonesia Rupiah)

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YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT bus																				
A1	42	42	42	43	43	43	43	44	44	44	44	44	45	45	45	46	46	46	47	47
A4	42	42	42	43	43	43	43	44	44	44	44	44	44	45	45	45	46	46	46	47
A3	42	42	43	43	43	44	44	44	44	45	45	45	46	46	46	47	47	48	48	49
A2	29	29	29	29	29	30	30	30	30	31	31	31	31	31	32	32	32	33	33	34
A5	29	29	29	30	30	30	30	31	31	31	32	32	32	33	33	33	34	34	35	35
A6	29	29	29	30	30	30	30	31	31	31	32	32	32	33	33	33	34	34	35	35
Car																				
A1	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13
A4	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	13
A3	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
A2	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13
A5	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
A6	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Moto																				
A1	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12	12
A4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11
A3	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14
A2	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12	12
A5	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14	14
A6	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13	13	13	13	13

Appendix C.4 : Projection of travel time (peak) by mode of transport in BAU land use plan A (in minutes)

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YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT bus																				
B1	42	42	42	43	43	43	43	44	44	44	44	45	45	45	45	46	46	47	47	47
B4	42	42	42	43	43	43	43	44	44	44	44	44	45	45	45	46	46	46	47	47
B3	42	42	43	43	43	43	44	44	44	45	45	45	46	46	46	47	47	47	48	48
B2	29	29	29	29	29	30	30	30	30	31	31	31	31	31	32	32	33	33	33	34
B5	29	29	29	30	30	30	30	31	31	31	32	32	32	33	33	33	34	34	34	34
B6	29	29	29	30	30	30	30	31	31	31	32	32	32	33	33	33	34	34	34	34
Car																				
B1	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13
B4	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13
B3	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
B2	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13
B5	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
B6	12	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	14	14	14	14
Moto																				
B1	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12
B4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11
B3	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14
B2	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12
B5	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	13	14	14
B6	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13	13	13	13

Appendix C.5 : Projection of travel time (peak) by mode of transport in planned-retreat land use plan B (in minutes)

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YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PT Bus																				
C1	42	42	42	43	43	43	43	44	44	44	44	44	45	45	45	46	46	46	47	47
C4	42	42	42	43	43	43	43	44	44	44	44	44	45	45	45	45	46	46	46	47
C3	42	42	43	43	43	43	44	44	44	45	45	45	46	46	46	47	47	48	48	48
C2	29	29	29	29	29	30	30	30	30	31	31	31	31	31	32	32	32	33	33	33
C5	29	29	29	30	30	30	30	31	31	31	32	32	32	32	33	33	34	34	34	35
C6	29	29	29	30	30	30	30	31	31	31	32	32	32	32	33	33	34	34	34	35
Car																				
C1	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13
C4	11	11	11	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	12	13
C3	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
C2	11	11	11	11	11	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13
C5	13	13	13	13	13	13	13	13	13	13	13	13	13	14	14	14	14	14	14	15
C6	12	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	14	14	14	14
Moto																				
C1	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12
C4	10	10	10	10	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11
C3	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	14	14	14
C2	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	12	12	12
C5	12	12	12	12	12	12	12	12	12	12	12	12	13	13	13	13	13	14	14	14
C6	11	11	11	11	11	11	11	12	12	12	12	12	12	12	12	13	13	13	13	13

Appendix C.6 : Projection of travel time (peak) by mode of transport in planned-retreat land use plan C (in minutes)

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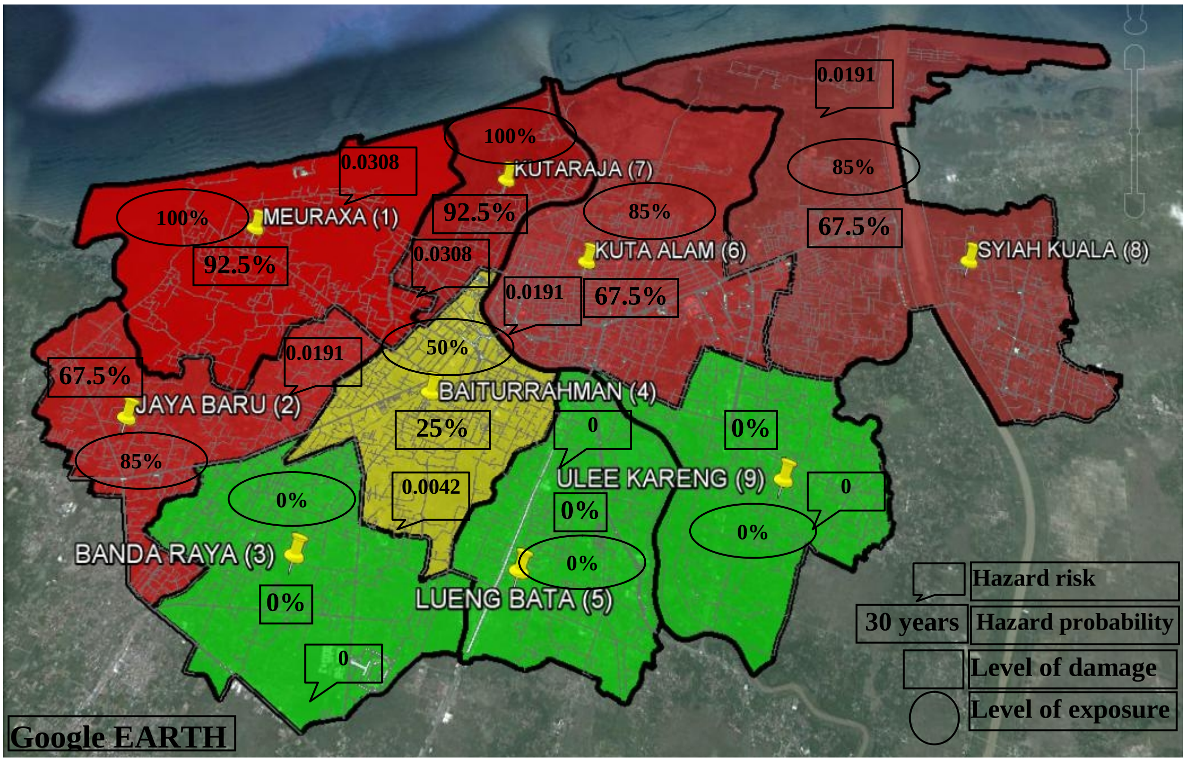
Appendix D Tsunami hazard risk in the case study area selected

Appendix D.1 below shows the calculation of tsunami hazard risk, which was calculated based on the information data in tsunami tragedy 2004 in the case study area as already explained in chapter 4 section 4.2. The formula used in calculation process refer to the formula in the sub section 8.3.1 equation 8.1.



Appendix D.1 : Hazard risk calculation for all zones in the case study area selected

The map provided in the Appendix D.1 shows the important aspect of the integration several information of disaster risk into the land use plan. In the reality, this issue has been becoming the main concern of Indonesian government through the application of spatial planning regulation for all Indonesian cities. The Indonesian National Board for Disaster Management (BNPB) has prepared some concept plan in the aspect of disaster mitigation in order to promote the urban development in the framework of urban risk reduction (e.g. disaster risk map). However, there have been not many cities that follow this regulation. In fact, the new building development are still allowed to be built in the high-risk areas of the city. It is needed a goodwill and serious commitment from the city local government to follow this regulation through implementation of land use policy (Utomo, 2014).

Appendix E Potential of loss from housing sector in high-risk areas of the city

In this part, the price of housing calculation used in the assumptions refer to the housing regulation in Indonesia regarding housing tax determination based on housing value per m square (Dirjen-Pajak, 2012). Appendix E.1 shows the lowest prices of Indonesian government building that classified into building with more than 1 floor and 1 floor building.

Buildings (more than 1 Floor Building)		Building (1 floor building)	
Classification of standard building	Classification of Specific Building	Classification of standard building	Classification of Specific Building
1	2	3	4
Rp. 4,553,000.00	Rp. 6,374,000.00	Rp. 3,339,000.00	Rp. 4,676,000.00

Appendix E.1 : The lowest prices for government building per m^2 (Dirjen-Pajak, 2012)

Furthermore, Appendix E.2 shows the government lowest prices of housing prices in Indonesia that classified into house type A, B and C.

Government Housing		
Type A	Type B	Type C
5	6	7
Rp. 3,805,000.00	Rp. 3,805,000.00	Rp. 3,004,000.00

Appendix E.2 : The lowest prices for government housing per m^2 (Dirjen-Pajak, 2012)

However, it should be noted that the assumptions used for housing prices above is slightly more expensive compared to other prices that used in the past study in the case study area selected. For instance, the assumptions used for average value of permanent housing in Indonesia was 76 million rupiah (for small house with type 36) in order to calculate the potential damage value of house (Marchand et al., 2009).

In the context of this study, it was assumed that the housing prices in the BAU scenario plan are more expensive compared to in the planned-retreat land use plan. The housing price standard for housing in the BAU land use plan refer to the government housing prices for 1 floor specific building as shown in the Appendix E.1, while the housing prices in the planned retreat strategy refer to the government housing prices type A as shown in the Appendix E.2.

ZONE_NAMES	BAU_2030 (A6)	PR1_2030 (B6)	PR2_2030 (C6)
MEURAXA (1)	12,343	4,215	6,480
JAYA BARU (2)	10,925	8,470	10,105
BANDA RAYA (3)	6,275	10,703	9,553
BAITURRAHMAN (4)	6,058	7,755	7,185
LUENG BATA (5)	6,630	9,423	8,483
KUTA ALAM (6)	19,000	17,328	19,518
KUTARAJA (7)	6,220	2,668	3,323
SYIAH KUALA (8)	15,570	18,840	15,860
ULEE KARENG (9)	6,873	10,495	9,385

Appendix E.3 : Housing distributions in all zones of the case study area in three land use plan selected

ZONE_NAMES	Level of damage	BAU_2030 (A6)	PR1_2030 (B6)	PR2_2030 (C6)
MEURAXA (1)	0.925	11,417	3,899	5,994
JAYA BARU (2)	0.675	7,374	5,717	6,821
BANDA RAYA (3)	0.000	0	0	0
BAITURRAHMAN (4)	0.250	1,514	1,939	1,796
LUENG BATA (5)	0.000	0	0	0
KUTA ALAM (6)	0.675	12,825	11,696	13,174
KUTARAJA (7)	0.925	5,754	2,467	3,073
SYIAH KUALA (8)	0.675	10,510	12,717	10,706
ULEE KARENG (9)	0.000	0	0	0

Appendix E.4 : Number of housing damage in three land use plan selected

ZONE_NAMES	Level of damage	BAU_2030 (A6) (in Rupiah)	PR1_2030 (B6) (In Rupiah)	PR2_2030 (C6) (In Rupiah)
MEURAXA (1)	0.925	1,921,860,549,000	534,067,897,500	821,058,120,000
JAYA BARU (2)	0.675	1,241,372,790,000	783,148,905,000	934,323,457,500
BANDA RAYA (3)	0.000	0	0	0
BAITURRAHMAN (4)	0.250	254,923,830,000	265,569,975,000	246,050,325,000
LUENG BATA (5)	0.000	0	0	0
KUTA ALAM (6)	0.675	2,158,909,200,000	1,602,126,641,250	1,804,617,326,250
KUTARAJA (7)	0.925	968,521,176,000	337,989,588,750	420,982,346,250
SYIAH KUALA (8)	0.675	1,769,169,276,000	1,741,974,660,000	1,466,439,390,000
ULEE KARENG (9)	0.000	0	0	0
Total		**7,642,445,983,200**	**8,314,756,821,000.00**	**5,264,877,667,500.00**
Total		**7.64 trillion**	**8.31 trillion**	**5.26 trillion**

Appendix E.5 : Projection of total loss from the housing sector based on model projection in three land use plan selected (in Indonesia rupiah)

Appendix F Net-Present Value Calculation

In this appendix, the net-present value (NPV) calculation was conducted tow show the cash flows time series of transport strategies implementation in Banda Aceh MARS model. The alternative policy measure A6 was selected to be evaluated using the NPV calculation. However, it should be noted that the potential loss as shown in the Appendix E.3, E.4 and E.5 regarding the vulnerability indicator was not included in the NPV calculation process. Nevertheless, this indicator was included in the discussions of chapter 8 and 9. It is important to present this discussion since after the tsunami tragedy the Indonesian government has started to include the disaster risk reduction (DRR) issue in national long term strategic plan. In the context of budget allocation, Indonesia government adopted the global agreement funding support, which recommended 1% of total national budget for support disaster risk reduction. In fact, in the reality, the total funding allocated for DRR has reached about 0.7% of the total national budget (Hadi, 2013).

The indicator selected in the NPV calculation consists of oil revenue, parking revenue, BRT fare revenue, BRT operational and maintenance cost and BRT road infrastructure cost. All the cost are in Indonesia Rupiah. The NPV then was calculated using the NPV formula feature option supplied in the Microsoft Excel that used a formula as shown below.

$$NPV\ (i) = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t} - BRT\ \ initial\ \ investment$$

Source : http://office.microsoft.com/en-gb/excel-help/npv-HP005209199.aspx

This interest rate used in the NPV calculation used an assumption refer to the average of Indonesia actual inflation from 2001-2013 (Indonesia, 2014). In the calculation process, the NPV calculation was conducted for all alternative policy measures selected in three land use plan, which consist of land use plan A (BAU), land use plan B with strict zoning plan and land use plan C with pricing policy. The results of NPV calculation can be seen in in the Appendix F.1 to Appendix F.18 in the next pages.

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	**Parking Revenue (B) (Billion Rupiah)**	**BRT Revenue (C) (Billion Rupiah)**	**Fuel Subsidy (D) (Billion Rupiah)**	**BRT O & M (E)(Billion Rupiah)**	**BRT infrastructure cost (F) (Billion Rupiah)**	**Revenue - Cost (A+B+C)-(D+E+F)**
0_(2011)	0.00	2.08	0.00	365.02	0.00	0.00	-362.94
1_(2012)	0.00	2.15	0.00	367.59	0.00	0.00	-365.44
2_(2013)	0.00	2.23	0.00	288.49	0.00	0.00	-286.26
3_(2014)	0.00	2.31	0.00	285.59	0.00	0.00	-283.28
4_(2015)	0.00	2.39	0.00	262.43	0.00	0.00	-260.04
5_(2016)	0.00	2.47	0.00	267.14	0.00	0.00	-264.67
6_(2017)	0.00	2.56	0.00	272.79	0.00	0.00	-270.24
7_(2018)	0.00	2.66	0.00	279.86	0.00	0.00	-277.20
8_(2019)	0.00	2.76	0.00	287.16	0.00	0.00	-284.40
9_(2020)	0.00	2.85	0.00	293.05	0.00	0.00	-290.21
10_(2021)	0.00	2.91	0.00	297.53	0.00	0.00	-294.62
11_(2022)	0.00	2.97	0.00	302.71	0.00	0.00	-299.74
12_(2023)	0.00	3.03	0.00	307.89	0.00	0.00	-304.86
13_(2024)	0.00	3.10	0.00	314.72	0.00	0.00	-311.63
14_(2025)	0.00	3.17	0.00	323.68	0.00	0.00	-320.50
15_(2026)	0.00	3.25	0.00	333.57	0.00	0.00	-330.32
16_(2027)	0.00	3.33	0.00	343.94	0.00	0.00	-340.60
17_(2028)	0.00	3.41	0.00	353.83	0.00	0.00	-350.42
18_(2029)	0.00	3.47	0.00	362.31	0.00	0.00	-358.84
19_(2030)	0.00	3.54	0.00	370.79	0.00	0.00	-367.25
NPV	**0.00**	**25.90**	**0.00**	**3041.36**	**0.00**	**0.00**	**-3,015.46**

Appendix F.1 : Result of NPV calculation for economic indicators selected in BAU land use plan A1 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	31.47	1.89	53.98	333.56	85.00	353.80	-685.02
1_(2012)	31.39	1.95	53.48	336.20	84.04	3.54	-336.96
2_(2013)	25.06	2.02	54.26	263.42	85.05	7.08	-274.21
3_(2014)	24.49	2.09	53.58	261.09	83.76	10.61	-275.30
4_(2015)	22.14	2.17	52.93	240.28	82.54	14.15	-259.74
5_(2016)	22.14	2.25	52.21	245.00	81.20	17.69	-267.29
6_(2017)	22.14	2.33	51.21	250.65	79.44	17.69	-272.09
7_(2018)	22.14	2.43	49.58	257.72	76.60	17.69	-277.85
8_(2019)	22.14	2.53	47.87	265.02	73.57	17.69	-283.74
9_(2020)	22.38	2.61	47.06	270.67	71.99	17.69	-288.30
10_(2021)	22.14	2.67	47.96	275.38	73.17	17.69	-293.47
11_(2022)	22.38	2.73	48.93	280.33	74.48	21.23	-302.00
12_(2023)	22.38	2.79	49.96	285.51	75.86	24.77	-311.01
13_(2024)	22.61	2.86	50.87	292.11	77.06	28.30	-321.13
14_(2025)	22.85	2.93	51.50	300.83	77.82	28.30	-329.67
15_(2026)	23.32	3.01	52.07	310.25	78.47	28.30	-338.63
16_(2027)	23.56	3.09	52.47	320.38	78.82	28.30	-348.39
17_(2028)	23.79	3.16	52.93	330.04	79.13	28.30	-357.59
18_(2029)	23.09	3.23	53.68	339.22	79.79	28.30	-367.32
19_(2030)	23.09	3.29	54.65	347.70	80.76	28.30	-375.74
NPV	**240**	**24**	**508**	**2,801**	**785**	**481**	**- 3,294**

Appendix F.2 : Result of NPV calculation for economic indicators selected in BAU land use plan A2 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	**Parking Revenue (B) (Billion Rupiah)**	**BRT Revenue (C) (Billion Rupiah)**	**Fuel Subsidy (D) (Billion Rupiah)**	**BRT O & M (E)(Billion Rupiah)**	**BRT infrastructure cost (F) (Billion Rupiah)**	**Revenue - Cost (A+B+C)-(D+E+F)**
0_(2011)	1.06	15.92	0.00	363.97	0.00	0.00	-346.99
1_(2012)	0.00	16.54	0.00	367.59	0.00	0.00	-351.05
2_(2013)	-0.54	17.17	0.00	289.02	0.00	0.00	-272.39
3_(2014)	-1.04	17.78	0.00	286.63	0.00	0.00	-269.89
4_(2015)	-1.41	18.39	0.00	263.84	0.00	0.00	-246.86
5_(2016)	-1.41	19.01	0.00	268.55	0.00	0.00	-250.96
6_(2017)	-2.12	19.71	0.00	274.91	0.00	0.00	-257.32
7_(2018)	-3.06	20.54	0.00	282.92	0.00	0.00	-265.44
8_(2019)	-3.77	21.40	0.00	290.93	0.00	0.00	-273.30
9_(2020)	-4.48	22.17	0.00	297.53	0.00	0.00	-279.83
10_(2021)	-5.18	22.75	0.00	302.71	0.00	0.00	-285.14
11_(2022)	-5.65	23.33	0.00	308.36	0.00	0.00	-290.69
12_(2023)	-6.36	23.92	0.00	314.25	0.00	0.00	-296.69
13_(2024)	-7.07	24.55	0.00	321.79	0.00	0.00	-304.31
14_(2025)	-8.01	25.24	0.00	331.69	0.00	0.00	-314.46
15_(2026)	-7.77	25.92	0.00	341.34	0.00	0.00	-323.20
16_(2027)	-7.54	26.62	0.00	351.47	0.00	0.00	-332.39
17_(2028)	-7.07	27.25	0.00	360.90	0.00	0.00	-340.71
18_(2029)	-7.07	27.81	0.00	369.38	0.00	0.00	-348.63
19_(2030)	-7.07	28.32	0.00	377.86	0.00	0.00	-356.61
NPV	**-30**	**202**	**-**	**3,071**	**-**	**-**	**-2,899**

Appendix F.3 : Result of NPV calculation for economic indicators selected in BAU land use plan A3 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	13.02	2.09	0.00	0	0.00	0.00	15.12
1_(2012)	13.51	2.17	0.00	0	0.00	0.00	15.68
2_(2013)	10.48	2.24	0.00	0	0.00	0.00	12.72
3_(2014)	10.68	2.32	0.00	0	0.00	0.00	13.00
4_(2015)	9.89	2.40	0.00	0	0.00	0.00	12.29
5_(2016)	10.13	2.48	0.00	0	0.00	0.00	12.61
6_(2017)	10.37	2.58	0.00	0	0.00	0.00	12.94
7_(2018)	10.60	2.69	0.00	0	0.00	0.00	13.29
8_(2019)	10.84	2.80	0.00	0	0.00	0.00	13.63
9_(2020)	11.07	2.89	0.00	0	0.00	0.00	13.96
10_(2021)	11.07	2.95	0.00	0	0.00	0.00	14.02
11_(2022)	11.54	3.02	0.00	0	0.00	0.00	14.56
12_(2023)	11.78	3.09	0.00	0	0.00	0.00	14.87
13_(2024)	12.01	3.16	0.00	0	0.00	0.00	15.18
14_(2025)	12.25	3.24	0.00	0	0.00	0.00	15.49
15_(2026)	12.72	3.33	0.00	0	0.00	0.00	16.05
16_(2027)	12.96	3.41	0.00	0	0.00	0.00	16.37
17_(2028)	13.19	3.50	0.00	0	0.00	0.00	16.69
18_(2029)	12.25	3.58	0.00	0	0.00	0.00	15.82
19_(2030)	12.01	3.65	0.00	0	0.00	0.00	15.66
NPV	**113**	**26**	**-**	**-**	**-**	**-**	**139**

Appendix F.4 : Result of NPV calculation for economic indicators selected in BAU land use plan A4 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	52.27	13.43	77.91	313	121.70	353.80	-644.64
1_(2012)	50.79	13.99	77.70	317	122.00	3.54	-299.86
2_(2013)	39.62	14.51	78.78	249	124.20	7.08	-247.23
3_(2014)	38.04	15.07	78.71	248	124.30	10.61	-250.63
4_(2015)	34.23	15.62	78.77	228	124.40	14.15	-238.13
5_(2016)	34.28	16.18	78.88	233	124.50	17.69	-245.72
6_(2017)	33.92	16.82	78.63	239	123.80	17.69	-250.99
7_(2018)	33.69	17.57	77.65	246	122.10	17.69	-257.06
8_(2019)	32.98	18.36	76.51	254	120.20	17.69	-264.22
9_(2020)	32.51	19.07	76.10	261	119.60	17.69	-270.15
10_(2021)	32.27	19.60	77.09	265	121.40	17.69	-275.38
11_(2022)	32.04	20.14	78.14	271	123.30	21.23	-284.88
12_(2023)	31.80	20.67	79.23	276	125.20	24.77	-294.35
13_(2024)	31.57	21.25	80.15	283	126.80	28.30	-305.30
14_(2025)	31.10	21.90	80.62	293	127.70	28.30	-314.97
15_(2026)	30.62	22.57	80.96	303	128.30	28.30	-325.40
16_(2027)	31.57	23.23	81.46	312	129.20	28.30	-333.62
17_(2028)	32.51	23.82	82.12	321	130.10	28.30	-341.28
18_(2029)	32.74	24.35	83.12	330	131.40	28.30	-349.06
19_(2030)	32.98	24.85	84.25	338	132.90	28.30	-356.93
NPV	**365**	**173**	**773**	**2,676**	**1,218**	**481**	**-3,065**

Appendix F.5 : Result of NPV calculation for economic indicators selected in BAU land use plan A5 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	70.96	13.22	83.17	0	129.80	353.80	-316.25
1_(2012)	69.98	13.78	83.22	0	130.60	3.54	32.85
2_(2013)	54.66	14.29	84.51	0	133.10	7.08	13.29
3_(2014)	53.10	14.85	84.69	0	133.70	10.61	8.33
4_(2015)	48.34	15.40	85.09	0	134.40	14.15	0.28
5_(2016)	48.93	15.96	85.55	0	135.00	17.69	-2.25
6_(2017)	49.23	16.60	85.65	0	134.90	17.69	-1.11
7_(2018)	49.45	17.36	85.04	0	133.80	17.69	0.36
8_(2019)	49.47	18.16	84.27	0	132.50	17.69	1.71
9_(2020)	49.71	18.87	84.20	0	132.50	17.69	2.59
10_(2021)	49.94	19.42	85.50	0	134.80	17.69	2.37
11_(2022)	50.41	19.96	86.85	0	137.20	21.23	-1.21
12_(2023)	50.65	20.51	88.24	0	139.60	24.77	-4.97
13_(2024)	51.12	21.10	89.48	0	141.80	28.30	-8.40
14_(2025)	51.59	21.77	90.26	0	143.20	28.30	-7.88
15_(2026)	52.06	22.46	90.88	0	144.30	28.30	-7.20
16_(2027)	53.47	23.14	91.65	0	145.60	28.30	-5.64
17_(2028)	55.36	23.75	92.75	0	147.30	28.30	-3.74
18_(2029)	56.30	24.29	94.12	0	149.20	28.30	-2.79
19_(2030)	57.48	24.80	95.58	0	151.10	28.30	-1.54
NPV	**538**	**171**	**846**	**-**	**1,334**	**481**	**-260**

Appendix F.6 : Result of NPV calculation for economic indicators selected in BAU land use plan A6 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	0.00	2.08	0.00	365.02	0.00	0.00	-362.94
1_(2012)	0.00	2.16	0.00	367.94	0.00	0.00	-365.78
2_(2013)	0.00	2.24	0.00	289.02	0.00	0.00	-286.78
3_(2014)	0.00	2.32	0.00	286.11	0.00	0.00	-283.79
4_(2015)	0.00	2.40	0.00	262.90	0.00	0.00	-260.50
5_(2016)	0.00	2.49	0.00	267.85	0.00	0.00	-265.36
6_(2017)	0.00	2.58	0.00	273.74	0.00	0.00	-271.15
7_(2018)	0.00	2.69	0.00	281.04	0.00	0.00	-278.34
8_(2019)	0.00	2.80	0.00	288.34	0.00	0.00	-285.54
9_(2020)	0.00	2.90	0.00	294.23	0.00	0.00	-291.33
10_(2021)	0.00	2.97	0.00	298.94	0.00	0.00	-295.97
11_(2022)	0.00	3.04	0.00	304.12	0.00	0.00	-301.08
12_(2023)	0.00	3.12	0.00	309.54	0.00	0.00	-306.43
13_(2024)	0.00	3.20	0.00	316.61	0.00	0.00	-313.41
14_(2025)	0.00	3.29	0.00	325.56	0.00	0.00	-322.27
15_(2026)	0.00	3.39	0.00	335.93	0.00	0.00	-332.54
16_(2027)	0.00	3.49	0.00	346.53	0.00	0.00	-343.04
17_(2028)	0.00	3.57	0.00	356.66	0.00	0.00	-353.08
18_(2029)	0.00	3.65	0.00	366.79	0.00	0.00	-363.14
19_(2030)	0.00	3.72	0.00	376.68	0.00	0.00	-372.96
NPV	**-**	**26**	**-**	**3,053**	**-**	**-**	**-3,027**

Appendix F.7 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B1 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	31.47	1.89	53.98	333.56	85.00	353.80	-685.02
1_(2012)	31.60	1.96	53.45	336.34	84.12	3.54	-337.00
2_(2013)	25.30	2.03	54.20	263.72	85.14	7.08	-274.41
3_(2014)	24.49	2.10	53.51	261.61	83.88	10.61	-276.00
4_(2015)	21.91	2.18	52.83	240.99	82.67	14.15	-260.89
5_(2016)	22.14	2.26	52.05	245.70	81.36	17.69	-268.30
6_(2017)	22.14	2.35	50.80	251.59	79.32	17.69	-273.30
7_(2018)	22.38	2.46	48.82	258.66	76.03	17.69	-278.72
8_(2019)	22.38	2.56	46.80	265.96	72.59	17.69	-284.50
9_(2020)	22.38	2.66	45.71	271.85	70.65	17.69	-289.45
10_(2021)	22.61	2.72	46.37	276.33	71.56	17.69	-293.87
11_(2022)	22.85	2.79	47.05	281.27	72.50	21.23	-302.31
12_(2023)	23.09	2.86	47.76	286.46	73.47	24.77	-310.99
13_(2024)	23.56	2.94	48.32	293.05	74.39	28.30	-320.93
14_(2025)	23.56	3.02	48.59	302.00	74.98	28.30	-330.12
15_(2026)	24.26	3.11	48.74	311.66	75.42	28.30	-339.27
16_(2027)	24.74	3.21	48.87	321.79	75.84	28.30	-349.12
17_(2028)	25.21	3.29	49.23	331.45	76.49	28.30	-358.51
18_(2029)	25.68	3.37	49.87	341.11	77.41	28.30	-367.91
19_(2030)	26.15	3.44	50.60	350.53	78.29	28.30	-376.94
NPV	**244**	**24**	**498**	**2,809**	**776**	**481**	**-3,300**

Appendix F.8 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B2 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	1.06	15.92	0.00	363.97	0.00	0.00	-346.99
1_(2012)	0.00	16.53	0.00	367.94	0.00	0.00	-351.41
2_(2013)	-0.54	17.19	0.00	289.56	0.00	0.00	-272.91
3_(2014)	-1.30	17.84	0.00	287.41	0.00	0.00	-270.87
4_(2015)	-1.88	18.50	0.00	264.78	0.00	0.00	-248.17
5_(2016)	-2.12	19.17	0.00	269.97	0.00	0.00	-252.92
6_(2017)	-2.59	19.92	0.00	276.33	0.00	0.00	-259.00
7_(2018)	-3.53	20.80	0.00	284.57	0.00	0.00	-267.31
8_(2019)	-4.48	21.69	0.00	292.82	0.00	0.00	-275.60
9_(2020)	-5.42	22.48	0.00	299.65	0.00	0.00	-282.59
10_(2021)	-5.89	23.07	0.00	304.83	0.00	0.00	-287.65
11_(2022)	-6.12	23.68	0.00	310.25	0.00	0.00	-292.69
12_(2023)	-6.60	24.29	0.00	316.14	0.00	0.00	-298.44
13_(2024)	-7.07	24.95	0.00	323.68	0.00	0.00	-305.79
14_(2025)	-7.54	25.67	0.00	333.10	0.00	0.00	-314.97
15_(2026)	-7.07	26.31	0.00	342.99	0.00	0.00	-323.75
16_(2027)	-6.60	26.95	0.00	353.12	0.00	0.00	-332.77
17_(2028)	-6.12	27.52	0.00	362.78	0.00	0.00	-341.39
18_(2029)	-5.18	28.02	0.00	371.97	0.00	0.00	-349.13
19_(2030)	-4.24	28.50	0.00	380.92	0.00	0.00	-356.66
NPV	**-31**	**204**	**-**	**3,084**	**-**	**-**	**-2,911**

Appendix F.9 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B3 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	13.02	2.09	0.00	0	0.00	0.00	15.12
1_(2012)	13.51	2.17	0.00	0	0.00	0.00	15.68
2_(2013)	10.48	2.25	0.00	0	0.00	0.00	12.73
3_(2014)	10.42	2.33	0.00	0	0.00	0.00	12.75
4_(2015)	9.66	2.42	0.00	0	0.00	0.00	12.07
5_(2016)	10.13	2.50	0.00	0	0.00	0.00	12.63
6_(2017)	10.37	2.60	0.00	0	0.00	0.00	12.97
7_(2018)	10.84	2.72	0.00	0	0.00	0.00	13.55
8_(2019)	11.07	2.83	0.00	0	0.00	0.00	13.90
9_(2020)	11.31	2.93	0.00	0	0.00	0.00	14.23
10_(2021)	11.78	3.00	0.00	0	0.00	0.00	14.78
11_(2022)	12.25	3.07	0.00	0	0.00	0.00	15.32
12_(2023)	12.49	3.15	0.00	0	0.00	0.00	15.63
13_(2024)	12.96	3.23	0.00	0	0.00	0.00	16.19
14_(2025)	13.19	3.33	0.00	0	0.00	0.00	16.52
15_(2026)	13.90	3.43	0.00	0	0.00	0.00	17.32
16_(2027)	14.37	3.53	0.00	0	0.00	0.00	17.90
17_(2028)	14.61	3.62	0.00	0	0.00	0.00	18.23
18_(2029)	15.31	3.71	0.00	0	0.00	0.00	19.02
19_(2030)	15.55	3.79	0.00	0	0.00	0.00	19.33
NPV	**117**	**27**	**-**	**-**	**-**	**-**	**143**

Appendix F.10 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B4 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	52.27	13.43	77.91	312.75	121.70	353.80	-644.64
1_(2012)	51.00	13.98	77.89	316.94	121.80	3.54	-299.41
2_(2013)	39.73	14.53	78.98	249.30	123.80	7.08	-246.93
3_(2014)	37.76	15.12	78.85	248.35	123.70	10.61	-250.94
4_(2015)	33.64	15.72	78.77	229.26	123.60	14.15	-238.88
5_(2016)	33.62	16.33	78.66	234.23	123.50	17.69	-246.81
6_(2017)	33.22	17.01	78.14	240.52	122.80	17.69	-252.64
7_(2018)	32.98	17.80	76.89	248.06	121.00	17.69	-259.08
8_(2019)	32.27	18.62	75.57	256.07	119.00	17.69	-266.29
9_(2020)	31.80	19.33	75.06	262.43	118.40	17.69	-272.33
10_(2021)	31.57	19.87	76.00	267.37	120.10	17.69	-277.73
11_(2022)	31.57	20.41	77.00	272.56	121.90	21.23	-286.71
12_(2023)	31.57	20.96	78.05	277.98	123.70	24.77	-295.86
13_(2024)	31.80	21.56	78.95	284.81	125.20	28.30	-306.00
14_(2025)	31.57	22.25	79.42	293.99	126.00	28.30	-315.06
15_(2026)	32.04	22.88	79.98	303.89	126.70	28.30	-323.99
16_(2027)	32.98	23.47	80.78	313.55	127.50	28.30	-332.12
17_(2028)	33.92	24.00	81.84	322.73	128.60	28.30	-339.88
18_(2029)	35.57	24.47	83.12	331.21	129.80	28.30	-346.16
19_(2030)	37.22	24.93	84.47	339.46	131.00	28.30	-352.14
NPV	**365**	**175**	**769**	**2,688**	**1,209**	**481**	**-3,069**

Appendix F.11 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B5 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	70.96	13.22	83.17	0	129.80	353.80	-316.25
1_(2012)	70.23	13.77	83.43	0	130.40	3.54	33.49
2_(2013)	54.77	14.3	84.73	0	132.70	7.08	14.02
3_(2014)	52.84	14.9	84.87	0	133.00	10.61	9.00
4_(2015)	47.80	15.5	85.14	0	133.50	14.15	0.79
5_(2016)	48.29	16.11	85.37	0	134.00	17.69	-1.92
6_(2017)	48.58	16.8	85.21	0	133.90	17.69	-1.00
7_(2018)	48.81	17.6	84.32	0	132.60	17.69	0.44
8_(2019)	48.76	18.42	83.36	0	131.30	17.69	1.55
9_(2020)	49.00	19.14	83.19	0	131.30	17.69	2.34
10_(2021)	49.47	19.68	84.48	0	133.60	17.69	2.34
11_(2022)	49.94	20.23	85.81	0	135.90	21.23	-1.15
12_(2023)	50.65	20.78	87.20	0	138.30	24.77	-4.44
13_(2024)	51.59	21.39	88.42	0	140.30	28.30	-7.20
14_(2025)	52.06	22.09	89.19	0	141.60	28.30	-6.56
15_(2026)	53.24	22.73	90.04	0	142.70	28.30	-4.99
16_(2027)	54.89	23.34	91.16	0	144.00	28.30	-2.92
17_(2028)	57.01	23.87	92.59	0	145.50	28.30	-0.34
18_(2029)	59.36	24.35	94.22	0	147.20	28.30	2.43
19_(2030)	61.72	24.81	95.92	0	148.90	28.30	5.25
NPV	**538**	**173**	**843**	**-**	**1,324**	**481**	**-252**

Appendix F.12 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan B6 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	0.00	2.08	0.00	365.02	0.00	0.00	-362.94
1_(2012)	0.00	2.15	0.00	367.59	0.00	0.00	-365.44
2_(2013)	0.00	2.23	0.00	289.02	0.00	0.00	-286.79
3_(2014)	0.00	2.31	0.00	286.11	0.00	0.00	-283.80
4_(2015)	0.00	2.39	0.00	263.13	0.00	0.00	-260.75
5_(2016)	0.00	2.47	0.00	268.08	0.00	0.00	-265.61
6_(2017)	0.00	2.56	0.00	273.97	0.00	0.00	-271.42
7_(2018)	0.00	2.66	0.00	281.51	0.00	0.00	-278.85
8_(2019)	0.00	2.76	0.00	288.81	0.00	0.00	-286.05
9_(2020)	0.00	2.85	0.00	294.94	0.00	0.00	-292.09
10_(2021)	0.00	2.91	0.00	299.88	0.00	0.00	-296.98
11_(2022)	0.00	2.97	0.00	305.07	0.00	0.00	-302.10
12_(2023)	0.00	3.03	0.00	310.72	0.00	0.00	-307.69
13_(2024)	0.00	3.10	0.00	317.55	0.00	0.00	-314.45
14_(2025)	0.00	3.17	0.00	326.74	0.00	0.00	-323.57
15_(2026)	0.00	3.25	0.00	336.63	0.00	0.00	-333.38
16_(2027)	0.00	3.33	0.00	347.23	0.00	0.00	-343.90
17_(2028)	0.00	3.41	0.00	357.13	0.00	0.00	-353.72
18_(2029)	0.00	3.47	0.00	366.79	0.00	0.00	-363.31
19_(2030)	0.00	3.54	0.00	376.68	0.00	0.00	-373.14
NPV	**-**	**26**	**-**	**3,056**	**-**	**-**	**-3,030**

Appendix F.13 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C1 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	31.47	1.89	53.98	333.56	53.98	353.80	-654.00
1_(2012)	31.29	1.95	53.48	336.31	53.48	3.54	-306.61
2_(2013)	25.25	2.02	54.28	263.77	54.28	7.08	-243.58
3_(2014)	24.49	2.09	53.62	261.61	53.62	10.61	-245.64
4_(2015)	22.14	2.17	52.98	240.99	52.98	14.15	-230.83
5_(2016)	22.14	2.25	52.24	245.94	52.24	17.69	-239.24
6_(2017)	22.14	2.33	51.01	251.83	51.01	17.69	-245.04
7_(2018)	22.38	2.43	49.05	259.13	49.05	17.69	-252.01
8_(2019)	22.38	2.53	47.05	266.43	47.05	17.69	-259.22
9_(2020)	22.61	2.61	45.98	272.32	45.98	17.69	-264.79
10_(2021)	22.85	2.67	46.66	277.03	46.66	17.69	-269.20
11_(2022)	22.85	2.73	47.37	282.22	47.37	21.23	-277.86
12_(2023)	23.32	2.79	48.10	287.40	48.10	24.77	-286.05
13_(2024)	23.32	2.86	48.74	294.23	48.74	28.30	-296.36
14_(2025)	24.03	2.93	49.13	302.71	49.13	28.30	-304.06
15_(2026)	24.26	3.01	49.43	312.37	49.43	28.30	-313.40
16_(2027)	24.97	3.09	49.70	322.26	49.70	28.30	-322.51
17_(2028)	25.21	3.16	50.19	331.92	50.19	28.30	-331.86
18_(2029)	25.44	3.23	50.87	341.34	50.87	28.30	-340.98
19_(2030)	26.15	3.29	51.62	350.53	51.62	28.30	-349.39
NPV	**244**	**24**	**500**	**2,812**	**500**	**481**	**-3,025**

Appendix F.14 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C2 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	1.06	15.92	0.00	363.97	0.00	0.00	-346.99
1_(2012)	-0.35	16.54	0.00	367.94	0.00	0.00	-351.74
2_(2013)	-0.54	17.19	0.00	289.56	0.00	0.00	-272.91
3_(2014)	-1.56	17.82	0.00	287.67	0.00	0.00	-271.42
4_(2015)	-1.88	18.46	0.00	265.02	0.00	0.00	-248.44
5_(2016)	-2.12	19.11	0.00	270.20	0.00	0.00	-253.21
6_(2017)	-2.83	19.84	0.00	276.80	0.00	0.00	-259.78
7_(2018)	-3.53	20.69	0.00	285.04	0.00	0.00	-267.89
8_(2019)	-4.71	21.56	0.00	293.52	0.00	0.00	-276.68
9_(2020)	-5.42	22.31	0.00	300.35	0.00	0.00	-283.47
10_(2021)	-5.65	22.87	0.00	305.54	0.00	0.00	-288.32
11_(2022)	-6.12	23.44	0.00	311.19	0.00	0.00	-293.88
12_(2023)	-6.36	24.01	0.00	317.08	0.00	0.00	-299.43
13_(2024)	-7.30	24.63	0.00	324.85	0.00	0.00	-307.53
14_(2025)	-8.01	25.32	0.00	334.75	0.00	0.00	-317.44
15_(2026)	-8.01	26.02	0.00	344.64	0.00	0.00	-326.63
16_(2027)	-7.54	26.74	0.00	354.77	0.00	0.00	-335.57
17_(2028)	-7.30	27.38	0.00	364.43	0.00	0.00	-344.35
18_(2029)	-6.60	27.96	0.00	373.38	0.00	0.00	-352.02
19_(2030)	-5.42	28.51	0.00	382.10	0.00	0.00	-359.01
NPV	**-33**	**203**	**-**	**3,089**	**-**	**-**	**-2,920**

Appendix F.15 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C3 (in Billion Rupiah)

Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	13.02	2.09	0.00	0	0.00	0.00	15.12
1_(2012)	13.17	2.17	0.00	0	0.00	0.00	15.33
2_(2013)	10.48	2.24	0.00	0	0.00	0.00	12.72
3_(2014)	10.42	2.32	0.00	0	0.00	0.00	12.74
4_(2015)	9.66	2.40	0.00	0	0.00	0.00	12.06
5_(2016)	10.13	2.48	0.00	0	0.00	0.00	12.61
6_(2017)	10.37	2.58	0.00	0	0.00	0.00	12.94
7_(2018)	10.84	2.69	0.00	0	0.00	0.00	13.52
8_(2019)	11.07	2.80	0.00	0	0.00	0.00	13.87
9_(2020)	11.54	2.89	0.00	0	0.00	0.00	14.43
10_(2021)	12.01	2.95	0.00	0	0.00	0.00	14.97
11_(2022)	12.25	3.02	0.00	0	0.00	0.00	15.27
12_(2023)	12.96	3.09	0.00	0	0.00	0.00	16.04
13_(2024)	13.19	3.16	0.00	0	0.00	0.00	16.35
14_(2025)	13.90	3.24	0.00	0	0.00	0.00	17.14
15_(2026)	14.13	3.33	0.00	0	0.00	0.00	17.46
16_(2027)	14.84	3.41	0.00	0	0.00	0.00	18.26
17_(2028)	15.31	3.50	0.00	0	0.00	0.00	18.81
18_(2029)	15.78	3.58	0.00	0	0.00	0.00	19.36
19_(2030)	16.25	3.65	0.00	0	0.00	0.00	19.90
NPV	**118**	**26**	**-**	**-**	**-**	**-**	**144**

Appendix F.16 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C4 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	52.27	13.43	77.91	312.75	121.70	353.80	-644.64
1_(2012)	50.48	13.99	77.77	317.11	121.90	3.54	-300.31
2_(2013)	39.54	14.51	78.89	249.48	123.90	7.08	-247.52
3_(2014)	37.55	15.07	78.79	248.56	123.80	10.61	-251.57
4_(2015)	33.64	15.62	78.76	229.49	123.70	14.15	-239.33
5_(2016)	33.55	16.18	78.71	234.54	123.60	17.69	-247.39
6_(2017)	33.22	16.82	78.25	240.75	122.90	17.69	-253.06
7_(2018)	32.98	17.57	77.05	248.53	121.10	17.69	-259.72
8_(2019)	32.27	18.36	75.78	256.54	119.20	17.69	-267.01
9_(2020)	31.80	19.07	75.30	263.13	118.50	17.69	-273.15
10_(2021)	31.80	19.60	76.28	268.08	120.30	17.69	-278.39
11_(2022)	31.80	20.14	77.29	273.26	122.10	21.23	-287.36
12_(2023)	31.80	20.67	78.34	278.92	124.00	24.77	-296.87
13_(2024)	31.57	21.25	79.23	285.98	125.50	28.30	-307.74
14_(2025)	31.33	21.90	79.68	295.41	126.40	28.30	-317.20
15_(2026)	30.86	22.57	79.97	305.77	126.90	28.30	-327.58
16_(2027)	31.57	23.23	80.43	315.67	127.70	28.30	-336.44
17_(2028)	32.51	23.82	81.21	324.62	128.80	28.30	-344.18
18_(2029)	33.69	24.35	82.20	333.10	130.00	28.30	-351.17
19_(2030)	35.34	24.85	83.27	341.34	131.40	28.30	-357.59
NPV	**362**	**173**	**769**	**2,694**	**1,211**	**481**	**-3,081**

Appendix F.17 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C5 (in Billion Rupiah)

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Year	MONEY IN			MONEY OUT			Differences
	Oil Revenue (A) (Billion Rupiah)	Parking Revenue (B) (Billion Rupiah)	BRT Revenue (C) (Billion Rupiah)	Fuel Subsidy (D) (Billion Rupiah)	BRT O & M (E)(Billion Rupiah)	BRT infrastructure cost (F) (Billion Rupiah)	Revenue - Cost (A+B+C)-(D+E+F)
0_(2011)	70.96	13.22	83.17	0	129.80	353.80	-316.25
1_(2012)	69.71	13.78	83.31	0	130.50	3.54	32.76
2_(2013)	54.61	14.29	84.65	0	132.80	7.08	13.67
3_(2014)	52.66	14.85	84.83	0	133.20	10.61	8.53
4_(2015)	47.82	15.40	85.15	0	133.70	14.15	0.52
5_(2016)	48.29	15.96	85.45	0	134.20	17.69	-2.19
6_(2017)	48.53	16.60	85.36	0	134.00	17.69	-1.20
7_(2018)	48.93	17.36	84.54	0	132.80	17.69	0.34
8_(2019)	48.76	18.16	83.64	0	131.50	17.69	1.37
9_(2020)	49.00	18.87	83.52	0	131.50	17.69	2.20
10_(2021)	49.71	19.42	84.84	0	133.90	17.69	2.38
11_(2022)	50.18	19.96	86.20	0	136.30	21.23	-1.19
12_(2023)	51.12	20.51	87.61	0	138.70	24.77	-4.23
13_(2024)	51.35	21.10	88.85	0	140.90	28.30	-7.90
14_(2025)	52.06	21.77	89.62	0	142.30	28.30	-7.15
15_(2026)	52.53	22.46	90.21	0	143.40	28.30	-6.50
16_(2027)	53.95	23.14	90.92	0	144.60	28.30	-4.90
17_(2028)	55.60	23.75	92.01	0	146.10	28.30	-3.05
18_(2029)	57.72	24.29	93.31	0	147.90	28.30	-0.89
19_(2030)	60.07	24.80	94.71	0	149.70	28.30	1.58
NPV	**536**	**171**	**843**	**-**	**1,327**	**481**	**-257**

Appendix F.18 : Result of NPV calculation for economic indicators selected in planned-retreat land use plan C6 (in Billion Rupiah)

Appendix G DATA USED IN BANDA ACEH MARS MODEL

The average trip rate for a trip Home - Work is 0.94 trips per employed and workday. The trip rate calculation is as follows: 365 days/year minus 52 weekends (104 days) is 261 weekdays/year. 261 weekdays/year minus 16 bank holidays (Indonesia bank holidays) gives 245 workdays per employee and year. 245 workdays divided by 261 weekdays is 0.94 trips Home - Work per employee and weekday.

There was no data collection for daily travel time budget per person in the case study area selected. According to a past study, time-use and travel surveys from numerous cities and countries throughout the world suggest that travel time budget was approximately 1.1 h per person per day (Schafer and Victor, 1999). Therefore, it is assumed that daily travel time budget per person = 1.1 x 60 = 66 minutes.

Car and Motorcycles Ownership (DISHUB, 2012a)

1985

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
514	651	784	1,241	325	1,609	362	738	495
2,266	2,870	3,460	5,476	1,434	7,100	1,598	3,254	2,184

2006

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
245	1,306	2,558	3,547	2,038	3,698	318	2,685	2,405
895	4,783	9,366	12,987	7,462	13,539	1,163	9,829	8,807

2011

Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
2,464	3,293	3,123	4,541	3,526	6,311	1,560	5,209	3,374
10,335	13,813	13,099	19,047	14,792	26,471	6,542	21,851	14,152

Car occupancy rate

Car occupancy rate assumption is 2.38 for car and 1.90 for motorcycles (HWH and HOH) (STTD, 2011). The walking speed pedestrian is assumed with 4.4 km/h for HWH and for HOH tours (HCM, 2000). The car free flow speed for car and motorcycles were assumed 40 km/h, while the speed for peak and off-peak are 39 and 38 km/h respectively. This speed refer to speed for urban road in Indonesia Highway Capacity Manual.

Public Transport trips time in the case study area selected

All the parameter trips time for public transport (PT) in the case study area selected were using the assumptions since there are no data available in the case study area selected (e.g. no time table, limited bus stops). The number of PT stop are only 43 for the whole area of Banda Aceh city, but they are not used because the public transports could stop anywhere to board and alight the passengers (DISHUB, 2007). Therefore, it is not realistic to calculate the access time to reach PT by only using number of PT stops. For solving this problems, the assumption of public transport time component refer to the past study that conducted in the case study area selected (Kamal, 2002). The assumptions are classified into three categories as namely (1) in the Pre Tsunami Model, (2) Post Tsunami Model and (3) Future Model.

In the pre tsunami model, it is assumed that the walking distance to reach public transport is very short because the public transport can reach/stop in front of the housing areas to pick up passenger. According to the past study, the walking distance to reach public transport are mostly in the range <100 to 400 meter for all zones, which are in the range walking time 4 to 6 minutes (range 200-500m) (Kamal, 2002). Moreover, according to the result of the same study, most of respondents informed that the waiting time for public transport is in the range <6 minutes (54.37%) and 7-15 minutes (30.10%) (Kamal, 2002). Therefore, in the pre tsunami model, it is assumed that headway time PT for peak and off-peak were 5 and 10 minutes respectively and the changing time were 3 and 5 minutes for peak and off-peak respectively.

In the post tsunami model, it is assumed that the public transport (PT) services become worse because the reduction of number of PT after the tsunami tragedy. The reduction of public transport number reduced the frequency services of PT, which increases the waiting time and changing time. Moreover, the private operator reduced the range of services area because the demand for using public transport also reduced. Therefore, the walking distance to reach the PT stops also increased compared to as it was before the tsunami tragedy. Therefore, it is assumed that the walking distance to access the public transport is more than in the range 200 to 500 meter (4-6 minutes walking time). In this period of time, the number of people that use public transport also reduced significantly compared to in the pre tsunami model because the poor condition of public transport and its services such as there were no representative and convenience PT stops (walking time >10 minutes), headway time (15 to 25 minutes) and changing time (5 to 10 minutes). The limitation of public transport services made the city residents to prefer more using private vehicles rather than public transport (Dirangga, 2008).

The similar assumption in the post tsunami model then was used in the Banda Aceh future model, but it is assumed that the condition is more worse. Based on the reality condition, there is no government attention to develop a well-integrated public transport infrastructure. The government vision more focus on the development road network in order to accommodate the increase of private vehicles rather than to manage the demand of urban mobility through the implementation public transport (pull) and other transport strategies (push). Therefore, it is assumed that this condition make the level of service public transport more worse compared to in the post tsunami model e.g. waiting time and changing time. The assumption of PT component in BAU for the future model are as follows : PT stops (walking time >10 minutes), headway time (20 to 30 minutes) and changing time (10 to 15 minutes).

Furthermore, in the Banda Aceh future model with implementation of Bus Rapid Transit (BRT), it is assumed that the government is started to develop the representative public transport infrastructure. Therefore, in this model, it is assumed that the time parameters in public transport become significantly much more better compared to in the BAU condition (e.g. for walking time in origin to PT stop, in PT time, changing time, walking time from PT stop to destination). The assumption of PT component in BAU for the future model are as follows : PT stops (walking time 5 minutes), headway time (5 to 10 minutes) and changing time (4 to 8 minutes). The public transport fare refer to the government regulation for public transport fares (Pemkot-Banda-Aceh, 2012). The detail explanation can be also seen in the modelling work.

Parking parameter

Regarding the data input for average walking distance to a parking place and the average walking distance to find a parking place for car and moto, it is used an assumption in the range between 0.07 to 1 minutes because the parking system refer to the on street parking.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	0.25	0.25	0.25	0.50	0.25	0.50	0.50	0.25	0.25
Moto	0.10	0.10	0.10	0.25	0.10	0.25	0.25	0.10	0.10

The average walking distance to a parking place for car and moto
(Model 1985-2000)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	0.07	0.07	0.07	0.25	0.07	0.25	0.25	0.07	0.07
Moto	0.07	0.07	0.07	0.13	0.07	0.13	0.13	0.07	0.07

The average time to find a parking place for car and moto
(Model 1985-2000)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	0.5	0.5	0.5	1.0	0.5	1.0	1.0	0.5	0.5
Moto	0.25	0.25	0.25	0.50	0.25	0.50	0.50	0.25	0.25

The average walking distance to a parking place for car and moto
(Model 2006-2011)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	0.5	0.5	0.5	1.0	0.5	1.0	1.0	0.5	0.5
Moto	0.25	0.25	0.25	0.50	0.25	0.50	0.50	0.25	0.25

The average time to find a parking place for car and moto
(Model 2006-2011)

The parking charge for car and motorcycles in 1985 was Rp 50 and 25 respectively. The parking charge for car and motorcycles in 2006 and 2011 was Rp 1000 and Rp. 500 respectively. The parking charge for car and moto in 2012 was Rp. 2000 and 1000 respectively. The parking charge is flat for all day (there is no restriction time and no difference price between peak and off-peak).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	0	0	0	60%	0	60%	60%	0	0
Moto	0	0	0	60%	0	60%	60%	0	0

Ratio of parking charge in all zones (Pre tsunami model), own analysis.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	20%	20%	20%	80%	20%	80%	80%	20%	20%
Moto	20%	20%	20%	80%	20%	80%	80%	20%	20%

Ratio of parking charge in all zones (Post tsunami model), own analysis.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Car	20%	20%	20%	80%	20%	80%	80%	20%	20%
Moto	20%	20%	20%	80%	20%	80%	80%	20%	20%

Ratio of parking charge in all zones (Future model model), own analysis.

Average distance to a PT stop

Average distance to a PT stop is calculated using equation as follows (Pfaffenbichler, 2003) :

$$t_{il}^{PT,w} = \sqrt{\frac{A_i}{n_i^{PT} \times \pi} \times \frac{60}{V^w} \times \alpha_d}$$

$t^{PT,W}_{il}$ .... Walking time from source i to public transport stop l (min)
A_i .... Area of zone i (km^2)
n^{pt}_i .... Number of public transport stops in zone i
V^w .... Walking speed (4.4 km/h)
α_d .... Detour factor (1.2)

Zones	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Area (km^2)	7.258	3.78	4.789	4.539	5.341	10.047	5.211	14.244	6.15
PT Stops	5	2	3	3	3	6	3	8	4
Walking time	11.13	12.70	11.67	11.36	12.32	11.95	12.17	12.32	11.45

Estimation of PT Stops for 12 minutes walking in BAU.

Zones	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Area (km^2)	7.258	3.78	4.789	4.539	5.341	10.047	5.211	14.244	6.15
PT Stops	25	14	17	16	19	35	19	50	22
Walking time	4.98	4.80	4.90	4.92	4.90	4.95	4.84	4.93	4.88

Estimation of PT Stops for 5 minutes walking in BRT.

	1	2	3	4	5	6	7	8	9
1	1.00	4.30	7.70	3.30	6.60	5.30	4.80	11.00	7.70
2	4.30	1.00	4.50	3.50	6.80	5.80	5.30	11.60	8.20
3	7.70	4.50	1.00	3.50	6.30	6.70	7.20	9.70	7.90
4	3.30	3.20	3.50	1.00	3.70	4.10	3.80	7.10	5.30
5	6.60	6.80	4.60	3.70	1.00	3.80	5.70	6.80	5.00
6	5.30	5.80	6.30	2.70	3.60	1.00	2.80	6.80	3.90
7	4.80	5.80	7.10	3.60	5.40	2.80	1.00	9.20	5.90
8	11.00	11.50	12.30	8.40	8.50	6.60	9.20	1.00	4.70
9	7.70	7.60	8.10	4.50	4.20	4.90	6.30	5.40	1.00

Distance matrix car

	1	2	3	4	5	6	7	8	9
1	1.00	4.30	7.70	3.30	6.60	5.30	4.80	11.00	7.70
2	4.30	1.00	4.50	3.50	6.80	5.80	5.30	11.60	8.20
3	7.70	4.50	1.00	3.50	6.30	6.70	7.20	9.70	7.90
4	3.30	3.20	3.50	1.00	3.70	4.10	3.80	7.10	5.30
5	6.60	6.80	4.60	3.70	1.00	3.80	5.70	6.80	5.00
6	5.30	5.80	6.30	2.70	3.60	1.00	2.80	6.80	3.90
7	4.80	5.80	7.10	3.60	5.40	2.80	1.00	9.20	5.90
8	11.00	11.50	12.30	8.40	8.50	6.60	9.20	1.00	4.70
9	7.70	7.60	8.10	4.50	4.20	4.90	6.30	5.40	1.00

Distance matrix motorcycle

	1	2	3	4	5	6	7	8	9
1	1.00	4.30	7.70	3.30	6.60	5.30	4.80	11.00	7.70
2	4.30	1.00	4.50	3.50	6.80	5.80	5.30	11.60	8.20
3	7.70	4.50	1.00	3.50	6.30	6.70	7.20	9.70	7.90
4	3.30	3.20	3.50	1.00	3.70	4.10	3.80	7.10	5.30
5	6.60	6.80	4.60	3.70	1.00	3.80	5.70	6.80	5.00
6	5.30	5.80	6.30	2.70	3.60	1.00	2.80	6.80	3.90
7	4.80	5.80	7.10	3.60	5.40	2.80	1.00	9.20	5.90
8	11.00	11.50	12.30	8.40	8.50	6.60	9.20	1.00	4.70
9	7.70	7.60	8.10	4.50	4.20	4.90	6.30	5.40	1.00

Distance matrix public transport

	1	2	3	4	5	6	7	8	9
1	1.00	4.30	7.70	3.30	6.60	5.30	4.80	11.00	7.70
2	4.30	1.00	4.50	3.50	6.80	5.80	5.30	11.60	8.20
3	7.70	4.50	1.00	3.50	6.30	6.70	7.20	9.70	7.90
4	3.30	3.20	3.50	1.00	3.70	4.10	3.80	7.10	5.30
5	6.60	6.80	4.60	3.70	1.00	3.80	5.70	6.80	5.00
6	5.30	5.80	6.30	2.70	3.60	1.00	2.80	6.80	3.90
7	4.80	5.80	7.10	3.60	5.40	2.80	1.00	9.20	5.90
8	11.00	11.50	12.30	8.40	8.50	6.60	9.20	1.00	4.70
9	7.70	7.60	8.10	4.50	4.20	4.90	6.30	5.40	1.00

Distance matrix pedestrian

	1	2	3	4	5	6	7	8	9
1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
6	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
8	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
9	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

Walking time to public transport stop (Pre Tsunami Model 1985-2000)

	1	2	3	4	5	6	7	8	9
1	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
3	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
4	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
5	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
6	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
7	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
8	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
9	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00

Walking time to public transport stop (Post Tsunami Model 2006-2011)

	1	2	3	4	5	6	7	8	9
1	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
3	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
4	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
5	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
6	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
7	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
8	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
9	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00

Walking time to public transport stop (Future Model 2011-2030_BAU)

	1	2	3	4	5	6	7	8	9
1	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
2	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
3	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
4	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
5	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
6	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
7	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
8	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
9	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Walking time to public transport stop (Future Model 2011-2030_BRT)

	1	2	3	4	5	6	7	8	9
1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
6	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
9	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Headway time off-peak stop (Pre Tsunami Model 1985-2000)

	1	2	3	4	5	6	7	8	9
1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
2	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
4	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
5	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
6	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
7	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
8	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
9	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0

Headway time off-peak (Post Tsunami Model 2006-2011)

	1	2	3	4	5	6	7	8	9
1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
2	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
3	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
4	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
5	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
6	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
7	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
8	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
9	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0

Headway time off-peak (Future Model 2011-2030_BAU)

	1	2	3	4	5	6	7	8	9
1	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
6	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
7	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
9	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Headway time off-peak (Future Model 2011-2030_BRT)

	1	2	3	4	5	6	7	8	9
1	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
2	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
3	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
4	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
6	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
8	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
9	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0

Headway time peak (Pre Tsunami Model 1985-2000)

	1	2	3	4	5	6	7	8	9
1	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
2	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
3	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
5	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
6	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
7	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
8	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
9	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

Headway time peak (Post Tsunami Model 2006-2011)

	1	2	3	4	5	6	7	8	9
1	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
2	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
3	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
5	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
6	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
7	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
8	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
9	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0

Headway time peak (Future Model 2011-2030_BAU)

	1	2	3	4	5	6	7	8	9
1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
2	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
4	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
6	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0

Headway time peak (Future Model 2011-2030_BRT)

	1	2	3	4	5	6	7	8	9
1	0.0	4.0	4.0	0.0	4.0	4.0	4.0	4.0	4.0
2	4.0	0.0	4.0	0.0	4.0	4.0	4.0	4.0	4.0
3	4.0	4.0	0.0	0.0	4.0	4.0	4.0	4.0	4.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	4.0	4.0	4.0	0.0	0.0	4.0	4.0	4.0	4.0
6	4.0	4.0	4.0	0.0	4.0	0.0	4.0	4.0	4.0
7	4.0	4.0	4.0	0.0	4.0	4.0	0.0	4.0	4.0
8	4.0	4.0	4.0	0.0	4.0	4.0	4.0	0.0	4.0
9	4.0	4.0	4.0	0.0	4.0	4.0	4.0	4.0	0.0

Changing time off-peak (Pre Tsunami Model 1985-2000)

	1	2	3	4	5	6	7	8	9
1	0.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	7.0
2	7.0	0.0	7.0	0.0	7.0	7.0	7.0	7.0	7.0
3	7.0	7.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	7.0	7.0	7.0	0.0	0.0	7.0	7.0	7.0	7.0
6	7.0	7.0	7.0	0.0	7.0	0.0	7.0	7.0	7.0
7	7.0	7.0	7.0	0.0	7.0	7.0	0.0	7.0	7.0
8	7.0	7.0	7.0	0.0	7.0	7.0	7.0	0.0	7.0
9	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0

Changing time off-peak (Post Tsunami Model 2006-2011)

	1	2	3	4	5	6	7	8	9
1	0.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	7.0
2	7.0	0.0	7.0	0.0	7.0	7.0	7.0	7.0	7.0
3	7.0	7.0	0.0	0.0	7.0	7.0	7.0	7.0	7.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	7.0	7.0	7.0	0.0	0.0	7.0	7.0	7.0	7.0
6	7.0	7.0	7.0	0.0	7.0	0.0	7.0	7.0	7.0
7	7.0	7.0	7.0	0.0	7.0	7.0	0.0	7.0	7.0
8	7.0	7.0	7.0	0.0	7.0	7.0	7.0	0.0	7.0
9	7.0	7.0	7.0	0.0	7.0	7.0	7.0	7.0	0.0

Changing time off-peak (Future Model 2011-2030_BAU)

	1	2	3	4	5	6	7	8	9
1	0.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
2	5.0	0.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
3	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	5.0	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0
6	5.0	5.0	5.0	0.0	5.0	0.0	5.0	5.0	5.0
7	5.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0	5.0
8	5.0	5.0	5.0	0.0	5.0	5.0	5.0	0.0	5.0
9	5.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	0.0

Changing time off-peak (Future Model 2011-2030_BRT)

	1	2	3	4	5	6	7	8	9
1	0.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	2.0
2	2.0	0.0	2.0	0.0	2.0	2.0	2.0	2.0	2.0
3	2.0	2.0	0.0	0.0	2.0	2.0	2.0	2.0	2.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.0	2.0	2.0	0.0	0.0	2.0	2.0	2.0	2.0
6	2.0	2.0	2.0	0.0	2.0	0.0	2.0	2.0	2.0
7	2.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0
8	2.0	2.0	2.0	0.0	2.0	2.0	2.0	0.0	2.0
9	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.0	0.0

Changing time peak (Pre Tsunami Model 1985-2000)

	1	2	3	4	5	6	7	8	9
1	0.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
2	5.0	0.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
3	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	5.0	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0
6	5.0	5.0	5.0	0.0	5.0	0.0	5.0	5.0	5.0
7	5.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0	5.0
8	5.0	5.0	5.0	0.0	5.0	5.0	5.0	0.0	5.0
9	5.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	0.0

Changing time peak (Post Tsunami Model 2006-2011)

	1	2	3	4	5	6	7	8	9
1	0.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
2	5.0	0.0	5.0	0.0	5.0	5.0	5.0	5.0	5.0
3	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0	5.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	5.0	5.0	5.0	0.0	0.0	5.0	5.0	5.0	5.0
6	5.0	5.0	5.0	0.0	5.0	0.0	5.0	5.0	5.0
7	5.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0	5.0
8	5.0	5.0	5.0	0.0	5.0	5.0	5.0	0.0	5.0
9	5.0	5.0	5.0	0.0	5.0	5.0	5.0	5.0	0.0

Changing time peak (Future Model 2011-2030_BAU)

	1	2	3	4	5	6	7	8	9
1	0.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0
2	3.0	0.0	3.0	0.0	3.0	3.0	3.0	3.0	3.0
3	3.0	3.0	0.0	0.0	3.0	3.0	3.0	3.0	3.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3.0	3.0	3.0	0.0	0.0	3.0	3.0	3.0	3.0
6	3.0	3.0	3.0	0.0	3.0	0.0	3.0	3.0	3.0
7	3.0	3.0	3.0	0.0	3.0	3.0	0.0	3.0	3.0
8	3.0	3.0	3.0	0.0	3.0	3.0	3.0	0.0	3.0
9	3.0	3.0	3.0	0.0	3.0	3.0	3.0	3.0	0.0

Changing time peak (Future Model 2011-2030_BRT)

Socio Economic Data

Residents	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	13,015	16,483	19,873	31,451	8,235	40,773	9,176	18,686	12,541
2006	2,320	12,395	24,272	33,657	19,339	35,088	3,013	25,473	22,823
2011	16,861	22,535	21,369	31,073	24,132	43,184	10,672	35,648	23,088

Number of residents in the years of 1985, 2006, and 2011 (BPS-Banda-Aceh, 1985-2012)

Employed	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	7,900	10,005	12,063	19,091	4,999	24,749	5,570	11,342	7,613
2006	1,731	9,247	18,107	25,108	14,427	26,176	2,248	19,003	17,026
2011	12,578	16,811	15,941	23,180	18,002	32,215	7,961	26,593	17,224

Number of employees in the years of 1985, 2006, and 2011 (BPS-Banda-Aceh, 1985-2012), own analysis.

Workplaces	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	5,987	7,582	9,141	14,467	3,788	18,756	4,221	8,596	5,769
2006	1,462	7,809	15,291	21,204	12,184	22,105	1,898	16,048	14,378
2011	10,622	14,197	13,462	19,576	15,203	27,206	6,723	22,458	14,545

Number of workplaces in the years of 1985, 2006, and 2011 (BPS-Banda-Aceh, 1985-2012), own analysis.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Production	80%	20%	80%	20%	80%	20%	20%	20%	80%
Service	20%	80%	20%	80%	20%	80%	80%	80%	20%

Share of business sector in Banda Aceh sub-districts (1985)(BPS-Banda-Aceh, 1985-2004), own analysis.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Production	80%	20%	80%	20%	80%	20%	20%	20%	80%
Service	20%	80%	20%	80%	20%	80%	80%	80%	20%

Share of business sector in Banda Aceh sub-districts 2006 and 2011 (BPS-Banda-Aceh, 2005-2011), own analysis.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Production	10	10	10	12	10	12	12	10	10
Service	15	16	15	42	20	46	29	25	17

Number of workplaces in Banda Aceh sub-districts 1985 (BPS-Banda-Aceh, 1985-2004, BAPPEDA, 2012b), own analysis.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Production	20	20	20	15	20	15	15	20	20
Service	30	31	30	60	40	65	41	50	34

Number of workplaces in Banda Aceh sub-districts 2006 and 2011 (BPS-Banda-Aceh, 2005-2011) (BAPPEDA, 2012b), own analysis.

HH size	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	4	4	4	4	4	4	4	4	4
2006	4	4	4	4	4	4	4	4	4
2011	4	4	4	4	4	4	4	4	4

Number of person per household in the years of 1985, 2006, and 2011 (BPS-Banda-Aceh, 1985-2004, BPS-Banda-Aceh, 2005-2011) (Average HH size for Banda Aceh city.

Income	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	50,000	55,000	58,000	80,000	55,000	75,000	55,000	50,000	35,000
2006	1,800,000	2,400,000	2,800,000	3,200,000	3,100,000	3,100,000	2,100,000	2,800,000	2,400,000
2011	2,160,000	2,880,000	3,360,000	3,840,000	3,720,000	3,720,000	2,520,000	3,360,000	2,880,000

Average of income (Rp/month) per sub-districts in the years 1985, 2006, and 2011 (BPS-Banda-Aceh, 1985-2012, NJOP, 2012), own analysis.

Avg. rent	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	20,000	31,000	34,800	58,000	33,000	55,000	38,000	30,000	21,000
2006	560,000	950,000	1,390,000	1,900,000	1,860,000	1,890,000	1,180,000	1,860,000	1,440,000
2011	616,000	1,045,000	1,529,000	2,090,000	2,046,000	2,079,000	1,298,000	2,046,000	1,584,000

Average of Housing rent (Rp/month) per sub-districts in the years 1985, 2006, and 2011. Estimation real estate company, own analysis.

Land price	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	34,000	35,000	47,806	109,555	60,000	50,000	62,000	38,842	36,850
2006	120,000	220,000	800,000	1,000,000	562,000	550,000	230,000	500,000	800,000
2011	240,000	440,000	1,600,000	2,000,000	1,124,000	1,100,000	460,000	1,000,000	1,600,000

Average of land price (Rp/m^2) per sub-districts in the years 1985, 2006, and 2011 (NJOP, 2012), own analysis.

Spatial Data

Residents	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Area (km^2)	7.26	3.78	4.79	4.54	5.34	10.05	5.21	14.24	6.15

Area per km^2 in all sub districts (RTRW, 2009)

Land Development	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
1985	40%	45%	60%	40%	45%	70%	30%	70%	50%
2006	80%	60%	10%	4%	51%	50%	45%	50%	25%
2011	70%	50%	10%	4%	41%	40%	35%	40%	15%

Land availability for development (BAPPEDA, 2012a, BPS-Banda-Aceh, 1985-2004), own estimation.

Land Development	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Residential	30%	30%	40%	65%	40%	70%	20%	70%	20%
Economic	20%	20%	20%	30%	20%	20%	30%	20%	20%
Protected	50%	50%	40%	5%	40%	10%	50%	10%	60%

Percentage area for development in MARS 1985 (Pre-tsunami model) (BAPPEDA, 2012a, BPS-Banda-Aceh, 1985-2004)

Land Development	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Residential	55%	60%	40%	20%	62%	65%	40%	70%	40%
Economic	10%	20%	30%	60%	30%	30%	30%	20%	25%
Protected	35%	20%	30%	20%	8%	5%	30%	10%	35%

Percentage area for development in MARS 2006 (Post-tsunami model) (BAPPEDA, 2012a, BPS-Banda-Aceh, 1985-2012)

Land Development	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9
Residential	55%	60%	40%	20%	62%	65%	40%	70%	40%
Economic	10%	20%	30%	60%	30%	30%	30%	20%	25%
Protected	35%	20%	30%	20%	8%	5%	30%	10%	35%

Percentage area for development in MARS 2011 (Future model) (BAPPEDA, 2012a, BPS-Banda-Aceh, 1985-2012, RTRW, 2009)

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