ANALYSIS OF LAND USE AND ENVIRONMENTAL CHANGE TRIGGERED BY DECENTRALIZATION POLICY IN SAMARINDA, INDONESIA

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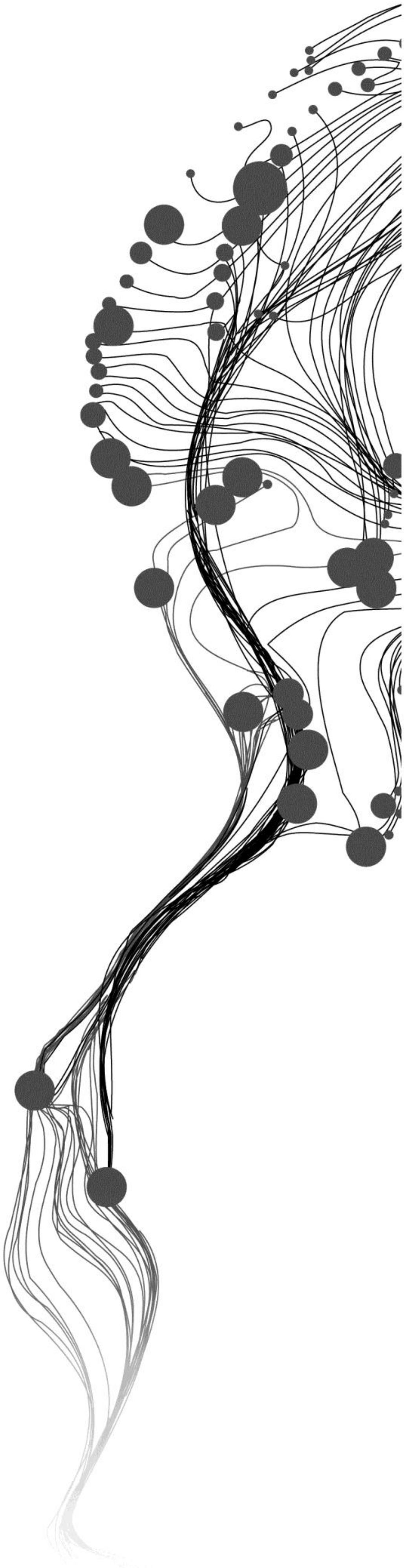

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Enschede, The Netherlands, September, 2011

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ABSTRACT

Implementation of decentralization in Samarinda has triggered the urban growth and expansion of mining activities in the city. These two factors have caused changes on land use/cover in the city. Land use/cover change is a direct driver of environmental change and affects ecosystem services. Ecosystems provide numerous services for human life and the land use/cover changes cause degradation of ecosystem capabilities to fulfil human needs. This study aims to analyze how land use/cover changes triggered by decentralization policy affect environmental degradation in Samarinda, Indonesia. To achieve the objective, two steps of analysis were conducted: 1) analysis land use-land cover change; 2) analysis of environmental degradation as a result land use – land cover changes based on ecosystem services concepts. First, multi temporal analysis was carried out to detect changes on land use-land cover. Change detection of land use maps 2000 and 2006 was performed to assess the land use change during the period. As a comparison to land use maps 2000 and 2006, the land use/cover mapping was performed using Landsat 2002 and Aster 2009 to assess the land use/cover change between 2002 and 2009. Post classification change detection was employed to analyze the change from 2002 to 2009. The two different periods of change detection analysis resulted similar trends revealing that built-up and mining areas increased while natural lands decreased over time. From 2000 to 2006, the total area of built-up area increased in size from 6653 ha to 11144 ha representing 6.38 % increase. Mining area also increased by about 3.38 % from 333 ha in 2000 to 2716 ha in 2006. In contrast, the area covered by shrub decreased 9.24% from 41571 ha in 2000 to 35061 ha in 2006. Mix vegetation also decreased from 11657 ha to 11144 ha, the reduction was 512 ha representing 0.73% of the total study area. The other land uses more or less were stable during the time periods. Second, analysis of environmental degradation based on ecosystem services concepts was performed using Spatial Multi Criteria Evaluation (SMCE) and Geographic Information System (GIS) analysis. Identification of important services was conducted by distributing questionnaire to local people in the study area. Eight ecosystem services were identified by local people in the study area including purification of air, prevention of floods, provisioning of foods, recreation, water resources, provisioning of fuelwoods, provisioning of timber and provisioning of medicinal plants. Assessing and mapping of the important ecosystem services were created to obtain land use/cover valuation maps for each ecosystem services where the assessment was based on land use/cover capabilities to provide the services. GIS techniques were applied to map the ecosystem services value. Spatial Multi Criteria Evaluation was applied to assess the total ecosystem services value for the eight ecosystem services. From the total value of the ecosystem services, forest and mix vegetation received the highest value, followed by agricultural land, shrub, river and swamp respectively, while built-up and mining area did not have a value at all. GIS analysis was performed to evaluate the environmental change from 2000 to 2006. The analysis revealed that environmental degradations occurred in the study area due to land use/cover changes at that time periods. Conversion of mix vegetation to mining and built-up area resulted in a very high level of environment degradation in area of 507 ha due to the loss of the capabilities of the ecosystem to provide the eight ecosystem services in the study area. Conversion of agricultural land to built-up and mining area caused the decrease of the ecosystem services capabilities in a high level in area of 664 ha, and conversion of shrub to mining and built-up area caused ecosystem degradation in a medium level in area of 5849 ha.

Key words : land use-land cover change, environmental change, ecosystem services, GIS analysis, Spatial Multi Criteria Evaluation

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1. INTRODUCTION

Decentralization is the delegation of authority from central government to local governments both administratively and territorially that means the policy will be delegated to a lower hierarchy and opens participation of all level in determination of policy (Smith, 1985). Although, there are several forms of decentralization including devolution, delegation and deconcentration (Cheema et al, 1983 in Mansberger R, 2003), the decentralization concept currently developed in Indonesia is more known as regional autonomy and started after the publication of Law 22/1999 on Local Government. The law authorizes local government in running the wide-ranging autonomy to set and manage its own problems based on autonomy principles, including autonomy in the utilization of natural and other resources. In land sector, the law becomes a foundation of land decentralization policy in Indonesia. Then, Presidential Decree 34/2003 on National Policy on Land Sector set the authorities of local government in land sector more detail. The authorities include giving location permits, the implementation of land acquisition for development purposes, utilization and completion vacant land issues, land use planning and others. The impact of implementation of these regulations is that private sectors are more easily able to obtain location permits than before. In economic sector, because of those regulations provide wide range of opportunities for local governments on utilization of their own resources, many local governments attempt to get more investment for their regional development. As a result, after decentralization many regions in Indonesia are growing at an unprecedented rate in economic growth.

Samarinda, the capital city of East Kalimantan, is one of the fast growing regions after decentralization era. Since the implementation of regional autonomy, many companies have invested in East Kalimantan, including Samarinda and the surrounding area of Kutai Kartanegara Regency. Kutai Kartanegara is a region that borders Samarinda in west, east, south and north side. Thus, Samarinda experiences the increase of the number of industries and mining companies which trigger the economic growth of the city. The economic growth in the period 2000-2007 has reached an average of over 7 percents per year, first time after regional autonomy (Bappeda samarinda, 2011). Samarinda also experiences urbanization. Population growth of Samarinda occurs very fast, due to the number of migrants. The population of Samarinda was 588.135 inhabitants in 2006, with a growth rate of 5-7% per year (BappedaSamarinda, 2010), and in 2010 the population was 799.972 inhabitants (BappedaSamarinda, 2011). It means that the population of Samarinda increases almost about 40% in the period of only four years from 2006 to 2010.

The growth of the city causes physical changes as a consequence of the increasing needs for housing, social-economic facilities, transportation facilities and others. Therefore this condition gives pressure on the land use changes. There are 14 housing complexes built in Samarinda from 1997 to 2003 and some of their activities on building new houses are still ongoing (Masjaya, 2007). Moreover, there are several new housing projects in Samarinda until 2010. Originally, land for housing projects is nature or agricultural land. For instance, a new estate in Samarinda hill area and a new housing complex located on the edge Mahakam River has changed the nature land on the hills area and on the banks of the river into built-up area.

Land use changes due to land development of housing complexes cause environmental problems in the city. Masjaya (2007) found that most of housing projects in Samarinda were not in line with the city planning and also did not consider the environment. Many wetlands, hills and catchment area were altered to housing projects. Some developers developed land by cut off the hills and pile up wetlands and water catchment areas. Ismail (2009) reported that large downstream areas of Karangmumus (the second largest river in Samarinda) river basin, which are swamp areas along the river bank, have been developed for residential and economic activities and it disturbed water equilibrium in the river.

Beside land use changes due to new housing projects, land use changes are also caused by coal mining activities. Since 2000 there is a lot of small-scale coal mining in Indonesia including Samarinda when the regional autonomy law enforced. Issuance of permits is to be part of the authority provincial and district governments. Regional autonomy authorizes local government to release the operation of general mining (except oil and gas) and then this authority is reaffirmed by Law 2009 on mineral and coal mining.

All coal mining activities in Samarinda are open pit mining. Open pit mining activities on large scale require large scale land for quarrying and building road network for their activities. Coal mining activities cause land use-land cover changes from natural land to bare land. In addition, the small-scale coal mines in Samarinda mostly do not have environmental impact assessment and they typically do not conduct site rehabilitation or restoration after mining. Therefore, small-scale coal mining activities have caused severe damage of environment.

Land use changes due to coal mining activities and land development of housing complexes caused environmental problems in the city. Those conditions cause flooding more often in Samarinda. Flooding will occur when rain falls more than two hours, and it will inundate until to Samarinda downtown. Before autonomy era and widespread changes on land use, flooding occurred in cycle of 5 or 10 years once. Meanwhile, since last 3 years, floods occurred repeatedly even could take place during the rainy season (Greenpeace Asia Tenggara-Walhi, 2010). Flooding as an impact of land use-land cover change has disturbed the community life of Samarinda residents. Some people suffered losses and crop failure because floods submerged their fields and ruined their fish ponds. In other case, people lose a source of water for drinking and bathing, because the river is polluted (Greenpeace Asia Tenggara-Walhi, 2010). Therefore, the massive land use-land cover changes in Samarinda have caused negative impacts on the environment and also human life there.

1.1. Background and Justification

Firman (2004) states that the economic crisis in the end of 1990s and new policy on regional autonomy and fiscal decentralization are two occurrences that influenced the urbanization pattern in Indonesia. As a result, rapid changes of land in urban centres and the conversion of agricultural land to residential area and other urban land uses have become the characteristic of recent urban development in Indonesia (Firman, 2004). The irrigated and prime agricultural land was involved in the large scale of land conversion, and it is feared that this will affect foodstuff production (Firman, 2000).

One of the major environmental impacts in most urbanized countries is transformation of natural or agricultural land to urban land (OECD, 1997 in Nuissl et al., 2009). Nuissl et al., (2009) note that economic growth and urbanization become the issue in land use-land cover change due to increase the land consumption for residential development, transportation, and other economic activities and they provide impacts to environment. Globally, earth system functioning can be affected by accumulation of land use-land cover changes (Lambin et al, 2001), and they give the big impact in the degradation of ecosystem services (Hu et al, 2008) because they reduce the ability of nature to fulfil human requirements (de Groot et al., 2002).

Ecosystem services are important goods and services that are provided by ecosystem to well-being of human life directly or indirectly (Nelson et al., 2009, Costanza et al., 1997). Direct goods obtained from ecosystems include foods, raw materials such as timber, lumber, and others, while other services provided by ecosystems include erosion control, water purification, climate regulation, and others. However, the capability of ecosystem to provide goods and services can be affected by human activities directly or indirectly. Millenium Ecosystem Assessment (2003) has identified land use-land cover change is a direct driver on ecosystem services in local regional and global level and it affects the human well-being and poverty reduction. Some studies also have shown that land use change impacts the ecosystem services. Research by Li et al, (2007) in Pingbian Miao, China, found that ecosystem services and functions were disturbed by the agricultural expansion and deforestation. They quantify the value of ecosystem services and the results show that conversion of forest and grassland to shrubland and cropland decrease the ecosystem services value. Daniel, (2008) conducted research to assess the effect of land use-land cover change on ecosystem services in Ejisu_juaben District, Ghana, which carbon sequestration as the case studies. He found that ecosystem capability in sequestering carbon decrease due to land use-land cover change.

1.2. Problem Statement

Decentralization regulations give some positive impacts for the economic growth and development of Samarinda. They provide many opportunities to local governments to utilize their own resources. As a result the cities experienced rapid growth. However this rapid growth has impacts for the region in many aspects including economic, social, cultural and physical aspects. In the physical aspect, the pressure of the urban growth is the land use – land cover change because of the needs more land for residential, commercial, and public utilities and facilities. Moreover, because Samarinda is rich coal resources, land use – land cover changes are also accelerated by coal mining activities. However, those activities offer negative impact on environment that affects ecosystem services.

Rapid change of land use/cover in Samarinda requires more attention because conversion of natural land to urban land and other economic activities has caused negative impact to environment. Flooding is an example of environment damage as a result of land use-land cover change where it not only causes environment damage but also provides further impacts on human life there. Therefore environmental damages due to land use change not only affect physical aspects but also human well-being. Ecosystems from which human obtain benefit can experience degradation or cannot fulfil the human needs. Thus, analysis of environment problems require integrated approaches to assess the ecosystem changes by human activities. Ecosystem service concept is a broad concept which offers concept of ecosystem analysis based on ecosystem function and human well-being point of view. However, it is still needed information how the land use changes affects degradation of environment and how to apply ecosystem services concepts to analysis environmental degradation in Samarinda.

1.3. Research Objectives

This research is conducted to assess how the land use-land cover changes triggered by decentralization policy affect environmental degradation in Samarinda. Based on the objective above, the following sub-objectives are formulated.

1. To analyze the land use-land cover change in Samarinda municipality after decentralization in 2000.
2. To analyze environmental degradation as a result land use – land cover changes based on ecosystem services concepts

1.4. Research Questions

1. How to measure land use – land cover change in Samarinda?

2. What changes occurred in land use-land cover in Samarinda after decentralization in 2000?
3. Which services are provided by the ecosystem in Samarinda?
4. How to map environmental degradation in the study area using the concepts of ecosystem services?
5. How do changes on land use – land cover affect ecosystem or environmental degradation in study area?

1.5. Conceptual Framework

The decentralization policy offers wide range of opportunities in obtaining location permits and it has caused massive land use/cover changes in Samarinda. The massive change on land uses/covers causes environmental problems. Analysis of environmental degradations is required to find out the existence of ecosystem services presently, and as an evaluation in order to anticipate degradation in the future.

Analysis of land use-land cover changes is carried out using multi-temporal analysis, and change detection is created to see the changes. Analysis environmental degradation due to land use changes is carried out by applying concepts of ecosystem services. Ecosystem services concept is used as an assessment framework because it is an approach linking ecosystem functions and human well-being.

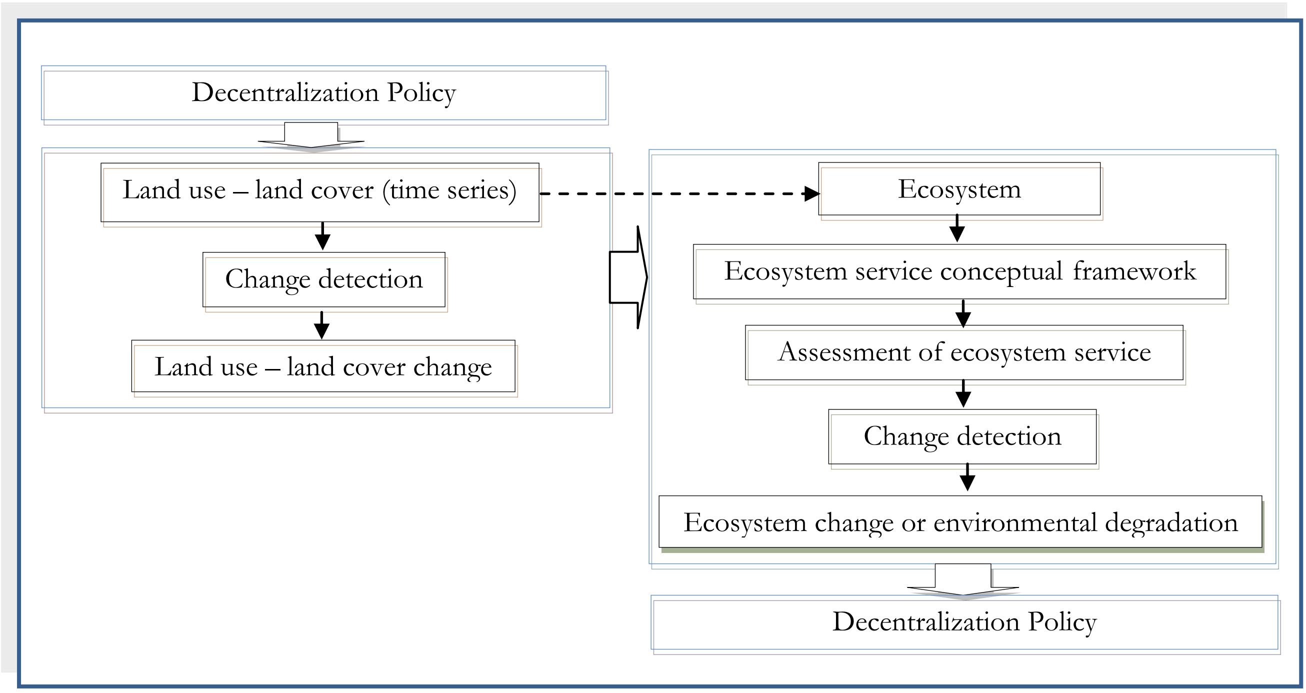


Figure 1. Conceptual Framework of this study

2. LITERATURE REVIEW

2.1. Land use – land cover

Land use is human interventions on land either permanent or cyclic in order to obtain benefits from it where the activities are relatively stable in a certain place at a certain time (Vink, 1975). According to Vink (1975), land use is the application of human controls in a relatively systematic manner within ecosystem in which human is inherent part of it. He divided land use into two categories which are rural land uses including agriculture, forestry, cropland, wildlife conservation; and urban land uses including town, villages, industrial complexes, highways and so forth. According to Meyer and Turner, (1994) land uses include settlement, cultivation, recreation, rangeland, pasture and so on. Land use refers to the purpose or function for which the land is being used. Data of land use are essential for public agencies and private organizations in order to know the current situation and to plan the future action in the dynamic land use situation (Anderson et al, 1976).

The concept of the land use has directly linkage to land cover and in many cases they are used interchangeably (Anderson et al, 1976, Meyer and Turner, 1994). Di Gregorio (2005) states land use is described by intervention of human in a certain land cover type, while land cover as the biophysical cover of earth surface. Land cover refers to natural and man-made construction that covers the land surface or describes the physical state of the land such as surface vegetation, water and earth materials (Meyer and Turner, 1994). Di Gregorio (2005) further argues that definition of land use creates a direct link to land cover and the activities of people in their environment. Knowledge about land use and land cover is important in determining solution of uncontrolled development problems and also environmental problems including deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat (Anderson et al, 1976).

2.2. Land use – land cover change

Meyer and Turner (1994) define land use change as alteration of physical environment caused by human actions on land which include shift from one use to different use or intensification of existing land. Then, they divided the land cover changes into two categories, which are conversion and modification. Human plays a vital role in land use change or land use dynamic. Effort of human for alteration of land use is often urgently needed on utilization of land for human needs (Vink, 1975). For instance, people have used land and changed it to derive food and other resources since thousand years ago. Directly or indirectly activities of people on land can cause land use change.

There are some factors that force the land use changes which are known as driving factors. The driving factors are used in analyzing land use changes. There are five major types of driving forces; political, economic, cultural, technological, and natural/spatial driving forces (Brandt et al., 1999 in Bürgi et al., 2004). Understanding of the causes of change or driving forces is important in modelling and projecting the land use changes. Understanding of changes is also required in order to gain appropriate alternative policies for the future because land use changes are a direct driver of environmental and ecological changes and thus contribute to global changes (Lambin et al, 2001; Meyer and Turner, 1994). Therefore, evaluation and understanding the negative consequences of land use-land cover change becomes the major interesting researchers and policymakers around the world (IPCC, 2000).

2.3. The role of Remote Sensing and GIS in analysis land use – land cover change

Analysis of land use-land cover change has been done for many purposes of studies. The analysis of land use-land cover change most commonly was conducted using remote sensing and geographic information system (Lu et al., 2004). According to Lu et al., (2004) change detection application using GIS approaches either with combination with remote sensing methods or not is practical in integration different source data. GIS approaches and remote sensing techniques have been widely used to monitoring changes in natural resources and urban development. Remote sensing techniques can be used effectively to complement ground survey observation. A lot of information on land cover and land use can be derived using remote sensing because it can cover large areas. Then the capability of this technique in obtaining land use-land cover data is improving due to improvement in equipment, interpretation techniques, and data processing (Anderson et al., 1976).

Remote sensing is an attractive source of thematic map such as land cover and image classification is a technique to produces thematic mapping from remotely sensed data (Foody,2002). The thematic map may result of visual or digital analysis. Digital image classification employed to obtain land use/land cover. Classification can be performed by supervised and unsupervised classification. Supervised classification means that training sample is determined by operator based on the spectral characteristic and unsupervised classification is a statistical clustering technique employed to combine pixels or group together based on spectral similarity (ITC, 2010).

2.4. Concepts and defenitions of ecosystem services

Ecosystems provide many essential goods for human societies such as seafood, timber, natural fiber, animals, fodder, fuelwood, and pharmaceutical products; and they also perform fundamental life-support services including the purification of air and water, detoxification and decomposition of wastes, regulation of climate, regeneration of soil fertility, and production and maintenance of biodiversity (Daily et al, 1997). According to Daily et al (1997) "ecosystem services is conditions and processes through which natural ecosystem sustain and fulfil human life." Other definitions came from, Constanza et al., (1997), de Groot et al., (2002) defining that ecosystem services is the benefits human obtain, directly or indirectly, from ecosystem functions. Boyd and Banzhaf (2007) define that ecosystem services are "the benefits of nature to households, communities and economies." In addition, Millenium Ecosystem Assessment (2003) states that ecosystem services are benefits people derive from ecosystem

Millenium Ecosystem Assessment (2003) grouped ecosystem services into four categories :

1. "supporting services which relate to underpin the provision of other services such as nutrient cycling and soil formation;
2. provisioning services which relate to provision of harvestable goods such as food, fiber, fuel, water, fruits and so forth;
3. regulating services which relate to regulate ecosystem process such as climate regulation, water purification, carbon sequestration, erosion control, and so forth;
4. cultural services which relate to services through recreation, aesthetic, spiritual and educational services."

while, de Groot et al., (2002) grouped the ecosystem services based on ecosystem functions into four categories including regulation, habitat, production and information functions. They argue that ecosystem functions reflect the goods and services provided by ecosystems. Even though, there are differences between categories from Millenium Ecosystem Assessment (2003) and de Groot et al., (2002), the explanation of ecosystem services for each categories are almost similar, the differences are lied in using the terms of supporting services and habitat functions, also in terms of cultural services and information functions. Furthermore, Hein et al., 2006 (based upon Ehrlich and Ehrlich, 1981; Costanza et al., 1997; de

Groot et al, 2002; Millennium Ecosystem Assessment, 2003) resumed the ecosystem services into three categories which not distinguish the supporting services because in their opinion this service is reflected in other the three types of services, namely : production services; regulation services; and cultural services. From all those definitions and categories of ecosystem services, they showed that there is a strong relationship between ecosystem services with benefit of human life.

Millenium Ecosystem Assessment (2003), Daily et al (1997), Constanza et al (1997) explain that ecosystem services are essential to human well-being. Human being has gained goods and services from ecosystem for hundreds and or billions years, for instance, ecosystem products which grow in the wild and that are used directly for human benefit, some of the services are so fundamental to life and easy to be obtained and so large in scale such as foods, and fishes (Daily et al, 1997). Some of the ecosystem goods have been traded in economic markets, such as harvestable goods (e.g. fruits, rice, timber, crops, fibers, etc). The trade of these goods represents important parts of the human economy. In relation with the availability of ecosystem in support human life, the some functions and services provided by ecosystem such as climate regulation, water purification are essential to support human life, but, they are not traded in economic market. Most of the services are in regulating services. Because they are not traded in economic market, they do not have a market price. Even though they do not have an economic price, ecologists have seen that they are essential and the loss of the services give a big impact on the human well-being, and give economic loss (Daily et al, 1997, Constanza et al, 1997; MA, 2003)

Human well-being will be affected by the changing of availability of ecosystem services including economic growth, livelihood security and poverty alleviation (MA 2003). The loss of these services will affect the human itself, and most of the services are not considered by human after they lose and give impacts on the human well-being (MA, 2003, Daily et al, 1997). Many human activities that alter or destroy natural ecosystems may cause a decrease in long-term ecological services (Daily et al, 1997). The degradation of ecosystem services has many causes, including economic growth, demographic changes, and individual choices because of excessive demand for ecosystem services (MA, 2003). Humans are changing the capability of ecosystems to continue to provide many of these services due to human demands for the ecosystem services which are growing rapidly (MA, 2003). Many human activities are considered as threats to ecosystem services on a large scale such as deforestation, overfishing, and so forth. Deforestation is one of the critical damage of ecosystem services because forest plays important roles in some ecosystem functions such as regulating the water cycle, mitigating floods, droughts, erosion controls and so forth, therefore the loss of forest will disturb capability of forest to provide the services (Daily et al, 1997).

In relation with the importance of ecosystem services, management of human needs and the capability of ecosystem services is required in order to maintain the contribution of ecosystem to human well-being without affecting their long-term capacity to provide services (MA, 2003). The function of the ecosystem will remain unbroken if the activity of human on the ecosystem is done with appropriate activities and at the right time. Identification and monitoring of ecosystem services both locally and globally are required because threats to ecosystems are increasing, and they are needed incorporation of their value into decision-making processes (Daily et al, 1997).

Identification and monitoring of ecosystem services need to consider the spatial scale. Understanding the spatial scale of ecological process is required in order to understand the scale of the decision process to handle the problem emerging on it (MA, 2003). Ecosystem services vary from the individual level, local level, to global level. Some ecosystem services are in global scale such as global climatic process which is influenced by carbon sequestration, other services may supplied in site level such as amenity services, thus the scale of ecosystem services assessment will influence level of issue, possible actions and institutional responses on it (Hein et al., 2006).

2.5. Land use – land cover changes and treat to ecosystem services

Study of land use change including causes, processes, and consequences of land use and land cover change is one of the main research topics in local and global scales (Meyer and Turner 1994, Lambin et al 2001, Pang et al, 2010, Wang et al, 2008). Land use changes are closely related to socioeconomic development and environmental changes (Wang et al, 2008). Land use-land cover composition and change are important factors that affect ecosystem condition and function, and any change of land use-land cover directly or indirectly has impact to ecosystems (Pang et al, 2010).

Millenium Ecosystem Assessment (2003) identified several factors which affect ecosystems into two categories; indirect drivers (such as population, technology and lifestyle), and direct drivers in which change in local land use/cover is one of the direct drivers that affects ecosystem services as shown in figure 2.

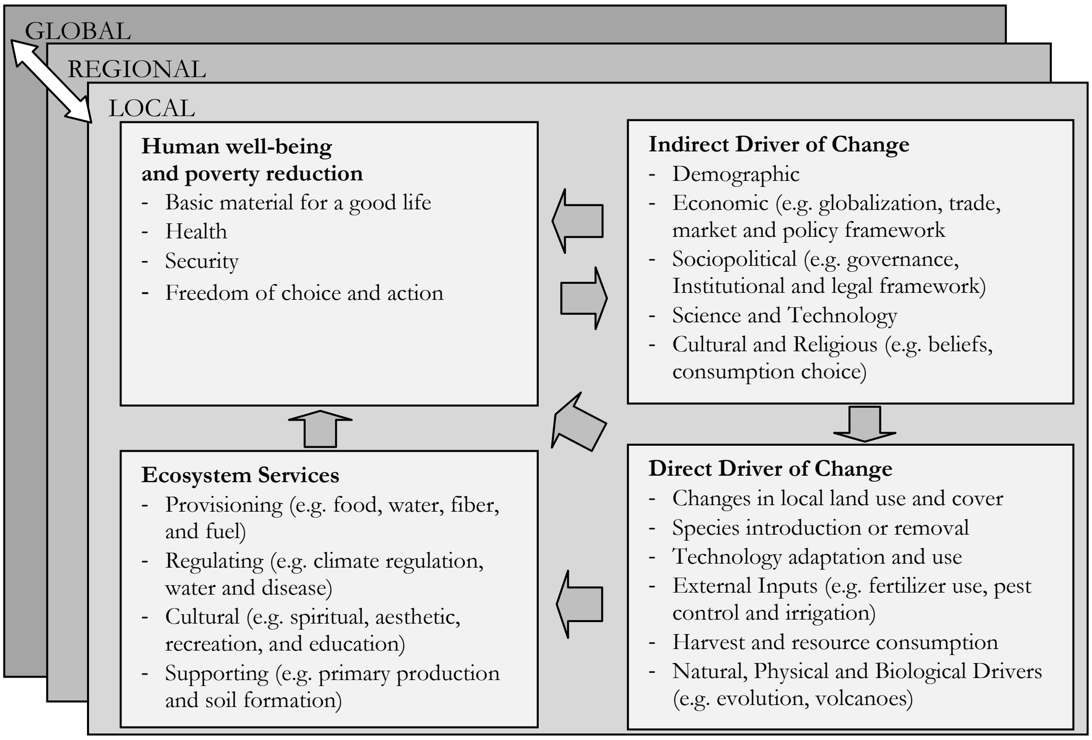


Figure 2. Millenium Ecosystem Assessment Conceptual Framework (adopted from MA, 2003)

Meyer and Turner (1994) state that land-use change is one of the major factors affecting environmental change through its influence on biodiversity, water and radiation budgets, trace gas emissions, and carbon cycling. Furthermore, Daily et al., (1997) also state that land use changes are the primary threats of ecosystem services because they cause losses in biodiversity, disruption of carbon, nitrogen, and other biogeochemical cycles. Study by Hu et al., (2008) described that change of land use has serious environmental impacts affecting the ecosystem services, particularly in the tropics because the change on land use affect changes in ecological functions such as nutrient cycling, erosion control, climate regulation, and water treatment. They found that abrupt shift of land use in the tropical forest result in a great loss of ecosystem services.

There are some significant impacts of land use-land cover change on ecosystem services, particularly in the regulating services;

Climate regulation

Ecosystem provides services as regulation of the local and global climate, and different land cover types have different influence of climate condition (de Groot, 1992). Clearing of forests results in raised land temperatures and replacement of natural land cover by urban and agricultural land uses in large scale has reduced precipitation, thus the change is linked to climate change and threat to the ecosystem (Turner et al., 2007). Changes in land use and land cover are drivers to significant changes in emissions because land use and land use change are the main factors that affect terrestrial sources and sink of carbon (IPCC, 2000). Deforestation and changing in vegetation cover reduce the overall rate of photosynthesis, then reduce capacity of green leaves to absorb $CO2$ (de Groot. 1992). Foley et al., (2005) state changes in atmospheric composition as an environmental impact of land use change have caused changing global carbon cycle then global climate. Roughly 35 % of $CO2$ emissions resulted directly from land use-cover changes since 1850 and deforestation was the largest sources of greenhouse gasses to the atmosphere (IPCC, 2000; Turner et al., 2007; Foley et al.,2005).

Purification of Air or Air quality regulation

Plants have capability in purification of air because they can improve air quality by removing pollutants such as carbon dioxide, sulfur dioxide, and nitrogen dioxide and trapping of particulates such as dust in their leaves (Li et al., 2010). The process of photosynthesis purifies the air because as part of this process plants absorb $CO2$ from the atmosphere and produce $O2$ (de Groot 1992). Tropical rain forests have effect on the oxygen-concentration of the atmosphere and deforestation disturbed large amount of oxygen concentration in the atmosphere. Land-use practices also change air quality by altering emissions and changing the atmospheric conditions because it often determine dust sources, biomass burning, vehicle emission patterns, and other air pollution sources (IPCC, 2000). Also, changes in vegetation cover and biogenic emissions affect on tropospheric ozone ($O3$) and also affect the air quality (Foley et al, 2005). Nowadays, the most problem in some largest city is the total air quality, because clean air, and thereby oxygen become scarce which is caused by fossil fuel burning of vehicles, industries and also it is caused by the decrease the amount of land surface covered by vegetation (de Groot, 1992) .

Regulation of runoff and flood prevention

Vegetation plays an important role in regulating the flow of water at the surface and buffering effect on extreme water levels, especially on hillslopes; "the higher vegetative biomass the greater the capacity to reduce runoff " (de Groot,1992). Pimentel et al., (1980) in de Groot (1992) calculated that water runoff on bare slopes is 10 to 25 times as great as that on slopes covered by vegetation. Rogers (1994) states that there are four major direct impacts of land use-cover changes on hydrological cycle and water quality; they can cause floods, droughts, changes in river and groundwater regimes, and affect water quality. For example : clear cutting forest can cause flooding in downstream, the destruction of vegetation can reduced infiltration into the soil as a result increase surface runoff. Foley et al., (2005) said that land use can disrupt the surface water balance and the partitioning of precipitation into evapotranspiration, runoff, and groundwater flow. The surface runoff and river discharge generally increase when natural vegetation (especially forest) is cleared. Deforestation plays several roles in the flooding because trees prevent sediment runoff and forests hold and use more water than other land uses (Rogers, 1994)

Water regulation

Land cover change can make less water available for groundwater recharge and land use-cover change also result in decrease the water quality (Rogers, 1994). For example, clearcutting of trees can increase sediment reaching downstream and these large scale sediments can seriously disrupt the natural riverine ecosystems (Rogers, 1994). Foley et al., (2005) also state that water quality is often degraded by land use; intensive agriculture increases erosion and sediment load, and leaches nutrients and agricultural chemicals to groundwater, streams, and rivers. Moreover, they stated that urbanization also substantially degrades water quality, especially where there is no wastewater treatment.

Table 1. Potential hydrological effects of urbanization

Urbanizing influence	**Potential hydrologic response**
Removal of trees and vegetation	Decreased evapotranspiration and interception; increased stream sedimentation
Initial construction of houses, streets, and culverts	Decreased infiltration and lowered groundwater table; increased storm flows and decreased base flows during dry periods
Complete development of residential, commercial, and	Increased imperviousness reducing time of runoff concentration thereby increasing peak discharge and compressing the time distribution of flow; greatly increased volume of runoff and flood damage potential
Construction of storm drains and channel improvements	Local relief from flooding; concentrations of floodwaters may aggravate flood problems downstream

Source : From Kibler, 1982:4-5;©AGU in Rogers, 1994

Soil regulation and erosion control

Soil provides services on ecosystem; soil retains and deliver nutrient to plant, decompose of dead organic matter and wastes, and also plays a role in regulating earth's element cycles such as carbon, nitrogen, and sulphur (Dayli et al, 1997). Land use and land cover changes have impact on soil and they are identified as important drivers of soil erosion and soil pollution. Vegetation protect soil from erosion, particularly vegetation with its deep roots, and clearing of vegetation cover has potentially increase surface runoff and it causes nutrient and soil loss. The land clearing of plant cover, for example, makes soils vulnerable to massive increases in soil erosion by wind and water, especially on steep terrain. Soil erosion is not only degrades soil fertility, but also reduces the suitability of land for future agricultural use. Also, soil erosion increase sedimentation and it can disturb the other aquatic ecosystems on downstream (Buol, 1994).

2.6. Assessment of ecosystem services

The ecosystem has a very important value to mankind, because human society is dependent upon ecosystem services, however, the quantification of the value of ecosystem services is not a simple task (Daily et al, 1997). According to MA (2003) valuation of ecosystem services is important because it can be used to assess the total contribution provided by ecosystem to human well-being, to understand the incentives that individual decision-makers face in managing ecosystems, and to evaluate the consequences of action. Hein et al., 2006 stated that the interest in analysis and valuation of ecosystem services has been started since the late 1960 due to increasing of awareness that benefits provided by ecosystem were often underestimated in decision making. Constanza et al., (1997) also state that consideration of ecosystem service value often receive too little weight in policy decision because the services are not fully captured in commercial market. However, with the awareness that the loss of ecosystem services can affect the human well-being, so the assessment of ecosystems has received much attention in scientific literature in recent decades (de Groot et al, 2002).

Many studies have developed methodologies of ecosystem services assessment; de Groot et al, (2002); Constanza et al (1997); Millenium Ecosystem Assessment (2003); Hein et al (2006), Slootweg and Van Beukering, (2008) and others. de Groot et al., (2002) divided the valuation methods of ecosystem functions, goods and services into three types : ecological, socio-cultural and economic value. According to de Groot et al (2002) ecological value is determined both by the integrity of the regulation and habitat functions of the ecosystem and by ecosystem parameters such as complexity, diversity, and rarity; while socio-cultural value describes that value or importance of ecosystem to human society is determined by social values, perceptions or social reasons. Then in economic value, there are four categories of economic valuation methods including direct market valuation, indirect market valuation, contingent valuation and group valuation.

Hein et al, (2006) introduced the valuation framework of three types of ecosystem services (production, regulating, and cultural services) in the four steps of valuation. The valuation framework can be applied in natural and semi natural ecosystem. The four steps of the valuation by Hein et al., (2006) include :

1. "specification of the boundaries of the ecosystem to be valued;
2. assessment of the services supplied by the ecosystem;
3. valuation of the ecosystem services and
4. aggregation or comparison of the ecosystem service values."

According to Hein et al, (2006) in valuing ecosystem services, the valuation needs to consider the spatial scale of the services and the stakeholders. Consideration of spatial scale and stakeholders is required because different stakeholders have different interests in the services, and they attach different value to ecosystem services. For instance, the utilization of forest, households more consider in obtaining goods from forest for their income and their livelihoods, however government institution more consider about the conservation of the area. Valuation of scales and stakeholders is needed in order to minimize the conflict interest among stakeholders. Analysis of ecosystem services in different scales needs at which scale of the assessment and to whom the benefits of the services either in the local, regional or global level. Then, the assessment of scales and stakeholders facilitate decision making process in managing the ecosystem services, and the analysis is required to anticipate the potential conflict in environmental management in all levels (Hein et al, 2006).

Slootweg and Van Beukering, (2008) also introduced the concept of the valuation of ecosystem services including the identification and recognition of ecosystem services; quantification of ecosystem services; societal valuation and economic valuation. According to Slootweg and Van Beukering, (2008) there are four reasons to value ecosystem services including advocacy, decision making, damage assessment and sustainable financing.

Many studies have conducted valuation of ecosystem services either in economic valuation (Constanza et al, 1997; Hein et al 2006; Wang et al, 2006; Hu et al, 2008; Martinez et al, 2009; Jim and Chen, 2009; Gatto et al, 2009; Tianhong et al, 2010) and others or valuation in combination of economic and biophysical assessment (Bolund and Hunhammar, 1999; Guo et al, 2001). Constanza et al, 1997 assessed 17 major categories of ecosystem services provided by global ecosystems and they generated the economic value of services provided by global ecosystems. Bolund and Hunhammar (1999) and Jim and Chen (2009) assessed the value of ecosystem services in urban areas. Wang et al., (2006); Li et al (2007); Hu et al (2008); Martinez et al (2009); and Tianhong et al (2010) focused on the impact of land use change to economic value of ecosystem services where they used the coefficient value of global ecosystem published by Constanza et al., (1997) as a basis valuation of ecosystem services in their study area.

The other approach in assessing of ecosystem services is assessment of ecosystem services indicators. World Resources Institute (WRI) built a database of ecosystem service indicators including categories and types of ecosystem services. Each category of ecosystem service has its own indicators and methods how to evaluate the ecosystem services. The indicator of ecosystem services can be used in the analysis of the current states and trends of ecosystems. The indicator can also be used for the environmental impact assessment which can help to support decision making process even for public or private sectors. There are some indicators which can be used in valuing ecosystem services. In provisioning services, some indicators include food production, fish catch, rice production, food consumption, biomass fuel, timber forest production and so on. In regulating services, the indicators include water resources-run off, drought frequency, temperature, carbon sequestration capacity and others. In cultural services, some indicators are strength of cultural identity, value of recreation and tourism, visitor to natural area, income from natural tourism, ecotourism potential, and so on. There are more categories of indicators. The selection of the indicator in analyzing the ecosystem services refers to the situation in the study area (WRI, 2011).

2.7. Multi Criteria Evaluation

Besides the assessment approaches described earlier, another approach that can be used in assessing the ecosystem services is multi criteria evaluation (MCE). The approach has been applied by Martinez-Harms & Gajardo (2008) and Zhang & Lu (2010). Martinez-Harms & Gajardo (2008) used this approach to value the ecosystem services provided by protected areas in Western Patagonia, South America. They assessed the ecosystem process, goods and services and based on the ecosystem process, the criteria were built with the expert judgments as a basis for scoring. Analytic Hierarchy Process (AHP) was applied to evaluate criteria, and to obtain weight of the criteria where pairwise comparison was applied in their study. In combining with Geographic Information System (GIS) analysis, the ecosystem services values as a result of the analysis are mapped in qualitative scale. According to Martinez-Harms & Gajardo (2008), the advantages of MCE are it can be used to identify ecosystem process, goods and services; this method opens opportunities to map each of ecosystem services in one information layer of evaluation by combining it with GIS techniques; and it allows the comparison of the provision of ecosystem processes and services capacity. However, they also stated that because this approach uses expert judgment as a basis for evaluation, this approach can be considered as a subjective approach. Even though there is a disadvantage of this methodology, they arrive in conclusion that MCE allowed the identification of ecosystem, processes, goods and services, and it is practical to evaluate and to map the ecosystem services value.

Zhang & Lu (2010) applied MCE to obtain the total ecosystem value of Ruoergai Plateu Marshes in southwest China which includes the social factors in their analysis. Similar with study by Martinez-Harms & Gajardo (2008), they used Analytic Hierarchy Process (AHP) to evaluate criteria, and to obtain weight based on pairwise comparison. In assessing the total services value, their appraisal used social welfare weight obtaining from stakeholder judgments related to the importance of the services. According to Zhang & Lu (2010) the judgment of stakeholder is important because evaluation of ecosystem services needs to consider social requirement of the services.

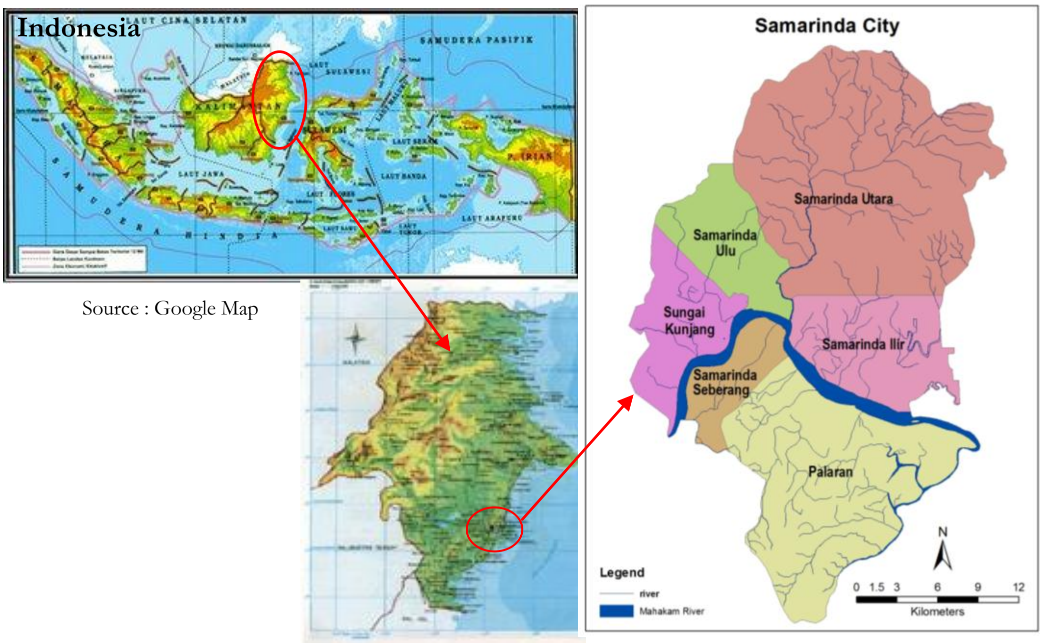
Multi Criteria Evaluation is a tool for decision making process that involves a set of criteria which is used a basis evaluation for complex problems (Proctor, 2001). Two simplest methodologies in multi criteria analysis are ranking and rating where ranking reflects the degree of importance relative to decision being made (CIFOR, 1999). Multi criteria evaluation without integration with spatial analysis is still aspatial and the integration with the Geographic Information System (GIS) analysis, it is referred as Spatial Multi Criteria Evaluation (SMCE) (Malczewski, 1999).

3. MATERIALS AND METHODS

3.1. Study Area

Samarinda, the capital city of East Kalimantan Province, geographically lies between 00 º 19'02 " S - 00 º 42'34 " S and 117 º 03'00 " E - 117 º 18'14" E in which Mahakam River divides the city into two parts. (figure 3). The northern part covers 4 sub-districts including Samarinda Utara, Samarinda Ulu, Samarinda Ilir, and Sungai Kunjang sub-districts. The southern part covers 2 sub-districts including Samarinda Seberang and Palaran sub-districts.

Samarinda is located in the equator area. Topographic condition of the study area is flat and hilly between 10-200 meters above sea level. The slope of Samarinda is 0-60%, with majority slope is a 0-2% at area 259.87 km² (36.19%) of the total area. The climate is wet tropical climate, and rain throughout the year. The temperature is between 24-32c, with the average rainfall 162 mm, and the average humidity 82.7%. Based on hydrological conditions, Samarinda is affected by about 20 rivers. Mahakam River is the main river and the biggest one. The second largest river is Karang Mumus with total watershed about 218.60 km² (BPS Samarinda, 2010).



Source : Google Map

Figure 3. Map of study area

3.1.1. Demographic conditions

Samarinda is the most populous city in East Kalimantan province with a population of 799.972 inhabitants in 2010 (BappedaSamarinda, 2011). Population of the city continues to increase each year. Besides natural growth, population growth in Samarinda also is caused by migration rates triggering by economic development in the area and its surrounding. Population growth is attributed to the considerable expansion of the city. As an urban area, most of the people in Samarinda work in industrial, trade and service sectors. The industrial sector employed 32.6% of the working population in 2009, while the trade and service sector absorbed 37.3% of the workforce in the study area. Then, the agricultural sector is the least employer employing 4.8% of the working population (BPS Samarinda, 2010).

Table 2. Population of Samarinda

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Population	516,916	529,767	539,726	561,471	569,004	576,047	588,135	593,827	640,878	770,190	799,972

Source : BPS 2010 & Bappeda, 2011

3.1.2. Economic conditions

Industries, trades and services are the main economic activities in the city. As the capital city of East Kalimantan province, Samarinda is a centre of governmental activities, trade and services in the province. East Kalimantan is one of the richest provinces of resources in Indonesia including renewable resources and non-renewable resources. Renewable resources include timbers and non-renewable resources include oil, gas, and mineral resources such as gold and coal. As the capital city of the province, Samarinda plays an important role as a centre of business of those resources. In addition, with the implementation of regional autonomy and fiscal decentralization, the economic growth of Samarinda increases significantly caused by wide-ranging opportunities to local government in the utilization of the resources and getting profit sharing and revenue from the utilization of the resources. The economic growth of Samarinda is also supported by the increase of production and price of goods and services in that area so that it increases Gross Regional Domestic Product (GRDP) value of the city. Economic growth of the city in the period 2000-2009 has reached an average of over 7 percent per year (Bappeda Samarinda, 2011), the high rate of the economic growth occurs in the city especially after the implementation of regional autonomy. GRDP of Samarinda is in positive growth where the industrial and service sectors are the largest contributor to the GRDP value. Mining and quarrying sector also shows positive growth but it does not significantly give a high contribution to the GRDP because there is also a financial balance between central and local government as stated in Law 25/1999 (it revised in Law 33/2004). One the other hand, the agricultural sector is the smallest contributor to GRDP of Samarinda and its sector experiences the negative growth each year. The economic development of Samarinda is shown in table 3.

Table 3. Development of Economic Structure of Samarinda 2000-2009 (Percentage)

Economic sector	**2000**	**2006**	**2007**	**2008**	**2009**
Agriculture	2,38	2,20	2,27	2,19	2,15
Mining and Quarrying	5,39	5,86	6,03	6,47	6,57
Manufacture/Industry	37.61	28.87	28.34	27.98	27.58
Service	54,62	63,07	63,97	63,35	63,70

Source :BappedaSamarinda, 2011

3.1.3. General descriptions of coal mining permits in study area

Since the implementation of the decentralization policy or regional autonomy, many mining permits have been issued in Samarinda. According to Rusdi A.R (the head of Mining and Energy Department of Samarinda city), there are many permits of coal mining in Samarinda;

- 30 permits from Samarinda City Government, the area covers about 13.075,25 Ha,
- 1 permit from East Kalimantan Province Government that located in Kutai Kartanegara Regency but 35 % the area enter the location of Samarinda about 23.153,30 Ha,
- 4 permits from Central Government from Ministry of Mining and Energy (Kaltim Post, May, 18 2009).

However the data are different from data stated by Governor of East Kalimantan province that there are 76 permits of mining concessions issued in Samarinda with total land being mined is 38.814 hectares (tekmira.esdm, 2010) and this is similar with the finding of Mining Advocacy Network (*Jaringan Advokasi*

Tambang), so that coal mining activities are accounted as the direct driver of deforestation and many environmental problems in the city (JATAM, 2010).

This area is chosen because it is experiencing urban expansion and exploitation of coal mining activities which are the most driving factors in the land use-land cover changes and cause environmental problems in the study area.

3.2. Data

Data were collected by primary and secondary surveys. The primary survey was carried out to collect the ground truth data used for land cover classification. In identifying of ecosystem services in the study area, the data were also obtained from primary survey using questionnaire. The secondary data collection came from other institutions including spatial and non spatial data.

The spatial data used in this research were obtained from various sources. The data also have different types and resolutions. This condition is caused by the availability of the data sources for the study area. The difficulties in searching homogenous data for the study area such as imagery data are because of cloud cover problems. Most of the images in the study area have high cloud covers. Thus this research used two different data types, namely land use maps and remotely sensed data.

Maps used in this study are land use maps 2000 and 2006 obtained from National Land Agency in Samarinda. Those maps were made through ground check and survey to the field by the institution. Both maps are in AutoCAD format with a scale of 1 : 50000.

The remotely sensed data used are Landsat-7 ETM (Enhanced Thematic Mapper) 2002 and ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) 2009. The Landsat-7 ETM covers the entire study area, but the ASTER image of 2009 only covers the western part of the study area. The two images have small parts of cloud covers and shadows. The specification of the image data is described in the table 4.

Table 4. Remotely data used in analysis land cover change

No	Image	Resolution	Date Acquisition	Path/Row	Source
1	Landsat 7 ETM	30 m	13/01/2002	116/60	http://glovis.usgs.gov.
2	ASTER	15 m	08/05/2009	116/60	ITC database

Ground Check

Ground check was carried out to collect sample points and ground points that will be used for classification process of land cover types in the study area. Collecting of coordinate points was done using GPS, and camera digital was used to take pictures of the land covers. Because the ground check was carried out in March 2011 which was not in the same year with the data images used in this study (2002 and 2009), then the ground check was more on understanding and observing the land cover types of the study area, and observing the unchanged area based on information from local people.

3.3. Research methods

The workflow of methodology in this study is presented in figure 4.

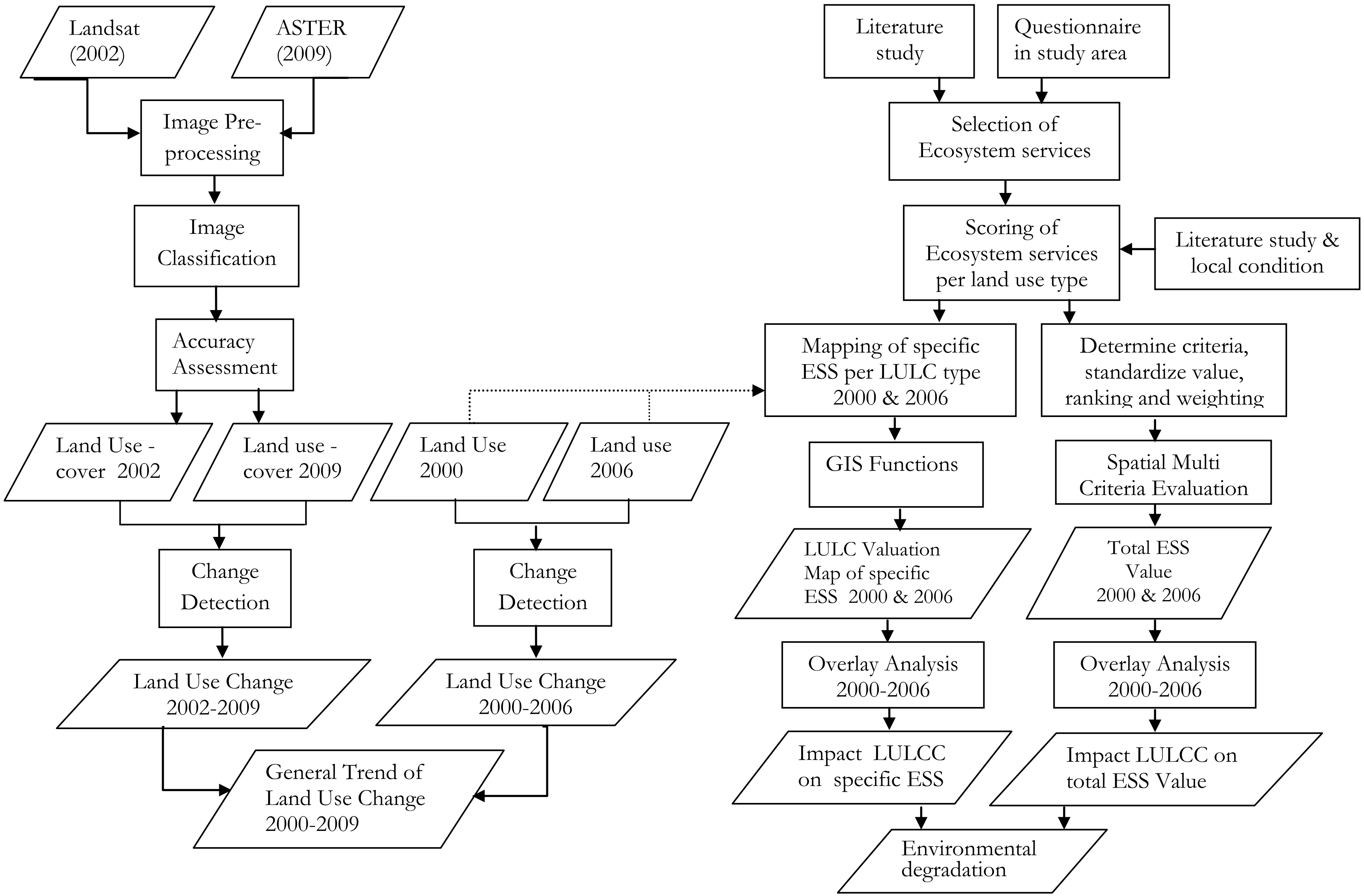


Figure 4. Methodology of the study

3.3.1. Analysis of land use-land cover change

3.3.1.1. Image Pre-processing

Multi-temporal analysis was conducted in this study using Landsat-7 ETM image of 2002 and ASTER image of 2009. Preparations of both images including layer stacking, georeference, and image masking were conducted using ERDAS Imagine 2010. Both images are geo-referenced to Universal Transverse Mercator projection system, zone 50 South of the equator. Georeference is aimed to register image to map coordinates (ITC, 2010). Then, the images were masked to obtain subset of the study area. Because of the two images have different resolutions, so that the Aster image which has a 15 m resolution was resampled to a spatial resolution of 30 m in order to be consistent with Landsat-7 ETM which has a 30 m resolution.

3.3.1.2. Image Classification

Digital image classification of image 2002 was carried out using supervised classification with Maximum Likelihood Algorithm in software ERDAS Imagine 2010. Supervised classification means that training samples are determined by operator based on the spectral characteristic (ITC, 2010; Foody, 2002). Because there is no ground point data of 2002, then selection of training samples for Landsat-7 ETM 2002 was only based on the spectral characteristic of the image which verified with Google Earth. For ASTER 2009, selection of training samples was done by picking training samples from unchanged area and also by verifying it with Google Earth 2002. Analysis of feature space plot was done to evaluate overlap and separability of each class. "Feature space plot is a two or three-dimensional graph in which the observations made in different bands are plotted against each other" (ITC, 2010). Based on the feature space plot, built-up area and bare land due to coal mining activities were overlap for all band combinations of the feature space plot. Agriculture and shrub were also overlap in some band combinations of the feature space plot. Therefore, in the classification process, the class of built-up area and bare land, and agriculture and shrub are mixed. The classes were separated later by visual classification based on the location, shape and pattern of the object. The visual classification was created using Software ARCMap10.

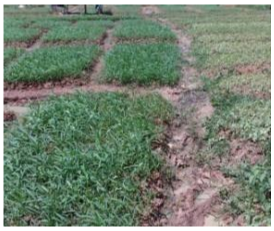
The description of land use/cover is presented in table 5.

3.3.1.3. Accuracy Assessment

Accuracy assessment is an important feature in thematic mapping from remotely sensed data because accuracy will express the "degree of correctness of classification" (Foody, 2002). In this study, accuracy assessment was conducted through error matrix and kappa statistic to measure accuracy of interpretation result. This assessment was performed for interpretation result of Landsat-7 ETM 2002 compared with image from Google Earth, and ASTER 2009 compared with ground truth data for unchanged areas and from Google Earth. An error matrix or confusion matrix provides tabulates overall total accuracy and determines the error such as interclass error, and Kappa coefficient which often be used as a standard measure of classification accuracy (Smits et al., 1999 in Foody, 2002). Overall accuracy including producer accuracy and user accuracy is determined by dividing the number of correct pixels of each class with the total number of reference pixels for the class (Foody,2002). The whole process of image processing was carried out in ERDAS software.

The detailed workflow of digital image classification and accuracy assessment can be seen in appendix 1.

Table 5. Description of land covers classes

Land cover	Description	Picture from fieldwork
Built-up Area- Bare land	Residential area and social-cultural facilities, including houses, schools, offices, commercial areas, industrial areas and also bare land	  
Mining Area	Area cover by bare land and water body because of coal mining activities	  
Mixed Trees	Areas that are predominantly covered by trees	  
Shrub & Agriculture land	Areas that are dominated by shrub such as small trees, alang-alang (*Imperatacylindrica*), and also cover by agriculture such as vegetables	  
Paddy field	Areas that are predominantly covered by paddy	  
Swamp	wetlands	
Water	Water bodies, including river, ponds.	  
Cloud Cover	Area in the images that covered by clouds	
Shadow	Area in the images that covered by shadows of cloud	

3.3.1.4. Land use map processing

The land use maps of 2000 and 2006 have different resolutions and different scales with land cover maps obtained from classification of images. Therefore they were processed differently from land cover maps which are produced from images. Since the land use maps were obtained in CAD format, they were converted first to ArcGIS format. The conversion was created in order to the land use maps can be extracted to the next step spatial analysis (overlay analysis) that will be performed in ArcMAP software. Reclassification was also done for these land use maps. The land use classes of offices, trades and services, educations, sport centres, and residential were combined to one class. Those classes were combined as built-up area. Therefore the land use maps have 8 classes including built-up area, mining area, forest, mix vegetation, agricultural land, shrub, swamp, and river. The description of land use maps is described in table 6.

Table 6. Description of land use map classes

Land use	Description
built-up area	Areas cover by infrastructure, houses, social-economic-cultural facilities including schools, offices, commercial areas, industrial areas, sport centre, etc
mining area	Area cover by bare land and water body because of coal mining activities
forest	Areas that are predominantly covered by trees and also has a function as protected area (educational and research forest) based on ministry of forestry decree No.270/Kpts/II/91 on 20-05-1991)
mix vegetation	Areas that are predominantly covered by trees, similarly with forest, but based on regulation is not determined as protected area.
agricultural land	areas that are dominated by agriculture activities including paddy field, plantation and cropland such as maize, vegetables, etc
shrub	areas that are dominated by shrub (small trees, alang-alang (*Imperata cylindrica*), etc)
swamp	Wetlands
river	water bodies

3.3.1.5. Change detection

Change detection is aimed to analyze changes in the various land use/cover types during the period of study, from 2000 to 2009. Change detection is process to recognize differences of an object or phenomenon in different times (Singh, 1989 in Lu et al 2004). According to Lu et al, 2004, change detection analysis using GIS approach is practical to be used if the data for change detection analysis are multi sources. Thus change detection in this study was carried out using GIS approaches because the data were obtained from two sources. GIS overlay analysis was created in two parts. The first part was overlay analysis of land use-land cover maps 2002 and 2009. The second part was overlay analysis of land use-land cover maps 2000 and 2006. The change detection was conducted into two parts and its process was separated because those two types of land use/covers have different classes and also different resolutions, therefore they did not combined in one analysis. The two separate change detections were done to see the general trend between those two periods (2000-2006 and 2002-2009). Finally, the output table as a result of process was calculated to quantify the land use-land cover change. The workflow of the change detection analysis is presented in Appendix 2.

3.3.2. Analysis environmental change by applying the concept of ecosystem services

This section discussed the methodological approaches for analysis environment degradation in the study area. Analysis of environmental degradation was carried out by applying the concept of ecosystem services. The ecosystem services conceptual framework assessment was applied in this research because it provides integrated approach linking ecosystem functions and their benefits to human life. Assessment of environment can be done by assessing the capacity of the ecosystem to support human life because human life depends on the capacity of the ecosystem to fulfill their needs. When people lose benefits that should be obtained from ecosystems is one indicator that the environment experiences degradation. Thus assessment of ecosystem services can aid to develop deeper understanding of natural function and human well-being because ecosystem services concepts integrating information of natural function and social life (MA, 2003).

The assessment of environmental damage by applying the concept of ecosystem services was done in this study in two steps :

1. Selection of relevant ecosystem services in the study area
2. Assessing and mapping the changes of ecosystem services using GIS analysis and Spatial Multi Criteria Evaluation

3.3.2.1. Selection of relevant ecosystem services in the study area

Methodological approaches used for selection of ecosystem services are literature study and questionnaire survey to local people in the study area.

a. Literature review

Literature review aims to get the pictures of general understanding about ecosystem services, what are the goods and services provided by ecosystem, what are the most ecosystem services affected by land use land cover change, and how to analyze the ecosystem services. Literature review includes journal papers, thesis, books, reports, and web references related to land use-land cover changes, ecosystem services, and natural functions.

b. Questionnaire survey

The main purpose of questionnaire is to obtain information about important ecosystem services for local people in the study area. Simple random sampling was applied in this survey. In order to covers representation of all sub-districts in the study area, this study was conducted in 6 sub-districts in the study area. The 6 sub-districts are Palaran, Samarinda Ilir, Samarinda Seberang, Sungai Kunjang, Samarinda Ulu, and Samarinda Utara. Respondents were randomly selected for each sub-district where the respondents were interviewed in four locations for each sub district. The respondents were requested to choose 3 choices based on their priority from the list of the ecosystem services in the questionnaire. The list of ecosystem services provided in the questionnaire was derived from literature review. The types of question are presented in Appendix 3.

3.3.2.2. Assessment and mapping the changes of ecosystem services

Ecosystem services assessment and mapping were carried out in GIS analysis and Spatial Multi Criteria Evaluation (SMCE). According to Hein et al, 2006, the first step in analysis the ecosystem services is specification of the boundaries of the ecosystem to be valued. In this term, the boundary of the ecosystem is based on land use/cover classification. The next step is assessment of ecosystem services. In this analysis, capacity of ecosystem to provide services is used as a basis assessment qualitatively. A value score is given qualitatively to each ecosystem (land use/cover) on its capacity to provide specific services in which the assessment is based on literature review and relevant condition with study area. Literature studies are used as a basis assessment qualitatively because there are no quantitative values either in economic or biophysical data obtained for this study. Score as a result of assessment was mapped qualitatively. GIS functions were used to map land use/cover as a unit provider of specific ecosystem services in study area. Assessing of land use/cover as a unit provider of total ecosystem services is used by SMCE. Criteria used are capacity of ecosystem (land use/cover) to provide services which are identified by local people in the study area.

Values of ecosystem as results of assessment the capacity of ecosystem to provide services were applied to two period times of study (2000 and 2006). The result is valuation map for each year. To assess the changes of the ecosystem service values, the GIS overlay analysis was created. The steps of the analysis are described in figure 5.

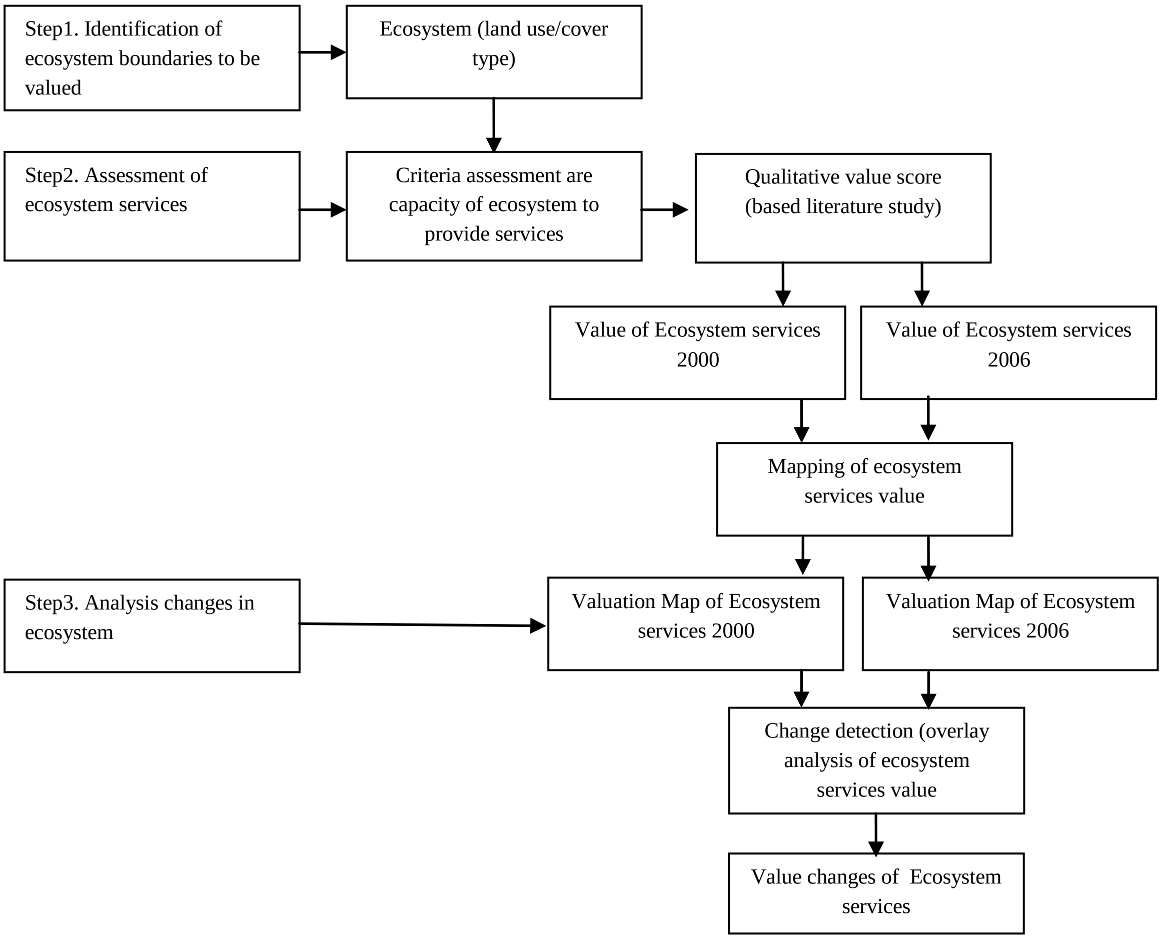


Figure 5. Steps in mapping the changes of ecosystem services

4. RESULT

4.1. Analysis of land use-land cover change

Analysis of land use/cover change was conducted to identify the change of land use/cover since 2000 after the implementation of decentralization policy in the study area. Multi-temporal analysis was applied for land use/cover maps of 2000, 2002, 2006 and 2009 to observe the change of land use/cover in the study area.

4.1.1. Land use-land cover classification

Processing and reclassification of land use maps 2000 and 2006 produced two land use maps of 2000 and 2006, and classification of images (Landsat-7 ETM 2002 and ASTER 2009) generated two land use/cover maps in the study area.

Land use 2000

Land use map 2000 is depicted in the figure 6.

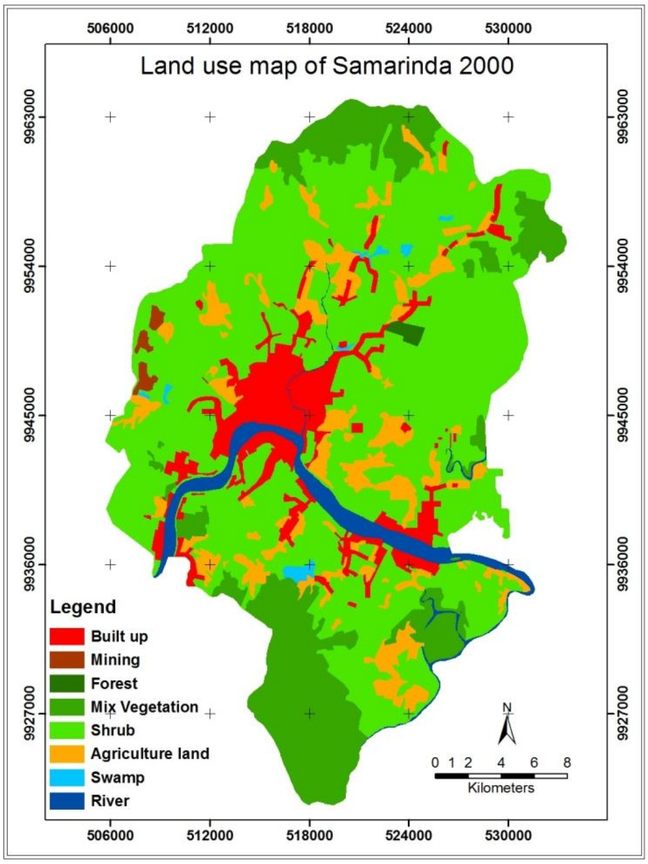


Figure 6. Land use map 2000

Land use of 2000 (see figure 6 and also table 7) was dominated by shrub covering 59.01% of the total area, followed by mix vegetation occupying 16.55 % of the total area. Mix vegetation was mostly located in the northern and southern parts were far away from built-up area but closed to border of the study area. Built-up area occupied 9.44 % of the total area and it was mostly located next to the river. It is because historically Samarinda city at first time was located in the Mahakam Riverside, and its populations used the river as a centre of their activities such as trade and transportation. Then, agricultural land occupied 9.97% of the total area. Agricultural land only covered small portion of the total study area. This is may be because populations in the study area mainly work in service, trade, and industrial sectors and only a few populations work in agriculture sectors. Mining area covered 0.47 % of total area located in western part of the study area.

Land use 2006

Land use map 2006 is depicted in the figure 7.

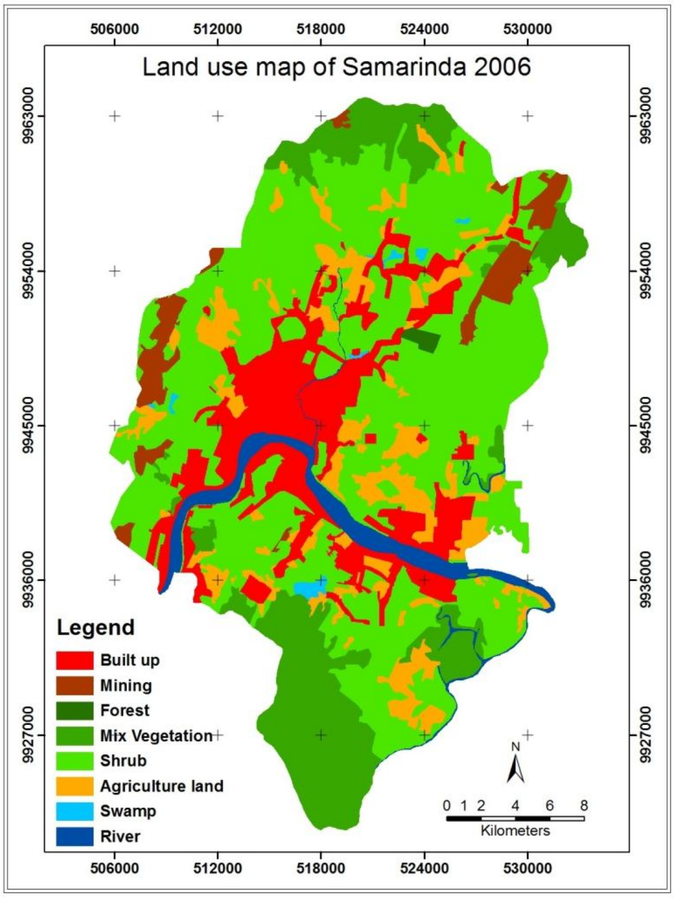


Figure 7. Land use map 2006

Similar with the land use map 2000, the major land use in 2006 (see figure 7 and also table 7) was dominated by shrub covering 49.77% of the total area, followed by mix vegetation (15.82 %), built-up area (15.82%), agriculture (10.21%) of the total area respectively. The remaining land uses are mining area, swamp and river. Mining area occupied 3,86% of total study area. The establishment of mining area occurred in the western, northern part of the study area and small area was in the southern part.

Land use cover 2002

Because the land use/cover map of 2002 did not represent the whole study area, only covered 79.35% of the total study area, therefore the calculation of the percentage of the area referred to the total study area as in land use maps 2000 and 2006. Land use/cover classification of 2002 is depicted in the figure 8.

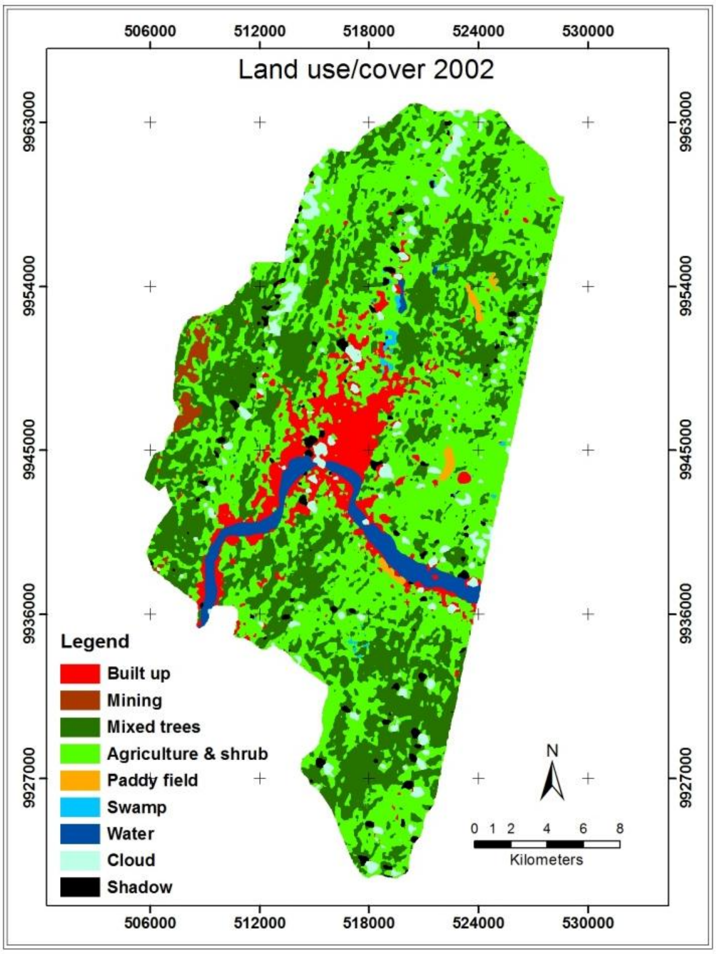


Figure 8. Land use/cover classification 2002

Land use/cover in 2002 (see figure 8 and also table 8) was dominated by mix of agriculture-shrub covering 39.03 % of total area. Agriculture-shrub spread in entire study area. Mixed trees covered 26.27% of total area, while built-up area occupied 5.86 % of the land cover in the study area. Similar with land use map 2000 and 2006, built-up area located in the middle of the study area, located mostly near the river. Then coal mining area was found in the western part of the study area covering 0.66% of the total area. This land use/cover had uncertainty areas because of cloud coverage and shadow. Cloud and shadow covered 4.41 % of the study area.

Land use/cover 2009

Land use/cover map of 2009 (see figure 9 and also table 8) had the same total area with land use/cover map 2002. This land use/cover map only covered 79.35% of the total area, therefore the calculation of the percentage also referred to the total study area.

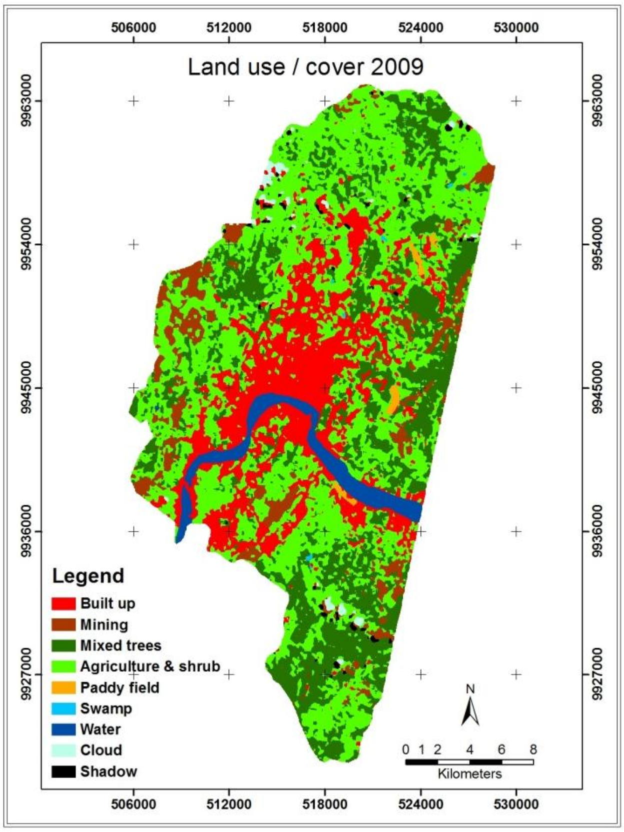


Figure 9. Land use/cover 2009

Land use/cover 2009 was dominated by agriculture-shrub covering 35.41 % of the total area. Compare with land use/cover 2002, mixed trees significantly decreased, it remained 19.54 %. Built-up area expanded to the northern and southern part of the study area, and it covered 15.17% of the total study area. Then, coal mining area spread in the study area, and covered the area about 5.17 %.

Accuracy Assessment

Accuracy assessment of classification of landsat-7 ETM 2002 and ASTER 2009 images was based on the error confusion matrix. The classified image 2002 has overall accuracy 86.36% and Kappa statistic 0.81. The classified image 2009 has overall accuracy 83.09% and Kappa statistic 0.77. Producer accuracy was determined by dividing the total number of correctly classified pixels for a class by the total number of reference for that class, and user accuracy was determined by dividing the number of correct accuracy for a category by the total number of accuracy assessment that were classified in that category. For the classification of the two images the class "water" produces the highest producer accuracy which is 100 %, and also for user accuracy which is 100 %, while class "mixed trees" and "agriculture and shrub" produces least accuracy because of the interclass error between vegetation classes. Error matrix and the total accuracy report for classified image 2002 and 2009 are given in Appendix 4 and 5 respectively.

4.1.2. Land use/cover change

The analysis of land use/cover change was performed in two different parts. The first part was analysis of the land use change from 2000 to 2006, the second part was analysis of the land use change from 2002 to 2009. As stated before, the separated process was conducted because the different class and different scale of data sources. Change detection of land use/cover 2002 and 2009 was conducted as a comparison to the change detection of the land use change from 2000 and 2006. The change detection of this time period was used to see if the trend of the change from 2000 to 2006 still on going or not.

Land use/cover change 2000 to 2006

Comparison of 2000 and 2006 land use maps (figure 6 and figure 7) showed different level of change of all the land use types in the study area. Change detection revealed that built-up, mining area and agricultural land increased, while shrub, mix vegetation and swamp decreased over time. Forest and river remained unchanged. Built-up area expanded to northern and southern part of the study area, adjacent to the existing built-up area in 2000, and from 6653 ha to 11144 ha representing 4491 ha (6.38%) increase from the total study area, but it represents the increase in size about 68% from its original area in 2000. Similarly, mining area increased but at lower percentage than built-up area. Mining increased from 333 ha to 2716 ha or an increase of 3.38 % from the total study area, but it showed the increase in size almost eight times from its original area in 2000. Mining area spread to the northern part of the study area and small area to the southern part. On the other hand, shrub and mix vegetation experienced considerable decrease over time. Shrub decreased 6509.56 ha (9.24 %) from its original in 2000, and mixed vegetation decreased 512.27 ha (0.73 %). The description on the land use change from 2000 to 2006 is depicted in table 7 and figure 10.

Table 7. Land use change from 2000 to 2006

Land use/cover	2000		2006		Difference	
	Ha	%	Ha	%	ha	%
Built-up	6653.38	9.44	11144.90	15.82	4491.52	6.38
Mining	333.67	0.47	2716.81	3.86	2383.15	3.38
Forest	197.08	0.28	197.08	0.28	0.00	0.00
Mix Vegetation	11657.15	16.55	11144.88	15.82	-512.27	-0.73
Agriculture	7020.53	9.97	7190.95	10.21	170.42	0.24
Shrub	41571.54	59.01	35061.99	49.77	-6509.56	-9.24
Swamp	357.09	0.51	333.83	0.47	-23.26	-0.03
River	2660.62	3.78	2660.62	3.78	0.00	0.00
Total	70451.05	100	70451.05	100		

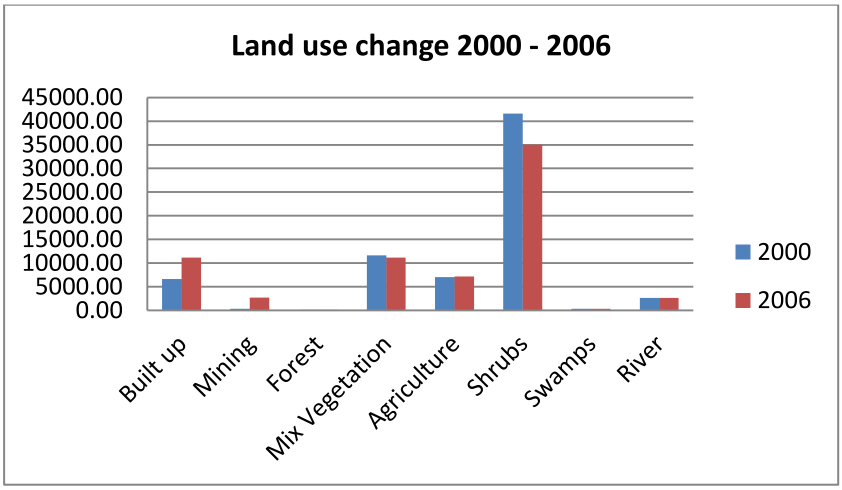


Figure 10. Land use change from 2000 to 2006

Land conversion matrix of land use change 2000 and 2006 is given in Appendix 6. Matrix conversion showed that shrub and mix vegetation lost because they were converted into built-up area, to mining area and also to agriculture. About 3905.48 ha shrub were converted to built-up area, 1938.57 ha to mining area, and 849.97 ha into agriculture land. Mix vegetation was changed into built-up 70.43 ha and to mining area was about 436.13 ha.

Land use/cover change from 2002 to 2009

Comparison of land use/cover map of 2002 and 2009 (figure 8 and figure 9) showed different level of changes in the land use/cover types due to conversion among the land use/cover types from 2002 to 2009. The comparison of total change of the land use/cover is described in table 8 and figure 11.

Table 8. Land use/cover change from 2002 to 2009

Land use/cover	2002		2009		Difference	
	ha	%	ha	%	ha	%
Built-up-Bare	4129.07	5.86	10685.84	15.17	6556.77	9.31
Mining	465.36	0.66	3643.54	5.17	3178.18	4.51
Mixed trees	18508.20	26.27	13767.03	19.54	-4741.17	-6.73
Paddy field	250.91	0.36	250.91	0.36	0.00	0.00
Agriculture & Shrub	27496.61	39.03	24945.29	35.41	-2551.31	-3.62
Swamp	187.97	0.27	60.32	0.09	-127.64	-0.18
Water	1752.80	2.49	1803.39	2.56	50.59	0.07
Cloud	2176.64	3.09	417.19	0.59	-1759.46	-2.50
Shadow	933.27	1.32	327.31	0.46	-605.95	-0.86
Total	55900.82	79.35	55900.82	79.35		

Change detection from 2002 to 2009 confirmed that the increase of built-up and mining area, and the decrease of mixed trees, agriculture-shrub and swamp. The change detection in this time period showed the same trend with land use/cover change from 2000 to 2006 where built-up and mining area increased while the other natural lands decreased. Built-up area experienced the significant increase from 4129.07 ha to 10685.84 ha. It increased of 9.31 % from 2002 and 2009. The built-up area expanded to the northern and southern part from the city centre adjacent to the existing built-up area in 2002. Mining area also increased 4.51%. In contrast, mixed trees lost 6.73 % from 2002 to 2009. Moreover, agriculture-shrub also decreased from 27496.61 ha to 24945.29 ha (-3.62%). While other land uses/covers remained more or less constant since 2002 until 2009.

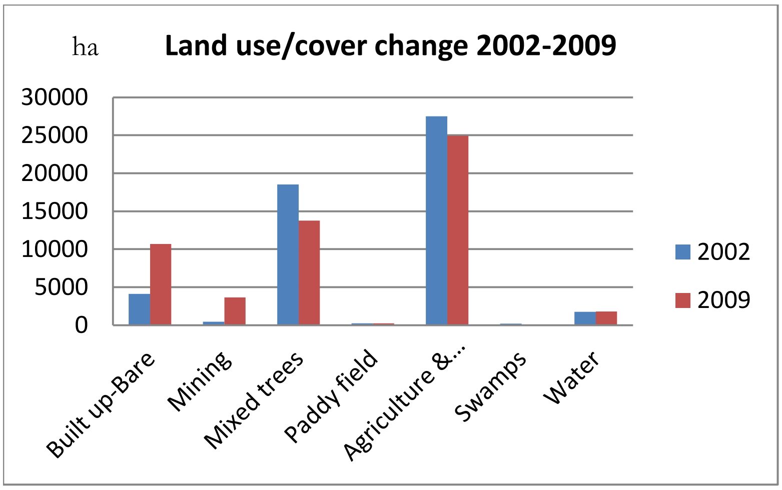


Figure 11. Changes in land use/cover from 2002 to 2009

Land conversion matrix of land use change 2002 and 2009 is given in Appendix 7. Matrix conversion showed that built-up and mining area increased by gaining land from mixed trees, agriculture-shrub and swamp. A total of 1152.57 ha mixed trees were converted to built-up area, 1652.22 ha were converted to mining, and a total of 5038.18 ha agriculture-shrub were changed to built-up, and 1681.17 ha was converted to mining area. Swamp was changed 47.33 ha into built-up and 2.24 ha into mining area.

Change detection from 2002 to 2009 shows the same trends with change detection from 2000 to 2006. It produced the similar result in which built-up area and mining area experinced an increase, and mixed trees and agriculture-shrub classes experienced a decrease. However, the land use-land cover classification of 2002 and 2009 has some limitations. The limitations are the land use/cover maps did not represent the entire study area becuase there is no available image data in 2009 for the whole study area. Second, the mix class of agriculture-shrub and also overlap of some parts of mining area which are located close to built-up area because they produce the same spectral characteristic. The land use/cover map has uncertain areas because cloud covers the area. Therefore, for the next step analysis in this research, analysis of land use change and ecosystem services, was only created based on land use maps 2000 and 2006 because land use maps 2000 and 2006 gave more separable class of the land use/cover in the study area and they cover the whole study area.

4.2. Analysis environment degradation by applying ecosystem services concepts

4.2.1. Selection of ecosystem services in study area

Results of selection and identification of important ecosystem services was obtained from questionnaire distribution to local stakeholders in the study area.

4.2.1.1. Distribution of respondents

The distribution of the respondents is depicted in figure 12.

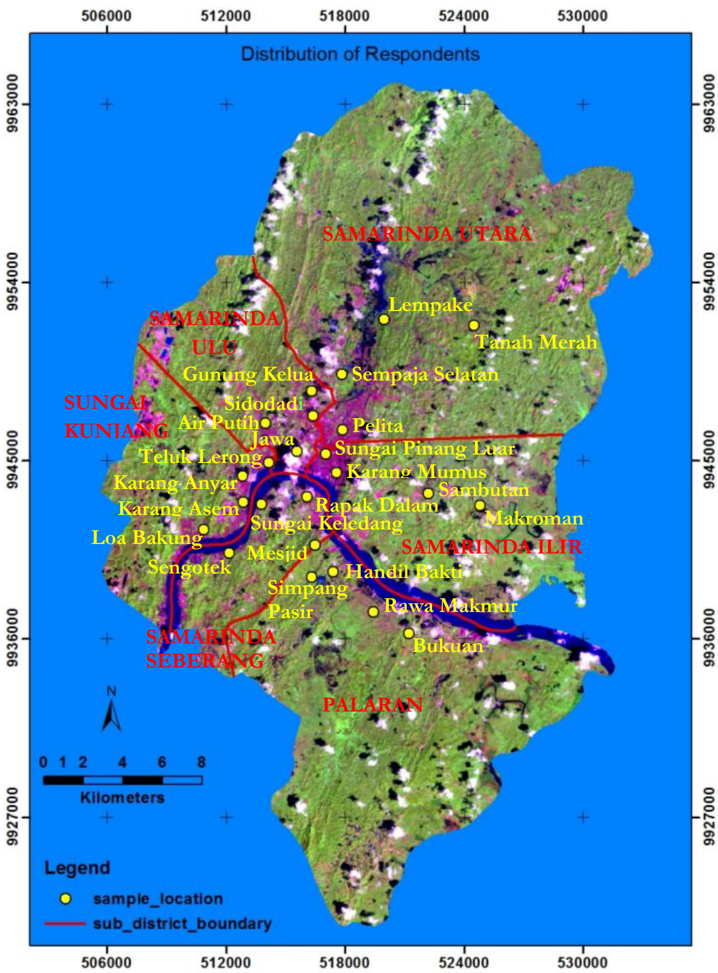


Figure 12. Distribution of respondent in the study area

Sample locations are displayed on the Landsat-7 ETM image acquired in 13/01/2002. The figure is displayed in the 543 band combination.

120 respondents were interviewed to identify the ecosystem services in the study area. The respondents are distributed in 6 sub-districts in the study area. The sub-districts are Samarinda Utara, Samarinda Ulu, Samarinda Ilir, Sungai Kunjang, Samarinda Seberang and Palaran.

Majority of respondents live in urban area, and some of them live in rural or suburbs area located in Tanah Merah, Lempake, Sempaja Selatan, Sambutan, Makroman, Loa bakung, Mesjid and Simpang pasir villages.

4.2.1.2. Characteristic of respondents

The characteristic of the respondent's occupations in the location observations is described in table 9.

Table 9. Occupation of respondents

Sub-district	Location observation	Occupation							Respondents per Sub-district
		Government officer	Private Employee	Business-man	Teacher	Retiree	Farmer	Student	
Samarinda Utara	Tanah Merah	-	-	-	-	-	5	-	20
	Lempake	-	-	1	-	-	4	-	
	Sempaja Selatan	1	1	-	-	-	3	-	
	Pelita	1	-	3	-	1	-	-	
Samarinda Ulu	Gunung Kelua	1	1	1	-	-	-	2	20
	Sidodadi	2	3	-	-	-	-	-	
	Air Putih	2	2	-	1	-	-	-	
	Jawa	1	2	1	1	-	-	-	
Samarinda Ilir	Sungai Pinang Luar	2	2	1	-	-	-	-	20
	Karang Mumus	1	2	1	-	1	-	-	
	Sambutan	-	1	1	-	-	3	-	
	Makroman	-	-	-	-	-	5	-	
Sungai Kunjang	Teluk Lerong	2	2	1	-	-	-	-	20
	Karang Asam	3	-	1	-	-	-	1	
	Karang Anyar	2	-	2	1	-	-	-	
	Loa Bakung	1	1	1	-	-	2	-	
Samarinda Seberang	Sungai Keledang	1	3	1	-	-	-	-	20
	Rapak Dalam	1	3	1	-	-	-	-	
	Mesjid	-	-	1	-	-	4	-	
	Sengkotek	-	4	1	-	-	-	-	
Palaran	Simpang Pasir	-	-	-	-	-	5	-	20
	Handil Bhakti	-	3	1	-	-	1	-	
	Rawa Makmur	1	2	2	-	-	-	-	
	Bukuan	-	2	2	-	-	1	-	
Total Respondent		**22**	**34**	**23**	**3**	**2**	**33**	**3**	120

Respondents in the study area have various occupations. In this term, the respondent working as a businessman means people who have their own business like trader or a respondent who has a small shop, etc. Then, the respondent who has a job as a student is a student in university level. From the table 9, the distribution of respondent occupation is 22 (18%) government officers, 34 (28%) private employees, 23 (19%) private (businessman), 3 (3%) teachers, 2 (2%) retirees, 33(28%) farmers, and 3 (3%) students. Most of the respondents who live in urban area work as government officers, private employees, businessman, teachers, retirees, and students. In the other hand, most of the respondents who live in rural area or suburbs area are farmers and only a few of them work as businessman and private employees. Majority of respondents in Samarinda Utara sub district are farmers about 60% which are distributed in Tanah Merah, Lempake and Sempaja Selatan. Other locations of farmers are in Sambutan and Makroman, Loa Bakung, Mesjid and Simpang Pasir villages. The distribution of respondent's occupations each sub-district is depicted in figure 13.

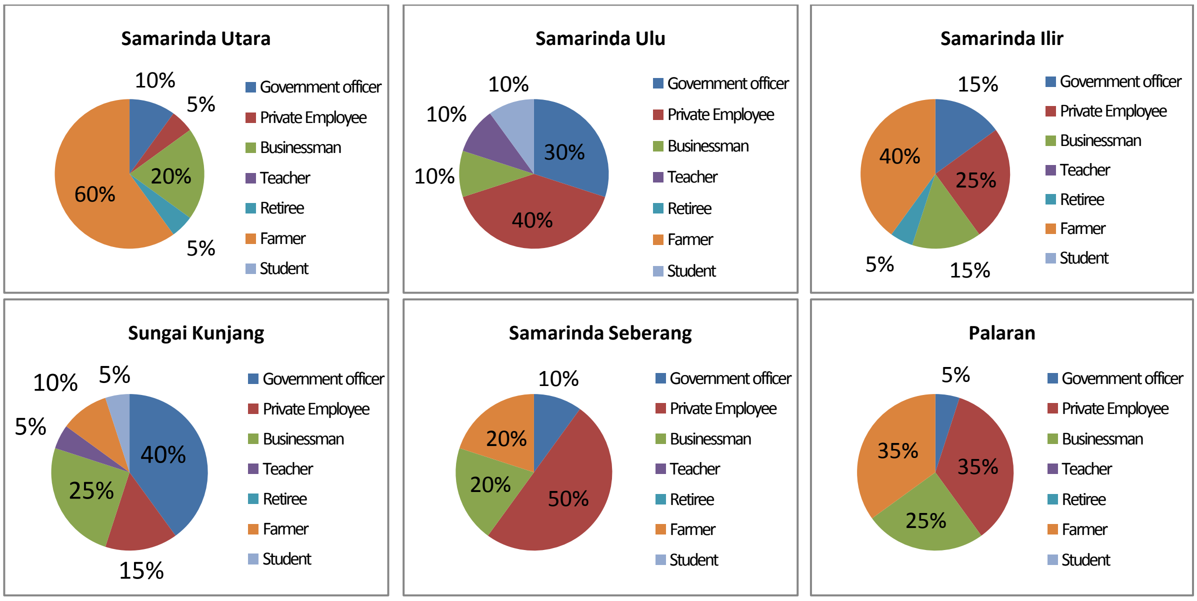


Figure 13. Respondent's occupation per sub-district

In the level of education, the characteristic of respondents is described in table 10.

Table 10. Education characteristic of respondents

Sub-district	Location observation	Education					Respondents per Sub-district
		Illiterate	Elementary	Junior	Senior	Diploma/Bachelor	
Samarinda Utara	Tanah Merah	1	1	2	1	-	20
	Lempake	-	-	3	2	-	
	Sempaja Selatan	-	-	2	3	-	
	Pelita	-	-	-	4	1	
Samarinda Ulu	Gunung Kelua	-	-	-	4	1	20
	Sidodadi	-	-	-	3	2	
	Air Putih	-	-	-	4	1	
	Jawa	-	-	-	4	1	
Samarinda Ilir	Sungai Pinang Luar	-	-	-	4	1	20
	Karang Mumus	-	-	-	4	1	
	Sambutan	-	-	1	4	-	
	Makroman	-	-	3	2	-	
Sungai Kunjang	Teluk Lerong	-	-	-	4	1	20
	Karang Asam	-	-	-	5		
	Karang Anyar	-	-	1	2	2	
	Loa Bakung	-	1	1	2	1	
Samarinda Seberang	Sungai Keledang	-	-	-	5	-	20
	Rapak Dalam	-	-	-	5	-	
	Mesjid	-	1	2	2	-	
	Sengkotek	-	-	-	5	-	
Palaran	Simpang Pasir	-	1	3	1	-	20
	Handil Bhakti	-	-	2	3	-	
	Rawa Makmur	-	-	-	5	-	
	Bukuan	-	-	1	4	-	
Total Respondent		1	4	21	82	12	120

In this term, education of respondents is based on the level of graduation. Illiterate means respondents who do not have educational background. There are 82 (68 %) of respondents in the study area graduated from senior high school, 21 (18 %) have graduated from junior high school, 12 (10 %) have had diploma/bachelor degree, 4 respondents graduated from junior high school, and 1 respondents is illiterate. Characteristic and distribution of respondent in each sub district are depicted in figure 14.

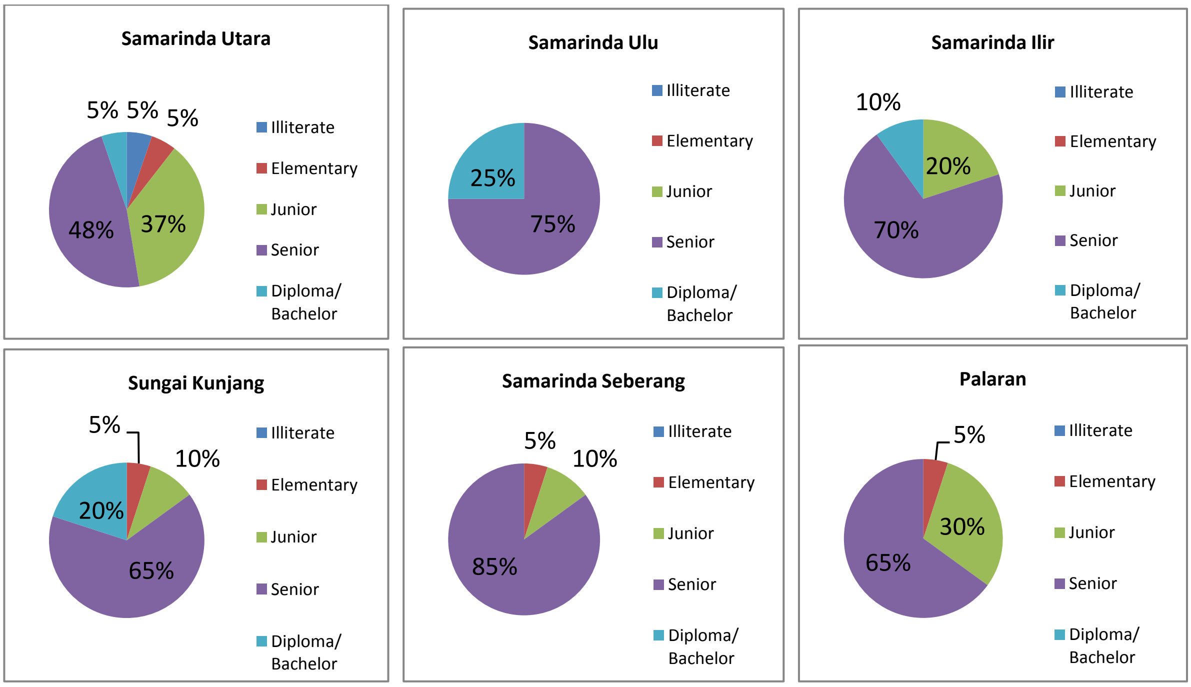


Figure 14. Distribution of education level for each sub-district

Based on figure 14, the distribution of respondent's education level did not present the significant differences among the sub-districts where the majority of respondents for each sub-district are dominated by respondents graduated from senior high school. However, from the distribution per village was obtained that the education level of respondents in rural area is lower than in urban area.

4.2.1.3. Identification ecosystem services based on local people perspective

In identifying the important ecosystem services in the study area, respondents have various preferences. There are eight ecosystem services where identified by respondent, namely purification of air, prevention of floods, provisioning of foods, recreation, water resources, provisioning of fuel wood, provisioning of timber, and provisioning of medicinal plant. Rank 1 is the first choice of respondent, means that the choice is the most important services for respondents. Rank 2 is the second choice of important services for respondent, means that the importance of the services one level down below rank 1. Then rank 3 is the third choice, means level of importance of the services is one level down below rank 2. In order to obtain the level of importance of all services and total rank based on respondent's preferences, rank1 is multiply by 3, rank 2 is multiply by 2, and rank 3 is multiply by 1. It is conducted to simplify calculation to obtain the level of importance or total rank for each service. The description of ecosystem services identified by respondents is presented in table 11 and figure 15.

Table 11. Identification of ecosystem services by respondents

Type of ecosystem services	Preference of Respondents			Total
	Rank 1	Rank 2	Rank 3	rank
Purification of Air	48	32	18	226
Prevention of Floods	37	42	30	225
Provisioning of foods	35	34	35	208
Recreation	-	3	28	34
Water resources	-	6	5	17
Provisioning of fuel wood	-	1	2	4
Provisioning of timber	-	1	1	3
Provisioning of medicinal plant	-	1	1	3
Total Respondent	120	120	120	720

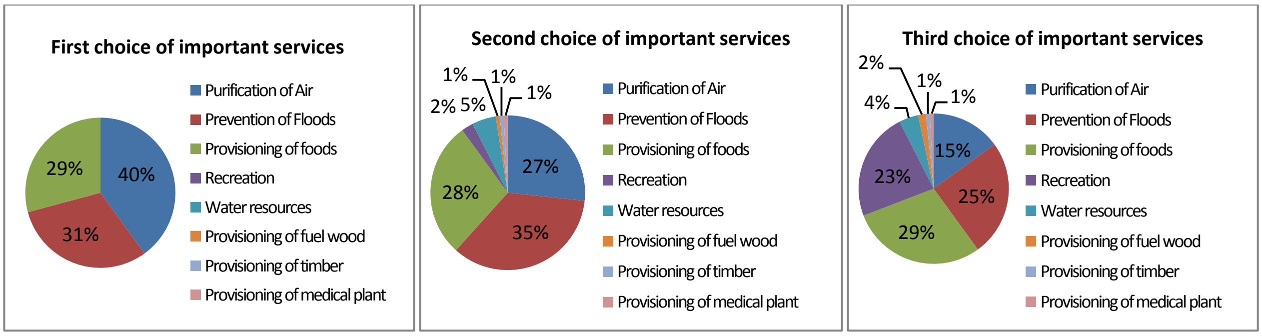


Figure 15. The important ecosystem services in the study area

Table 11 and figure 15 revealed that the three most important ecosystem services (rank 1) in the study area are purification of air, prevention of floods and provisioning of foods. 48 (40%) respondents select the purification of air as the most important services, 37 (31 %) select prevention of floods, and 35 (29%) respondents choose the provisioning of foods. In rank 2 (second choice) and rank 3 (third choice), the respondents identify eight types of services provided by ecosystems. In these two choices, purification of air, prevention of floods and provisioning of foods are also dominant choices, but in the third choice, besides the three choices, recreation is selected by 23% of the total respondents. From the total rank, purification of air has the highest level, followed by prevention of floods, provisioning of foods, recreation, water resources, provisioning of fuelwoods, provisioning of timber and provisioning of medicinal plants respectively.

4.2.1.4. Important services from different occupation

The distribution of occupation and the first choices of important ecosystem services in the study area is presented in table 12.

Table 12. First choice of important services based on respondent occupations

Type of ecosystem services	Choice of Respondent based on occupation							Total
	Government officer	Private Employee	Business-man	Teacher	Retiree	Farmer	Student	
Purification of Air	11	21	14	1	-	-	1	48
Prevention of Floods	11	12	8	2	2	-	2	37
Provisioning of foods	-	1	1	-	-	33	-	35
Total Respondent	22	34	23	3	2	33	3	120

Table 12 revealed that purification of air and prevention of floods as the first choice of important ecosystem services in the study area are chosen by government officer, private employees, businessmen, teachers and students. Almost all respondents (except farmers) identified purification of air and prevention of floods as the most important services. While, all farmers, 33 (100%) respondents in the study area identified the provisioning of foods as the first choice of important ecosystem services, and only 1 private employee and 1 businessman selecting this services as the first choice of important services.

The distribution of occupation and the second choices of ecosystem services is presented in table 13.

Table 13. Second choice of important services based on respondent occupations

Type of ecosystem services	Choice of Respondent based on occupation							Total
	Government officer	Private Employee	Business-man	Teacher	Retiree	Farmer	Student	
Purification of Air	4	11	9	1	2	4	1	32
Prevention of Floods	8	6	7	1	-	20	-	42
Provisioning of foods	9	16	6	1	-	-	2	34
Recreation	1	1	1	-	-	-	-	3
Water resources	-	-	-	-	-	6	-	6
Provisioning of fuel wood	-	-	-	-	-	1	-	1
Provisioning of timber	-	-	-	-	-	1	-	1
Provisioning of medicinal plant	-	-	-	-	-	1	-	1
Total Respondent	22	34	23	3	2	33	3	120

For the second choices of important ecosystem services, the respondent choices are more variety than the first choices. Prevention of floods is identified by 42 (35%) respondent, provisioning of foods is identified by 34 (28%) respondents, and purification of air is identified by 32 (27%) respondents. Recreation as an ecosystem service is only identified by government officers, private employees and businessmen. However the other provisioning services besides provisioning of foods are only identified by farmers such as provisioning of timber, fuel woods and medical plants. Also, water resources as important services are only identified by farmers.

The distribution of occupation and the third choices of ecosystem services is presented in table 14.

Table 14. Third choice of ecosystem services based on respondent occupations

Type of ecosystem services	Choice of Respondent based on occupation							Total
	Government officer	Private Employee	Business-man	Teacher	Retiree	Farmer	Student	
Purification of Air	3	2	-	-	-	13	-	18
Prevention of Floods	3	8	8	-	-	11	-	30
Provisioning of foods	11	8	11	2	2	-	1	35
Recreation	5	16	4	1	-	-	2	28
Water resources	-	-	-	-	-	5	-	5
Provisioning of fuel wood	-	-	-	-	-	2	-	2
Provisioning of timber	-	-	-	-	-	1	-	1
Provisioning of medicinal plant	-	-	-	-	-	1	-	1
Total Respondent	22	34	23	3	2	33	3	120

For the third choice of important ecosystem services, three most choices are provisioning of foods, prevention of floods and recreation. Recreation is chosen by 28 (23%) respondents. Recreation as ecosystem services is only identified mostly by private employee, government officers, businessmen, and teachers. The same pattern with the second choice, water resources, provisioning of timber, fuel-wood and medical plant are only recognized by farmers.

4.2.1.5. Distribution preferences of important ecosystem services from each sub-district

The spatial distribution of the first choices of respondents regarding the most important ecosystem services in the study area is presented in table 15 and figure 16.

Table 15. distribution of the first choice of important services from each sub-district

Sub-district	Location observation	Ecosystem services			Respondents per Sub-district
		Purification of air	Prevention of floods	Provisioning of foods	
Samarinda Utara	Tanah Merah	-	-	5	20
	Lempake	-	1	4	
	Sempaja Selatan	-	2	3	
	Pelita	-	5	-	
Samarinda Ulu	Gunung Kelua	-	5	-	20
	Sidodadi	-	5	-	
	Air Putih	-	5	-	
	Jawa	3	2	-	
Samarinda Ilir	Sungai Pinang Luar	-	5	-	20
	Karang Mumus	-	5	-	
	Sambutan	-	2	3	
	Makroman	-	-	5	
Sungai Kunjang	Teluk Lerong	5	-	-	20
	Karang Asam	5	-	-	
	Karang Anyar	5	-	-	
	Loa Bakung	3	-	2	
Samarinda Seberang	Sungai Keledang	5	-	-	20
	Rapak Dalam	5	-	-	
	Mesjid	-	-	5	
	Sengkotek	5	-	-	
Palaran	Simpang Pasir	-	-	5	20
	Handil Bhakti	4	-	1	
	Rawa Makmur	5	-	-	
	Bukuan	3	-	2	
Total Respondent		**48**	**37**	**35**	120

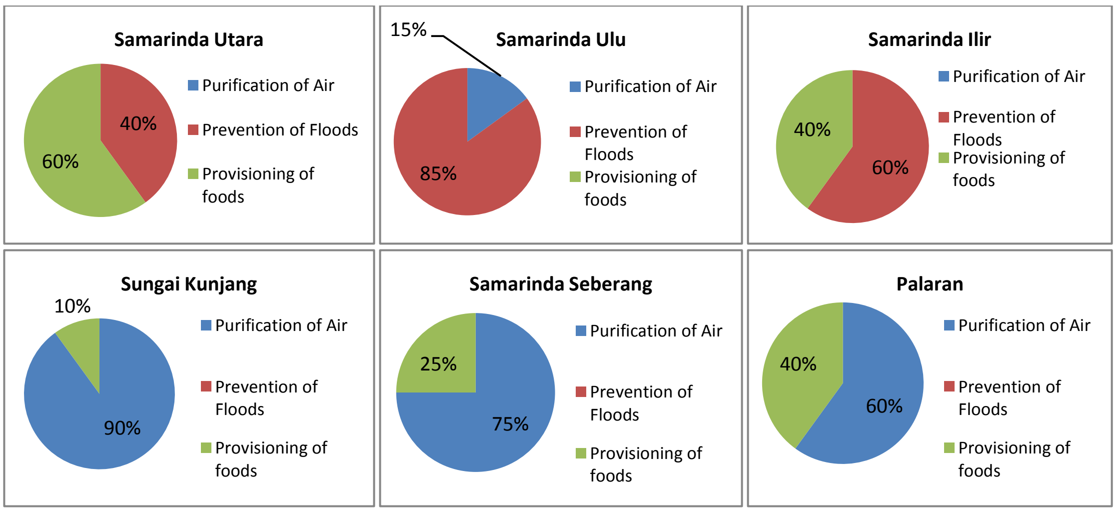


Figure 16. Distribution of the first choice of important services from each sub-district

For the first choices (table 15 and figure 16), the distribution of the most important ecosystem services confirms the different pattern among the sub-districts. In Samarinda Utara, Samarinda Ulu and Samarinda Ilir sub-districts, the important services are prevention of floods and provisioning of foods. Prevention of floods is the most important services identified by respondents in urban area including Pelita, Gunung Kelua, Sidodadi, Air Putih, Jawa, Sungai Pinang Luar, and Karang Mumus villages. Then the second important services is provisioning of food. This service is the most preferences in Tanah merah, Lempake, Sempaja selatan, Sambutan and Makroman villages. These villages are categorized as rural areas and the majority respondents in these villages are farmers.

In the three other sub-distrcits; Sungai Kunjang, Samarinda Seberang and Palaran, the first choice of respondents was purification of air and provisioning of foods. Purification of air was identified by 75 % respondents in these three sub-districts, and provisioning of foods was identified by 25 % respondents. Purification of air as the most important services was identified by respondents in urban area. Then provisioning of foods as the first preference of the most important services was preferred by respondents in rural area including Mesjid and Simpang Pasir villages. In Sungai Kunjang sub-district 18 (90%) respondents chose the purification of air as the first choice of important services and 2 (10%) respondents chose the provisioning of foods. In Samarinda Seberang, 15 (75%) respondents chose purification of air and 5 (25%) chose provisioning of foods as the first choice of important services. In Palaran, about 12 (60%) recognized purification of air and 8 (40%) chose provisioning of foods as important services.

For the second choices (see Appendix 8, detailed distribution per village), the distribution of important ecosystem services confirmed that generally three most choices of important services identified in this level were purification of air, prevention of floods and provisioning of foods. Based on distribution per village, recreation as an ecosystem service was only identified in urban area in Pelita, Sengkotek and Bukuan villages, while the other provisioning services including water resources, provisioning of fuel wood, timber and medicinal plants were only identified by respondents in rural area in Mesjid and Simpang pasir villages.

For the third choices (see Appendix 9, detailed distribution per village), the pattern of the distribution of choices was almost similar among subdistricts. In this level, the three most choices of important services identified were also purification of air, prevention of floods and provisioning of foods. Based on distribution per village, similar with the second choices, recreation as an ecosystem service is only identified in urban area while the other provisioning services including water resources, provisioning of fuel wood, timber and medicinal plants were mostly identified by respondents in rural area.

4.2.2. Ecosystem services assessment and mapping

Literature review describes there are some ecosystem services which are affected by land use - land cover changes. Then, based on the questionnaire survey in the study area, there are 8 important ecosystem services identified by local people in the study area. Assessment and mapping of the ecosystem services and the impact of land use change to the degradation of ecosystem service was done qualitatively by applying spatial multi criteria evaluation and GIS analysis.

4.2.2.1. Assessment and mapping of land use/cover based on each ecosystem services provided

Assessment of ecosystem services was conducted for each land use/cover type as a unit provider of specific services. The criteria used in assessment are the capability of the land use/cover (ecosystem) to provide the services. A matrix was developed to show the services provided versus land use/cover as a service provider. The valuation of capability of land use/cover type to provide the ecosystem services is measured on a - -/++ scale. Because the qualitative measurement in - -/++ scale only based on the capacity of each land cover to provide the services, then - - score is the minimum value that means that the land use/cover do not have capacity to provide the services, and the ++ score is maximum value that means that the land use/cover has the highest capacity to provide the services, and the other scores are in between. The matrix of land use/cover capacity is shown in table 16.

Table 16. Matrix of ecosystem services per land use/cover type

Ecosystem Services	Land Use - Land Cover							
	Built-up area	Mining area	Forest	Mix vegetation	Shrub	Agriculture land	Swamp	River
Purification of Air	- -	- -	++	++	+	+/-	-	-
Prevention of floods	- -	- -	++	++	+/-	-	- -	- -
Provisioning of foods	- -	- -	+/-	+/-	- -	++	- -	+/-
Recreation	- -	- -	++	- -	- -	- -	- -	- -
Water resources	- -	- -	- -	- -	- -	- -	- -	++
Provisioning of fuel-woods	- -	- -	++	++	-	- -	- -	- -
Provisioning of timbers	- -	- -	++	++	- -	- -	- -	- -
Provisioning of medicinal plants	- -	- -	+	+	- -	++	- -	- -

Note : - -(No value), - (Low), +/-(Medium), +(High), ++(Very High)

The basis for valuation is related to literature study and the condition of study area. The basis reasons of valuation are described below.

Purification of air

Built-up and mining areas are given the worst score in purification of air because these land use/cover types do not provide this service. Instead built-up and coal mining activities will generate negative effect for air quality. Coal mine activities produce air pollutant such as fugitive emission of particulate matter and gasses including methane, sulphur dioxide and oxides of nitrogen (Bian et al, 2010). Then, forest and mix vegetation are given the highest score due to the high capacity to provide this service. One indicator in measuring the capacity of this ecosystem to provide the services is the capacity to produce oxygen ($O2$). Bernatzkty, (1978) describes the capacity of global ecosystem in the production of oxygen including temperate cold deciduous forest, conifer boreal forest, temperate rain forest, tropical and subtropical rainforest, dry woodlands, agricultural, grassland, tundra, desert and glaciers. Refer to study by Bernatzky, (1978), the highest capability of ecosystem to release $O2$ is provided by forest, followed by shrub and agricultural land. In addition, Nowak et al., (2006) studies the capacity of urban trees and shrubs to remove air pollution in the United States showed that urban trees and shrub has a high capacity to remove air pollutant. Moreover, de Groot (1992) describes that aquatic ecosystems also have a capability to release $O2$. Besides $O2$ production, another indicator in measuring this service is the capacity of natural ecosystem in removing $CO2$. The capacity of ecosystem in removing $CO2$ is related to carbon stock in the ecosystems. Refer to study of IPCC (2000) tropical forest is the highest capacity in carbon stock is about 428 Gt C for whole tropical forest of the world, then it is followed by other ecosystems including tropical savannas, wetlands and croplands. Similarly, study by ICRAF (2003) in Nunukan, East Kalimantan, forest has highest carbon stock, followed by agroforestry and *jakaw* (dominated by light and medium tree species), then upland rice. Refer capability of ecosystems described in those studies, the score value was attached to the land use/cover in study area (table 16) with some generalizations and assumptions that the ecosystems in the literature are almost similar with ecosystems in the study area.

Prevention of floods

Built-up and mining areas are given the worst score in prevention of floods because these land use/cover types do not provide the services. However built-up and coal mining activities will give negative effect for flood preventions. Built-up area which is mostly covered by concrete and tarmac can increase water flow, thus the impervious surface has caused high proportion of rainfall to be surface runoff which will increase peak flood discharge (Bolund and Hunhammar, 1999). Mining areas are covered by bare land, which do not have vegetation cover, they have reduced the capacity of ecosystems to reduce runoff. Water runoff on bare slopes is 10 to 25 times as great as that on slopes covered by vegetation (Pimentel, et al., 1980 in de Groot 1992). The best score in providing this service is given to forest and mix vegetation. de Groot (1992) states that "the higher the vegetative biomass the greater the capacity to reduce runoff." Moreover, Agus et al., (2004) shows that forest has the highest capacity in flood mitigation due to canopy interception capacity, and it followed by multistrata cropping, annual upland crops, and paddy fields. Millenium Ecosystem Assessment (2005) states that a forest plays an important role in floods regulation as a protection from floods providing flood attenuation and protection of soil loss, then the cultivated land provides flood protection on good management part, and dryland has a role in flood regulation in protection through its vegetation cover.

Provisioning of foods

Agriculture is given the best score in provisioning of foods because the land use is a main source of foods in the study area which provides foods such as paddy, vegetables, fruits, etc. It is followed by forest and mix vegetation because these ecosystems provide some foods including fruits (such as ; durian, jackfruits), vegetables forest, honey, etc. River is also as a source of fishes. The other land uses/covers do not provide the service.

Recreation

For recreation, only forest has a value for this service. Forest identified in this study area has a zone for recreation, education and research. This zone is opened for visitors, and it is usually used for recreation and other research purposes in the study area (samarindakota, 2011). Number of visitors to the place from 2005 to 2010 is presented in Appendix 11. The other land uses/covers do not provide this service.

Water resources

River receives the highest score for water resources. In the study area river is used as a source of drinking water. The other land uses/covers do not provide the service thus they do not have score.

Provisioning of fuelwoods

Fuel wood is collected from forest and mix vegetation in the study area, so that forest and mix vegetation are given the highest score for this service. The goods are also collected from shrub. The other land uses/covers do not provide this service.

Provisioning of timbers

Forest and mix vegetation are sources of timbers in the study area. Therefore the two land uses are given the highest score. The other land uses/covers do not provide this service.

Provisioning of medicinal plants

In the study area, medicinal plants are cultivated in agricultural land such as betel (*Piper betle* L.), temulawak (*Curcuma xanthorhiza* Roxb.), ginger (*Zingiber officinale* Rosc.), turmeric (*Curcuma domestica* Val.) etc, so that agricultural land is given the highest score for this service. The other medicinal plants is provided by forest and mix vegetation such as pasak bumi (*Eurycoma longifolia*), kayu singgah bini *(Macrosolen sp)* for cancer, hazelnut (*Aleurites moluccana*), etc (Dinas Pertanian, Perkebunan dan Kehutanan Samarinda, 2010). However, other land uses/covers do not provide the services.

The value of each land use/cover type (table 16) as a unit provider of specific services is mapped to get the valuation map of land use/cover for each service provided. Valuation mapping is used to visualize and to show the spatial distribution of the value of ecosystem services in the study area. The qualitative value (from table 16) is applied for land use/cover map in 2000 and 2006 to get the land cover valuation map for each year. In visualizing the value of ecosystem services is used the qualitative scale, from - - score as no value to ++ score as very high value. The land use/cover valuation map is shown in figure 17 and 18.

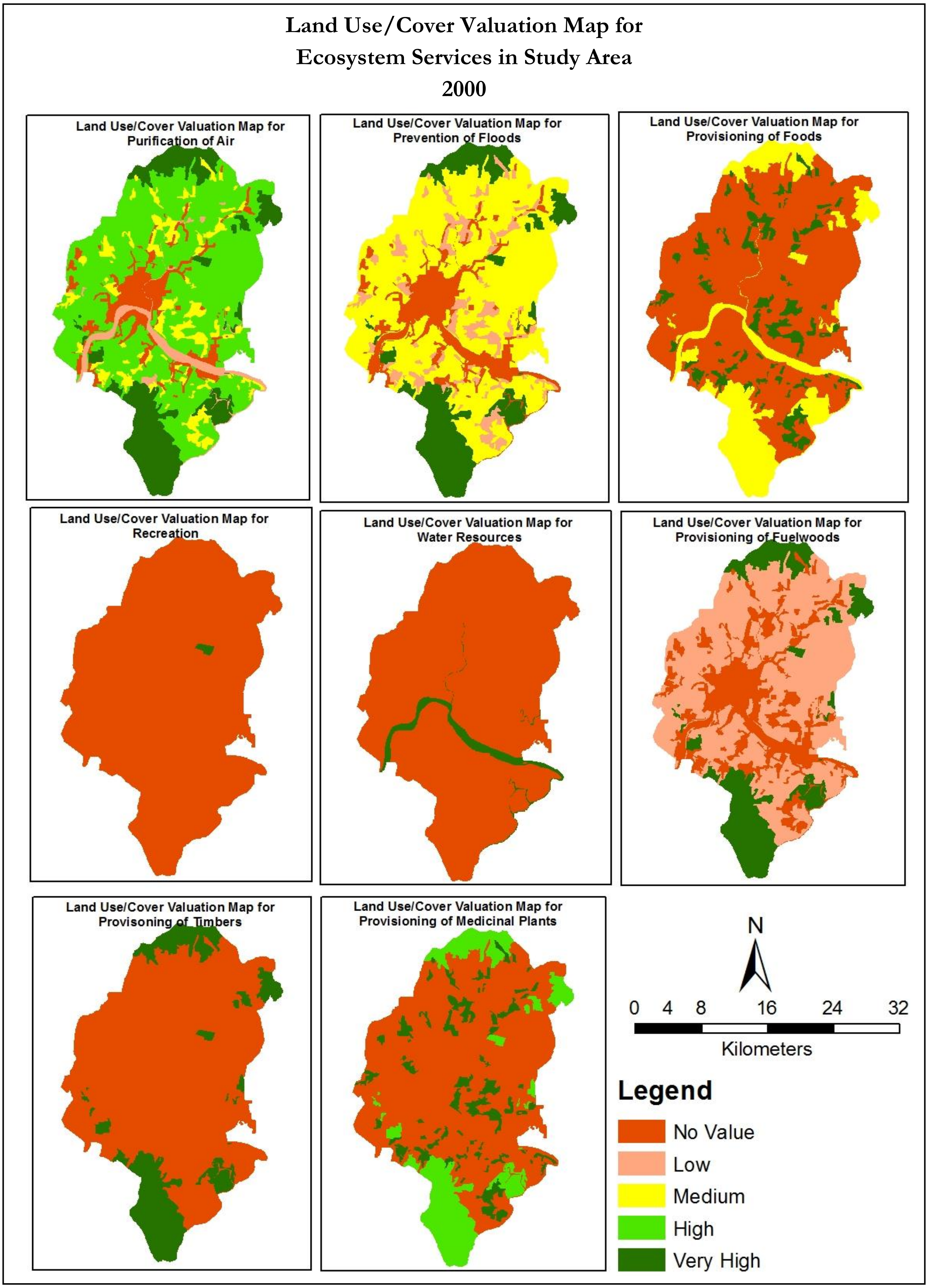


Figure 17. Land use/cover valuation map for ecosystem services provided in 2000

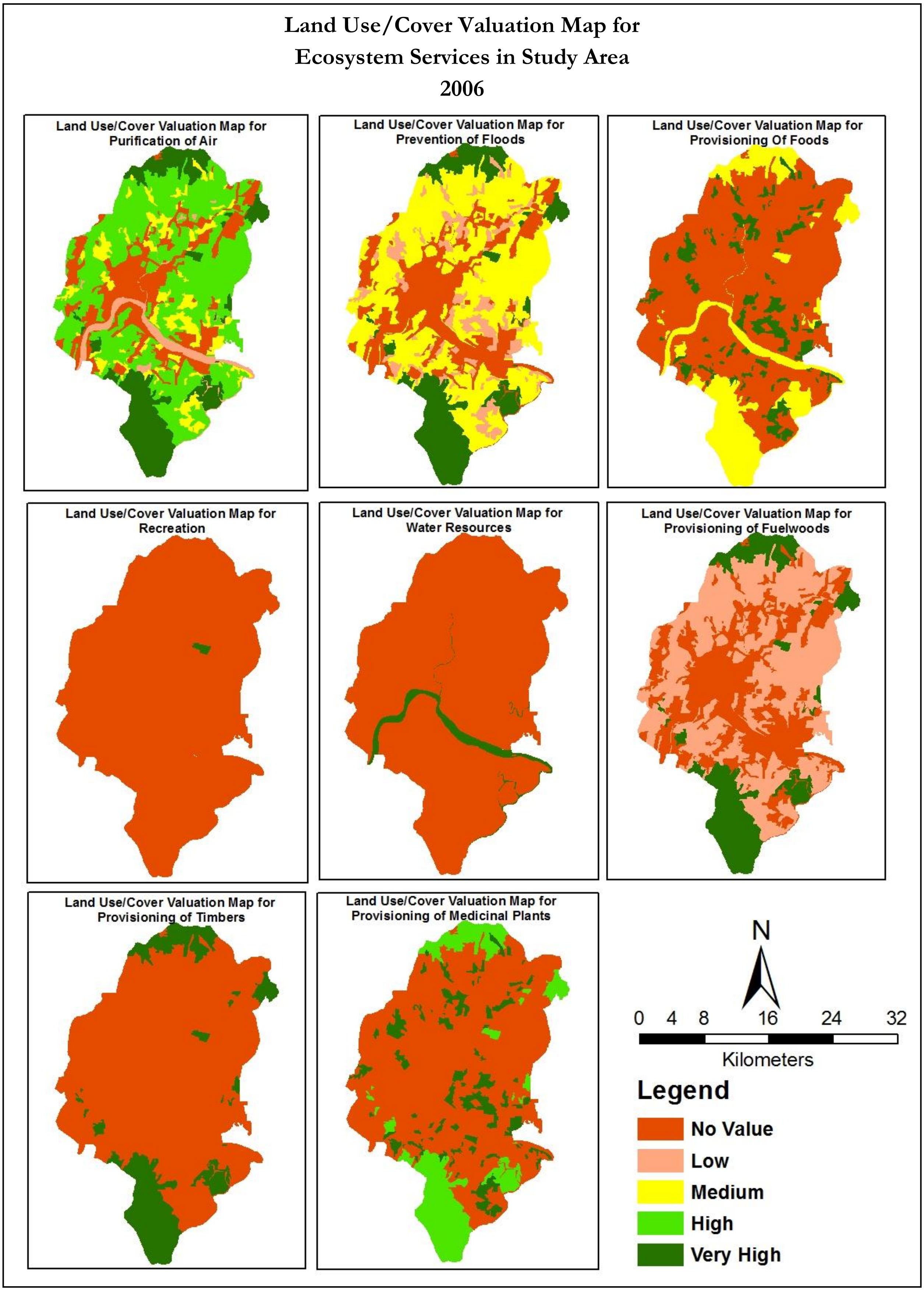


Figure 18. Land use/cover valuation map for ecosystem services provided in 2006

4.2.2.2. Assessment and mapping of impact of land use/cover change on each ecosystem services provided

Mapping of the impact of land use/cover change on ecosystem services is based on the land cover valuation map of 2000 and 2006 (figure 17 and 18) for each ecosystem service identified in the study area. The analysis of value change from 2000 and 2006 was done by overlay analysis, and the result of analysis is depicted in figure 19 and table 17.

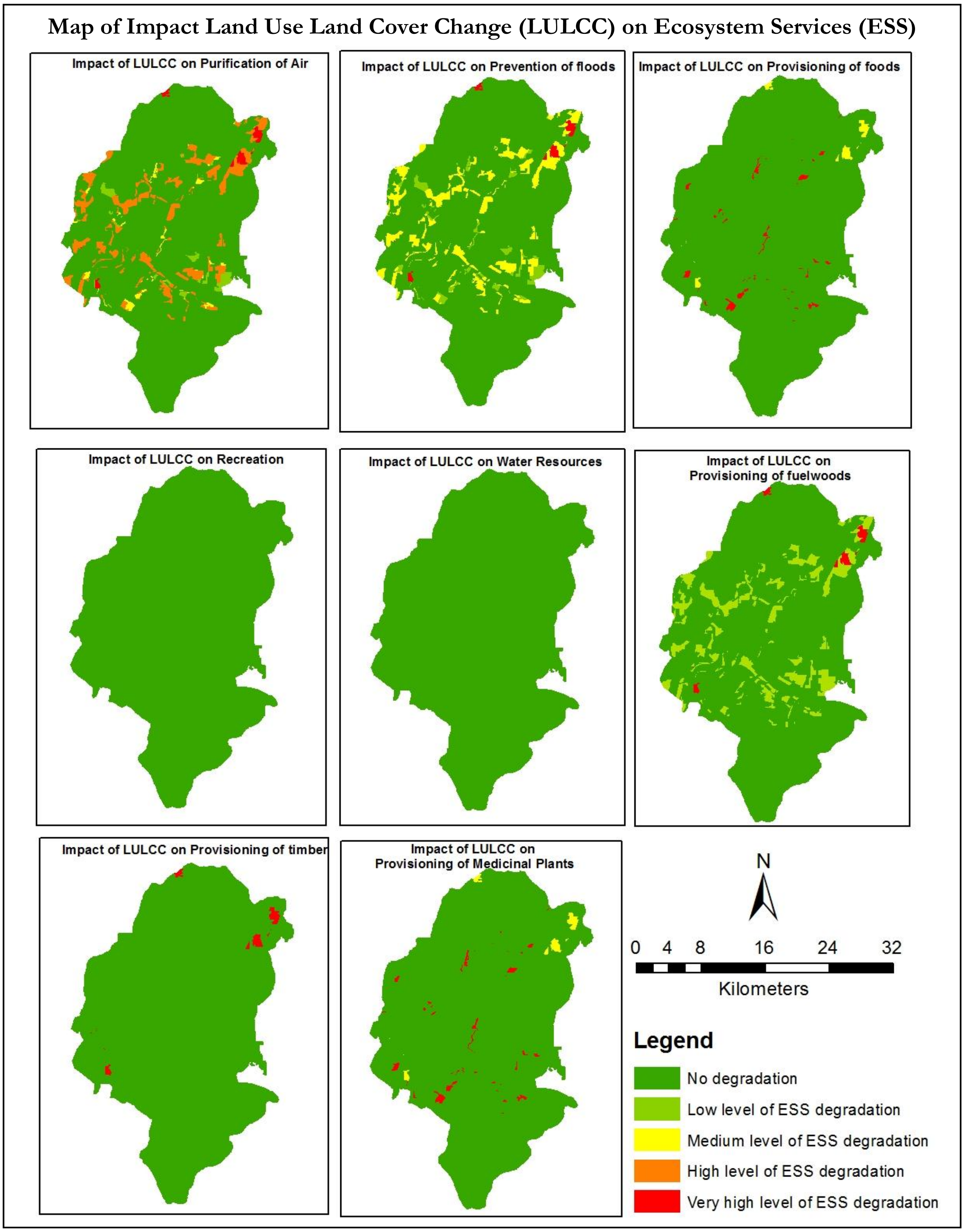


Figure 19. Maps of impact on land use/cover change on ecosystem services

Table 17. Total area which experience degradation of the services

Level of degradation	Total area experience degradation of services (Ha)							
	Purification of air	Prevention of floods	Provisioning of foods	Recreation	Water resources	Provisioning of fuelwoods	Provisioning of timbers	Provisioning of medicinal plants
Low	879	1514	0	0	0	6694	0	0
Medium	665	5849	512	0	0	0	0	0
High	5844	0	0	0	0	0	0	512
Very high	507	507	682	0	0	508	513	682

Purification of air
Figure 19 and table 17 revealed that 879 ha in the study area experienced degradation of ecosystem capability to purify air in low level due to conversion of shrub to agriculture and conversion of swamp to mining area. Then this service decreased in 665 ha area in medium level because agricultural land was changed to built-up and mining area. About 5844 ha area experienced degradation of this service in high level because of shrub land was changed to built-up and mining area. Then 507 ha area had lost this service in very high level due to conversion of mix vegetation to built-up and mining area.

Prevention of floods
The capability of ecosystem to provide this service has decreased in 1514 ha area in low level because the land use has changed from shrub to agriculture and also from agriculture to built-up and mining area. Then, this service has lost in 5849 ha area in medium level because conversion of shrub to built-up and mining area, and 507 ha area in very high level due to conversion of mix vegetation to built-up and mining area.

Provisioning of foods
As many as 512 ha area in the study area experienced degradation of this services in medium level due to conversion of mix vegetation to built-up and mining area. Then 682 ha area lost this services in very high level because agricultural land was converted to built-up and mining area.

Recreation
There is no change or decrease of this service because there no change in the forest area as an ecosystem which provides this service.

Water resources
There is no change or decrease of this service because there no change in river as an ecosystem which provides this service.

Provisioning of fuelwoods
This service decreased in low level in area of 6694 ha because shrub was changed to built-up and mining area and 508 ha area experienced loss of this service in very high level due to conversion of mix vegetation to built-up and mining area.

Provisioning of timbers
Conversion of mix vegetation to built-up and mining area caused as many as 513 ha area had loss this service.

Provisioning of medicinal plants
Land use change from mix vegetation to built-up and mining area caused degradation of this service in high level in 512 ha area, and conversion of agriculture land to built-up and mining area also caused the loss of this service in very high level in 682 ha.

4.2.2.3. Assessment and mapping of land use/cover based on total value of ecosystem services provided

Spatial Multi Criteria Evaluation was applied to assess and map ecosystems (land use/covers) as unit provider of all ecosystem services in the study area. The eight criteria used were capacity of the ecosystems to provide the eight ecosystem services identified in the study area. The assessment was based on each ecosystem services identified. One criterion represented capacity of an ecosystem to provide one service. Steps of this analysis including standardization, ranking and weighting were carried out in ILWIS software. The first step is to standardize the measurement of capacity of each land cover type in providing the services. Then measurement of capacity of ecosystem services on a - -/++ scale (in table 16) was converted to value in the 0 - 1 scale for the eight criteria. 0 is the minimum value and 1 is the maximum value. This means that the minimum score (- -) is given the value of 0, the maximum score (++) is given the value of 1, and the other scores in between are scaled proportionally.

After standardization of each criterion value, the next step is ranking and weighting of each criterion. In this analysis, ranking and weighting of each criterion are based on the importance of the services for local people in the study area (the rank of important services based on local perspective is as depicted in table 10), then weight of this analysis is depicted in table 18.

Table 18. Weight of Criteria in SMCE

Criteria (Ecosystem capacity to provide the services)	Weight
Purification of Air	0.314
Prevention of Floods	0.313
Provisioning of foods	0.289
Recreation	0.047
Water resources	0.024
Provisioning of fuel woods	0.005
Provisioning of timbers	0.004
Provisioning of medicinal plants	0.004
	1

All the steps were applied to the land use/cover map of 2000 and 2006. The result of this analysis is total value of ecosystem services provided by land use/cover (ecosystem) in the study area. The result of this analysis is depicted in figure 20.

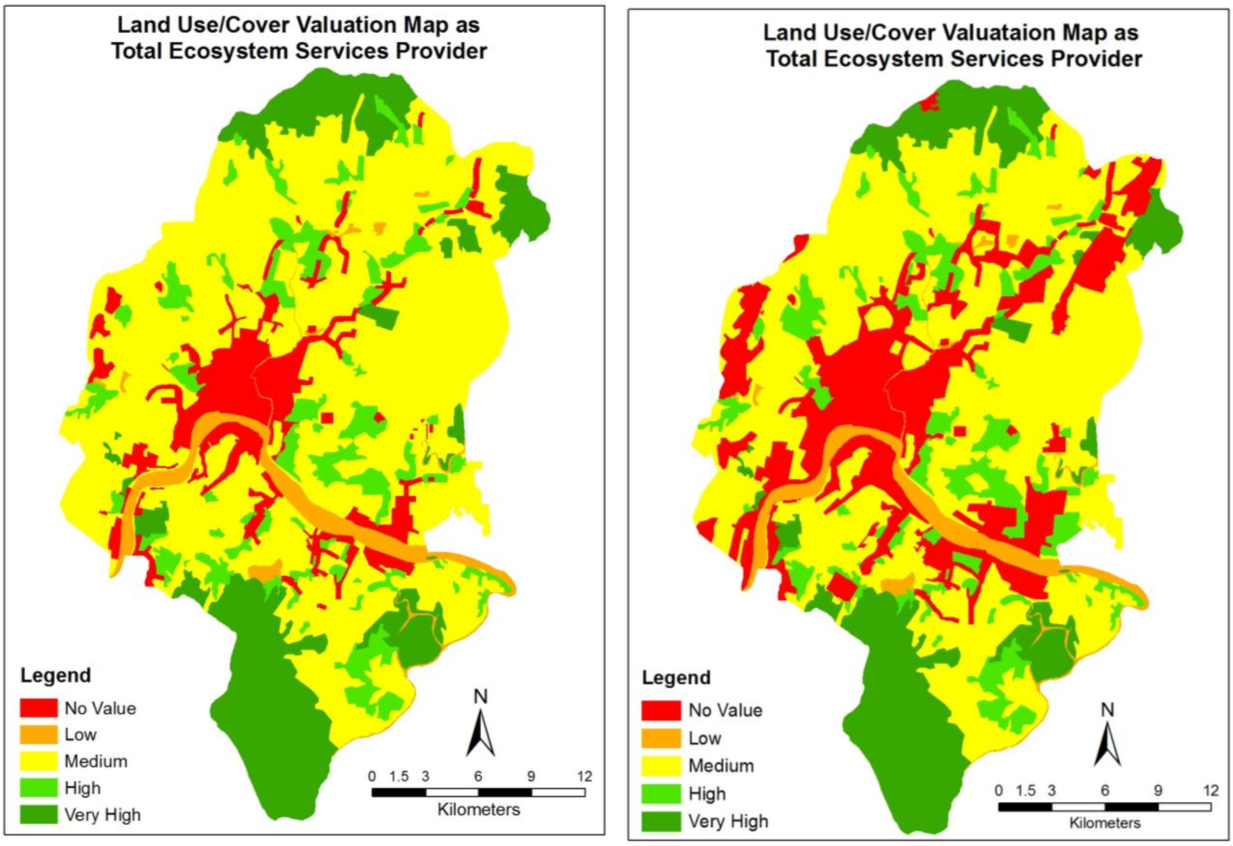


Figure 20. Land use/cover valuation map as total ecosystem service provider

Figure 20 revealed that forest and mix vegetation classes had the highest value in providing all ecosystem services identified in the study area based on local people preferences of the important ecosystem services. Then the capacity of agricultural land was in one level below of forest and mix vegetation classes. Shrub obtained the medium value, while river and swamp had low value in providing all ecosystem services in the study area. Built-up and mining area did not have value.

4.2.2.4. Assessment and mapping of impact of land use/cover on degradation of total ecosystem services value

Mapping of the impact of land use/cover change on the total value of ecosystem services was based on the total value of the services per land cover type (as depicted in land cover valuation map as total services provider for all ecosystem services, figure 20). The analysis of total value change from 2000 and 2006 was done by overlay analysis, and the result of analysis is depicted in figure 21 and table 19.

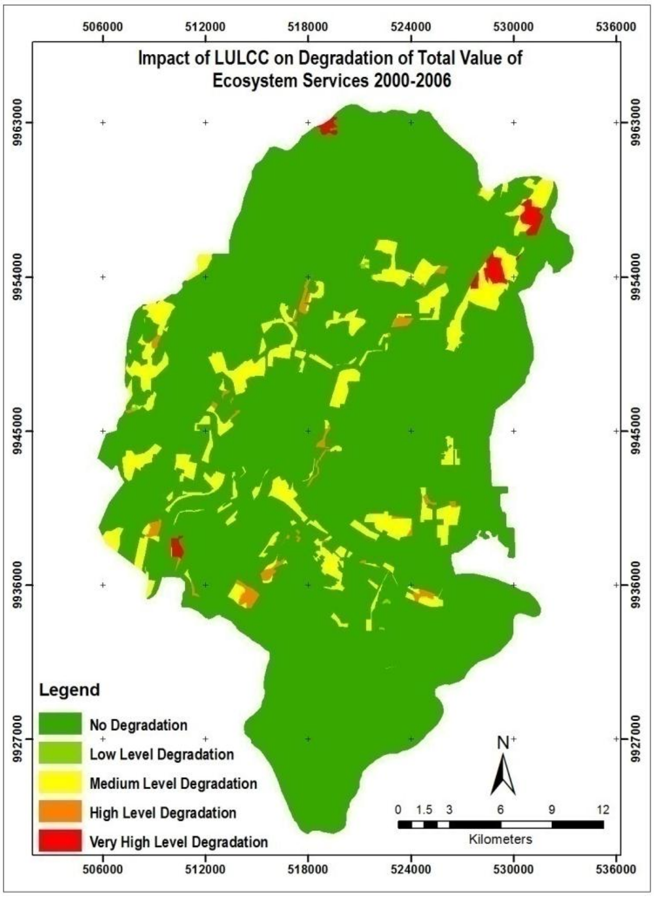


Figure 21. Degradation of ecosystem services due to land use/cover changes

Table 19. Impact of LULCC on degradation of total value of ecosystem services

Degradation of Ecosystem Service Value	Total area experience degradation of services (Ha)
Very High	507
High	664
Medium	5849
Low	43
No degradation	63388

Figure 21 and table 19 revealed that land use cover changes caused degradation of the ecosystem capacities to provide the eight ecosystem services in the study area. The highest degradation was caused by changing the land use/cover from mix vegetation to mining and built-up area in area about 507 ha, followed by conversion of agricultural land to built-up and mining area in high level of degradation. As many as 5869 ha of the total area lost the ecosystem services in medium level due to conversion of shrub to mining and built-up area Then, in low level ecosystem experience degradation due to conversion of swamp to built-up and mining area.

From spatial distribution of ecosystem degradation in figure 21 was obtained that the highest loss of ecosystem services was in the northern part of the study area where the mining activities took place there. Land conversion due to mining activities in that location has caused loss of services provided by mix vegetation and shrub. The land use change in that part caused the decrease of the total ecosystem services value based on value attached by local stakeholders in very high and medium level. Then land use change due to expansion of built-up area occurred around the city centre causing the loss of shrub and agricultural land and services provided by those two ecosystems in high and medium level. Therefore the land conversion caused the loss of several ecosystem services provided by all natural ecosystems (land use/cover) in the study area.

5. DISCUSSION

5.1. Analysis of land use-land cover change

5.1.1. Land use-land cover classification

From Landsat image of 2002 and Aster image of 2009, land use/cover types were classified into built-up, mining, mixed trees, agriculture-shrub, paddy field, swamp and water bodies (regardless cloud and shadow). However in the process of supervised classification and accuracy assessment, only 5 classes were included because two classes were mixed, namely built-up-bare land, and agriculture-shrub. The feature value of built-up and bare land due to coal mining activities is almost similar, and based on feature space analysis, the feature signature of those classes overlap for all bands of the image. In the next steps, those classes were separated by visual classification. However, separation between built-up and mining area can only be done at some mining sites are far from the built-up area, while mining sites found very close to built-up area cannot be separated because they produce very similar shape, pattern and spectral characteristic. Based on field observation, there are many small-scale coal mining locations near built-up areas, some of them are located beside main road and inside the residential area. Therefore, the condition should be considered in the result of classification. From land use maps 2000 and 2006, land use classes obtained are eight classes; built-up, mining, forest, mix vegetation, shrub, agriculture, swamp, and river. Built-up area is a result reclassification from office, trades and services, education, sport centre, and residential classes.

The most important consideration in this process is related to data availability, and data quality. In this research one of the major problems is associated with image availability. The most problem of images in tropical area is cloud coverage. Researcher tried to find the image is free cloud coverage, however there is no image data in study area from 2000 which is free cloud coverage, the best image found is Landsat image of 2002 even if it has 4 % cloud covers. Besides, researcher tried to find the most recent imagery, but the availability of image in study area is only Aster image 2009. But the problem with this image is that it does not cover the whole study area. Moreover, regarding ground truth data for accuracy assessment, the problem is because there is no field work data at that time (2002 and 2009). The ground truth for 2002 was only conducted by picking ground point from Google Earth in 2002, then for accuracy assessment of 2009 was only based on picking ground point from Google Earth of 2002 because Google Earth data are not available in 2009, and combining it with ground point in 2011 for unchanged area based on informal interview from local people in the study area during the field work in 2011. Other problems come from land use maps of 2000 and 2006 obtained from local institution in the study area. The scale of the maps is in large scale 1 : 50000, and the map is very general in classification. However, these maps are the best data which can be obtained for this study. Thus, generalization and some uncertainties are covered in this study.

5.1.2. Land use- land cover change

Change detection from 2000 to 2006 revealed that the increase of built-up, mining area, and agriculture. On the other hand, change detection indicated the decrease of mix vegetation and shrub. Swamp and river remained more or less constant. The decrease of mix vegetation and shrub was mostly caused by conversion to built-up area and mining area, and a small portion due to conversion to agriculture land. Moreover, change detection from 2002 to 2009 also showed the similar result that built-up and mining area increased while mixed trees and agriculture-shrub decreased. Because shrub and agricultural land are mixed, there is uncertainty either shrub or agriculture which experience a decrease. Swamp and water body are more or less constant. Generally, even though the change detection was conducted in two different parts of analysis, the trend showed the similar result.

Expansion of built-up area in 2006 generally expanded in around the existing built-up area in 2000. It could probably because the existing built-up has had existing infrastructure and other facilities. This is also similar with the expansion of built-up area from 2002 to 2009. Built-up area in 2002 to 2009 expanded to the northern and southern part of the study area adjacent to the existing built-up area in 2002. Then, from 2000 to 2006, the land use/cover changes from natural land to mining area occurred mostly in the northern part of the study area, and small portion expanded to the southern part of the study area, while the conversion of natural land to mining area in 2009 spread to the whole side of the city. The expansion of mining area is triggered by the implementation of decentralization policy or regional autonomy in the study area. Without permits, mining activities (companies) do not have access to land. Based on mining law 11/1967, issuance of mining permits is authorization of central government. However with law 22/1999, local government has authorization for giving location permits (include permits for general mining such as coal mining). It caused the expansion of coal mining activities in the study area. Land use map of 2000 showed that mining area at that time was only located in the western part of Samarinda city. The mining sites are owned by PT. Bukit Baiduri Enterprise which got permits from the central government (Zamri and Suhandi, ESDM, 2010). Then the land use/cover map of 2002, 2006 and 2009 showed the dispread of mining areas gradually to the northern, southern and eastern part of the study area. Nevertheless, the data of mining permits issued by local government of Samarinda since 2000 cannot be obtained officially from authorized institutions of the local government.

Regardless all the limitations and the data quality of land use/cover maps, the study has shown that the land use/cover changes occurred in the study area.

5.2. Analysis of environment degradation by applying ecosystem services concepts

5.2.1. Identification of important ecosystem services in the study area

Ecosystem services recognized as important services for local people in the study area encompass eight services. The eight ecosystem services include in three ecosystem services categories defined by Millenium Ecosystem Assessment (2003). There are two ecosystem services categorized in regulating services, namely purification of air and prevention of floods. Five ecosystem services belong to provisioning services, namely provisioning of foods, water resources, provisioning of fuelwoods, provisioning of timbers, and provisioning of medical plants. Finally, recreation includes in cultural services.

Based on spatial distribution, regulating services (purification of air and prevention of floods) and cultural services (recreation) are mostly identified as important services by local people in urban area. This result is almost similar to the study by Bolund and Hunhammar (1999) and Jim and Chen (2009), even though in different methodology. Bolund and Hunhammar (1999) defined six ecosystem services in urban area of Stockholm including air filtration, micro climate regulation, noise reduction, rainwater drainage, sewage treatment, and recreational and cultural values. The services are provided by seven urban ecosystems identified in their study: street trees, lawns/parks, urban forests, cultivated land, wetlands, lakes/sea, and streams. From study by Bolund and Hunhammar (1999) was obtained a description that generally ecosystem services in urban areas are regulating and cultural services. This result is also similar to the study by Jim and Chen (2009) which identified and assessed the economic value of ecosystem services provided by urban forests in China. Jim and Chen (2009) obtained that urban forests in China provide regulating services (air quality regulation, microclimate regulation, and water regulation); cultural services (recreation and amenity); and supporting services (photosynthesis). The similarity among these studies lies in regulating and cultural services are the two ecosystem services recognized in urban areas. Even though those two previous studies conducted assessment of ecosystem services in biophysical and economic assessment without consideration of local people perceptions, the result is similar with this study where in this study recognition of ecosystem services based on local people preferences.

In this study, purification of air is identified by local people as a first choice of important services in area close to CBD (*central business district)*, warehousing location and industrial area. In the study area, warehousing location is located in Sungai Kunjang subdistrict. Then, the industrial estates, majority of plywood industries are located in Samarinda Seberang subdistrict. The reasons behind the choice were not explored by researcher during the field work, however, the assumption why they chose the purification of air as a first choice of important services might be because they more deal with air pollutant.

Prevention of floods is the first choice of important services identified by local people in Samarinda Utara, Samarinda Ulu and Samarinda Ilir sub-districts. The reasons behind their choice were also not explored, however, their choices might be influenced by their location was in Karangmumus watershed (the description of Karang Mumus watershed is given in Appendix 12). People living in the watershed area more suffer by flooding due to land use/cover change on upstream area of the watershed. Analysis of land use/cover change in the previous chapter showed that land use/cover change occurred in northern part of the study area which is upstream of Karangmumus watershed.

On the other hand, provisioning services including provisioning of foods, water resources, provisioning of fuelwoods, provisioning of timber, and provisioning of medicinal plants are mostly identified as the most important services by local people in rural area who majority are farmers. All respondents who are farmers in study area chose the provisioning of foods as a first choice of important services. Provisioning services are mostly recognized by farmers because they depend on the services and they directly link to the services because natural ecosystems are a source of their livelihood. This result is almost similar with the study by Daniel (2008) in Ejisu-Juaben District, Ghana that local people, who majority are farmers, mostly recognized provisioning services (harvestable goods) as goods/services provided by ecosystem in his study area. This result also in line with the ecosystem typology described by de Groot et al (2002) which characterized that mostly foods and raw materials can be obtained from cultivated land and forested areas.

From the spatial distribution of the respondents, this study found that spatial location is important factors in determining important services for stakeholders. This fact is in line with the opinion of Hein et al, (2006) that stated that in valuation of ecosystem services the spatial scale and stakeholders need to be considered because different spatial scale and stakeholders have different interest in the ecosystem services.

5.2.2. Ecosystem services assessment and mapping

A lot of studies in valuing ecosystem services were done in monetary terms and biophysical terms, while this study used GIS analysis and Spatial Multi Criteria Evaluation (SMCE). GIS Analysis and SMCE were employed to assess and map the ecosystem services in the study area. This analysis was conducted with the consideration that spatial factor and value attached by local stakeholders are important in assessing ecosystem services as discussed by Millenium Ecosystem Assessment (2003), Hein et al (2006), Zhang and Lu (2010). In this analysis, capacity of ecosystems to provide services is used as a basis assessment qualitatively. A value score is given qualitatively to each ecosystem (land use/cover) on its capacity to provide each service in which the assessment is based on literature review and relevant condition with study area. This is used because there are no quantitative values either in economic or biophysical data obtained for this study. Score as a result of assessment was mapped qualitatively to each land use/land cover type as a unit provider of specific services in the study area.

In assessing and mapping land use/land cover as a unit provider of single ecosystem services, land use/cover is determined as boundaries of ecosystem to be valued. It is based on Hein et al (2006) stated that the first steps in valuation of ecosystem services is specification of the boundaries of ecosystem to be valued. The result of assessment revealed that forest provide 7 of 8 ecosystem services in the study area, mix vegetation provide 6 services, agricultural land provide 4 services, shrub provide 3 services, river provide 2 services, swamp provide 1 services, while built-up and mining do not provide services at all.

Forest has the highest value as provider of 5 important ecosystem services including purification of air, prevention of floods, provisioning of foods, recreation, provisioning of fuelwoods, and provisioning of timbers. Then mix vegetation has the highest value as a unit provider of 4 ecosystem services which are similar with forest, but without recreation. Agriculture has the highest value for provisioning of foods and provisioning of medicinal plants, while river receives the highest value for water resources.

The highest service of purification of air is provided by forest and mix vegetation because these two land use/cover classes are dominated by trees which have high capacity to purify air. Many studies also have showed that forests have highest value as service providers of air purification (air quality regulation or air filtering regulation) either in economic terms valuation (Jim and Chen, 2009; Constanza et al, 1997) or in biophysical terms valuation (Bolund and Hunhammar, 1999; Guo et al, 2001).

In assessing and mapping the land use/cover as a unit provider for ecosystem services in prevention of floods category, the result also shows the highest value for forest and mix vegetation as a provider of this service. Forest as a best provider for prevention of floods has been showed by some literature; MA (2003) showed that forest play important role in mitigation of floods; Daily et al, (1997) also stated that forest which is covered by trees with deep roots has high values for their role in flood control.

Furthermore, forest and mix vegetation have highest value also for provisioning of fuelwoods and provisioning of timber in this study. Those land use as best provider unit of this services. Many case studies and also many literatures stated that forest is the source of raw materials including timber, fuelwoods, lumber etc (Daily et al, 1997; Constanza et al, 1997; de Groot et al, 2002; Gatto et al, 2009).

In this study, forest also has the highest value for recreation. This is because forest provides place for pleasure, amenities and relaxation for local people as indicated by the number of visitor to the place. Gatto et al, (2009) previously assess value of forest by applying cost benefit analysis; they found that forest has a high value for recreation services. Also similar with study by Jim and Chen (2009) that urban forest is highly used by people for recreation and amenities purposes, it therefore has high economic value based on willingness to pay of visitors to the place. This is in line as de Groot et al., (2002) and Hein et al., (2006) stated that natural ecosystem provide unconstrained “aesthetic, leisure, cultural, natural, and recreational quality.”

For provisioning of foods, agriculture is a unit provider that receive the highest value because agricultural land is the source of foods which cultivated by local people in the study area. For provisioning of medicinal plants, this land use/cover is also has the highest value because most of the medicinal plants in the study area is cultivated in agricultural land. Finally, river as the source of drinking water in the study area, therefore it has the highest value as provider unit for water resources services.

SMCE is used to calculate the total value of all important ecosystem services and to obtain spatial distribution of the total value of all ecosystem services. Using the ranking and weighting based on local stakeholder preferences of important services, this study calculated the total value of land use/cover as a provider of all ecosystem services. Multi Criteria Evaluation as a tool to assess ecosystem services has been applied by some studies (Zhang & Lu, 2010; Martinez-Harms & Gajardo, 2008) in a different objectives and different methods of weighting. Martinez-Harms & Gajardo (2008) used multi criteria evaluation in assess the ecosystem process, goods and services, and mapping the result in qualitative scale using GIS analysis.

Using SMCE to calculate the total value of all important ecosystem services in the study area, forest and mix vegetation also receive the highest value as a services provider of all ecosystem services in the study area based on eight criteria of capabilities of ecosystem to provide the services, and based on weighting by local stakeholder judgments of this services. Built-up and mining areas are land use/covers which do not have value at all. From the overall analysis, both from the assessment and mapping using GIS analysis to assess land use/cover as a unit provider of specific ecosystem service, and from assessment and mapping using SMCE to assess total value of land use/cover as unit provider for all services, forest and mix vegetation receive the highest value. Therefore it is need to consider that these land uses/covers should be protected because the loss of those ecosystems will cause the loss of the services or functions of ecosystem to provide benefits for local people in the study area.

However, in using SMCE, the result really depends on the local judgment. The result mostly relies on the point of view of local stakeholders toward what are the values of ecosystem for them. In terms of ranking and weighting of MCE criteria only consider local people perspective, without considering other external factors that may influence the value, thus, level of objectivity and uncertainty should be considered toward the results because different judgment will give different result of this analysis. As stated by Martinez-Harms & Gajardo (2008) this technique is very useful and simple, however it is very much based on the expert's opinion where experts can have different opinions. Although this method is said to be very subjective, but in the assessment of ecosystem services, consideration of stakeholders is important, as stated by Hein et al, (2006) that stakeholders have value attached to ecosystem services, and as stated by Zhang and Lu (2010) that the judgement of stakeholders is important because evaluation of ecosystem services needs to consider social requirement of the services

Other consideration or limitations in this analysis is that the assessing and mapping value of ecosystem was conducted only by using classification and scoring value from literature review. This condition occur because there are no sufficient data that are obtained for assessing the ecosystem based on the monetary terms or based on indicator approach. The sufficient of data availability are the most problems in measuring the benefits of ecosystem services as stated by World Resources Institute (2009) because ecosystem services concepts are broad issues which need a lot of data.

GIS analysis and Spatial Multi Criteria Evaluation has been used by researcher as a tool to assess and mapping the ecosystem services, even though there are a lot of generalization and uncertainty in applying this approach in this study due to several limitations of the methods and data availability, however this approach has given a useful result in assessing ecosystem services qualitatively in the study area.

5.2.3. Impact of land use – land cover change on ecosystem services

Assessing and mapping of ecosystem services show that each land use/cover has functions to provide the ecosystem services. One land use/cover may provide one service but one land use/cover can provide several services. Therefore, the loss of one land use/cover type can cause loss of one ecosystem service, but the loss of one land use/cover type can cause the loss of several ecosystem services. As a result the loss of the ecosystem will relieve the benefits of ecosystem to fulfil human needs.

Assessing the impact of land use/cover change on each ecosystem service in the study area showed that the highest level degradation of purification of air occurred in the northern part of the study area caused by conversion of mix vegetation to mining area. One level down, the degradation is caused by changing of shrub to mining and built-up area. This condition in line with the study by Foley et al, (2005) explained that land use-cover change can affect the air quality regulation.

In assessing the capacity of land use/cover to prevent floods, the impact of land use/cover change also in very high level of degradation is caused by conversion of mix vegetation to mining and built-up area. From spatial distribution of ecosystem degradation, the most area experiencing degradation is in northern part of the study area due to conversion of mix vegetation and shrub to mining area.

The capacity of ecosystem in provisioning of foods declines due to conversion of agriculture and mix vegetation to mining and built-up area where the highest level of degradation is experienced by agricultural land. Recreation and water resources do not experience loss because there is no change to the forest as a provider of recreation and there is no change to the river as a provider of water resources. Then, very high level loss of provisioning of fuelwoods and timbers are caused by changing of mix vegetation to built-up and mining areas. The capacity of ecosystems in provisioning of medicinal plants decreases in very high level because of conversion of agriculture to built-up area.

Overall, mix vegetation experiences the highest level of degradation. This is because this ecosystem (land use/cover) provides 6 services in the study area. Consequently, one change from mix vegetation caused the loss of 6 services or functions provided by this ecosystem including purification of air, prevention of flood, provisioning of food, timber, fuelwoods, and medicinal plants. Then, the loss of agricultural land caused the loss of 4 ecosystem services provided by this land use/cover, and the conversion of shrub caused the degradation of ecosystem to provide 3 ecosystem services.

Assessing the impact of land use/cover change on the total ecosystem services value showed that the highest level degradation of ecosystem to provide all services occurred because of conversion mix vegetation. One level down, the degradation of ecosystem capacity is caused by conversion of agriculture and shrub to mining and built-up area. As a unit provider of all ecosystem services in the study area, the land use changes from natural land to built-up and mining area have caused the decrease of the total ecosystem services value based on the value attached by local stakeholders. It means that the decrease of ecosystem capacities to provide all important services identified by local people in the study area. From this assessment, it can be seen that one change in land use/cover has caused a lot of loss in services provided by ecosystem. One change in land use/cover produces several impacts on the ecosystem services.

According to MA (2003), land use/cover change is a direct driver on ecosystem services. The condition in this study area is in line with the concept of MA (2003) because the land use-land cover changes in the study area have caused loss of the ecosystem services. The loss of mix vegetation and shrub due to conversion to mining area particularly in the northern part of the city has showed the high level loss of services provided by the ecosystem. The area experienced damage and loss of many functions of ecosystems.

This study found that the ecosystem services will be affected by the changing of land use-land cover. The other studies which have conducted the analysis of impact land use change on ecosystem services in economic valuation (Hu et al, 2008; Martinez et al, 2009; Li et al, 2007, Wang et al, 2004) have found that land use change caused the decrease of ecosystem services value. As comparison to the other studies, this study also showed the similar result even if the analysis was done qualitatively using SMCE.

As stated by MA (2003) that the degradation ecosystem services can affect human well-being, this statement can be related to this study. The loss of natural ecosystem has caused the loss of a lot of ecosystem services and functions in the study area. The loss of mix vegetation will affect the loss of source of foods, fuelwoods, timbers, and medicinal plants so that this condition can affect the availability of the goods to fulfil local people needs. Then the loss of agricultural land due to built-up expansion showed the degradation of ecosystem capacity to provide foods in high level, this also may affect the farmer's livelihoods because farmers depend on this ecosystem. Moreover, the loss of the natural ecosystem in one part does not only give an impact for that location, but it also has some impacts for the whole study area. For example, the loss of natural ecosystem in northern part of the study area has showed the decrease of capability in that part to prevent floods. As an upstream area, it will affect water flows downstream at rain. As a result, downstream area may experience flooding at rain, and it may also increase the frequency of floods in the study area, then the floods may disturb the human life there.

Furthermore, based on the analysis of impact on the land use/cover change on ecosystem services and from the result of assessment total value of ecosystem services showed that the highest value of ecosystem services is provided by forest and mix vegetation, and the highest degradation of ecosystem is caused by conversion of the land cover to other uses, so that those two ecosystems should be avoided from conversion. If the conversion continues without protection and strong attention from all stakeholders in the study area, it can be predicted that the ecosystem services will be lost in to the next certain years. The policy regulation should protect the land from conversion to other uses or it will be better if the land is protected by zoning regulation.

Regardless the limitation of this data related to data quality of land use/cover maps, the limitation on determining scoring, criteria, ranking and weighting of the method used, the results can reveal the relationships between land use/cover change and threat to ecosystem services in the study area which are not known before. Also using SMCE and GIS analysis, the study can provide spatial distribution of the location of ecosystem which has a high value. The result at least can be used as input to decision making in avoiding to issue the location permits without consideration of ecosystem value.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

This chapter summarizes the research based on analysis and results obtained and draws some conclusions and recommendations from the findings obtained. The general objective of this study is to assess how the land use-land cover changes triggered by decentralization affect environmental degradation in Samarinda. It focuses on analyzing land use-land cover changes and its impact on environment based on ecosystem services concepts. To achieve the main objective, two specific objectives were formulated along with number of research questions. First, to analyze the land use-land cover change in Samarinda municipality after decentralization in 2000. Second, to analyze environmental degradation as a result land use – land cover changes based on ecosystem services concepts

1. to analyze the land use-land cover change in Samarinda municipality after decentralization in 2000.

Implementation decentralization policy in Samarinda provides some positive and negative impacts on the city. On one hand, the policy opening wide-range authorizations to local government in the utilization of its own resources has accelerated the development of the city. On the other hand, this research observed that the policy has also triggered some negative impacts toward environmental quality because of land use/land cover changes after the implementation of the policy in the study area. Multi temporal analysis using GIS approaches is practically in observing the change on land use/cover during the periods of study. In 6 years (2000-2006), this research examined that land use changes in Samarinda have occurred significantly. Built-up area expanded from 6653 ha to 11144 ha representing 6.38 % increase from the total study area, but it represents the increase in size about 68% from its original area in 2000. Mining area has also increased from 333 ha to 2716 ha or an increase of 3.38 % from the total study area, but it showed the increase in size almost eight times from its original area in 2000. In contrast, natural land uses including shrub and mix vegetation decreased over time. Area cover by shrub decreased from 41571 ha to 35061 ha or reduced about 9.24% from the total study area. It represents reduction 16% from its original in 2000. Mix vegetation also decreased from 11657 ha to 11144 ha, the reduction was 512 ha representing 0.73% decrease from the total study area. Whilst other land uses including forest, swamp and river are more or less constant.

2. to analyze environmental degradation as a result land use – land cover changes based on ecosystem services concepts

Land use changes have created environmental changes in the study area. Environmental changes have caused degradation of ecosystem capability to provide eight important ecosystem services identified in the study area. The eight ecosystem services identified by local people in the study area includes purification of air, prevention of floods, provisioning of foods, recreation, water resources, provisioning of fuelwoods, provisioning of timbers and provisioning of medicinal plants. Two main causes of the ecosystem service degradation are urban sprawl and expansion of mining areas. The analysis revealed that environmental degradations occurred in the study area due to land use/cover change from 2000 to 2006. Conversion of mix vegetation to mining and built-up area resulted in very high level of environment degradation in area of 507 ha due to the loss of the capabilities of ecosystem to provide eight ecosystem services in the study area. Conversion of agriculture land to built-up and mining area caused the decrease of ecosystem services capabilities in high level in area of 664 ha, and conversion of shrub to mining and built-up area caused the decreased the capabilities of ecosystem in medium level in area of 5849 ha. The analysis revealed that the main ecosystem services, as identified by local stakeholders, all have been impacted in negative way by land use change.

6.2. Recommendations

Wide-range authorizations to local government in the utilization of its own resources which focus on economic growth without consideration of environment quality cause environmental damage or/and loss of ecosystem functions and services which are important to human life in the study area. Therefore, it is necessary to be ensured that local development should not only consider the economic benefits of the utilization of the resources but also the environmental impacts of the resources utilization. Furthermore, one consideration which is important to evaluate in the implementations of this policy is the issuance of the permits on mining activities. This research found that the highest level of environmental damage is caused by mining activities. The conversion of natural ecosystems to mining activities has generated loss of ecosystem benefits to local society welfare. Indeed mining activities are sometimes needed to promote economic growth of the city, but the important things are how the activities can be conducted with minimal impacts on the environment.

Therefore for future consideration, planning and implementation of policies should be ensured that they will not open chance to generate harmful effects for environment. The policies must be guaranteed to manage human activities to prevent and mitigate negative effect on nature. Thus the permits should not be issued in area having a high ecosystem services value which provides high benefits for communities.

In addition, it is necessary to improve the awareness of the decision making concern toward the environment quality. Local government is necessary to consider the land protection of natural ecosystem through environmental protection policy particularly protection or conservation of some natural ecosystems provided high benefits for local society. Thus in the development of the city, the government policy should take into account ecological dimension, social dimension (quality of life) and economic dimension. Consideration of ecological dimension (environment quality) is needed because the degradation of environmental quality will also influence the quality of life.

Other recommendations is based on the limitation of this study related to data availability and data quality, for further studies is needed to find the more accurate data and up to date data in doing the study. GIS analysis and Spatial Multi Criteria Evaluation are applicable to be used to analyze ecosystem services. However, further studies in applying this method in more accurate and higher resolution data is required to apply this methods in assessing and mapping ecosystem services. Further study of impact assessment of the mining activities quantitatively is recommended to be done to achieve better understanding the environment damage due to these activities, and also study of impact ecosystem services loss on people livelihood in the study area.

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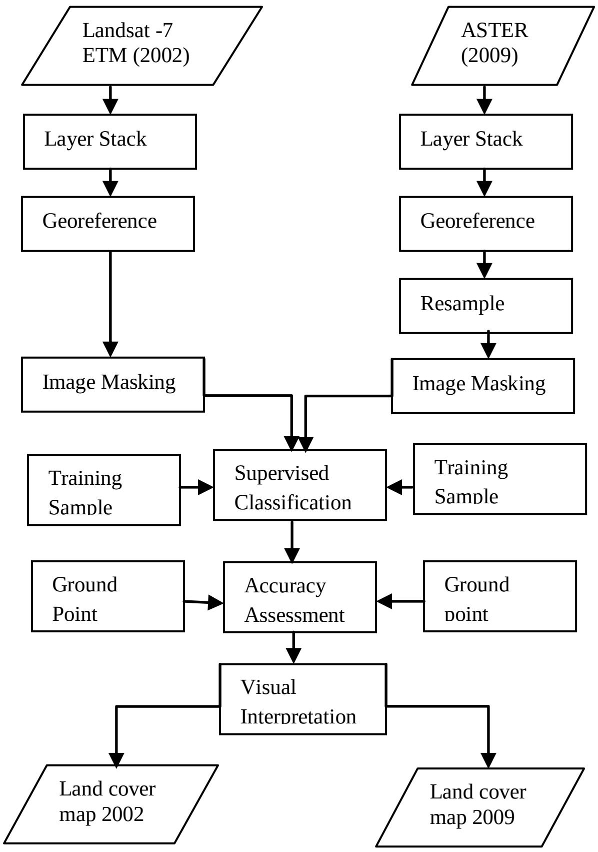
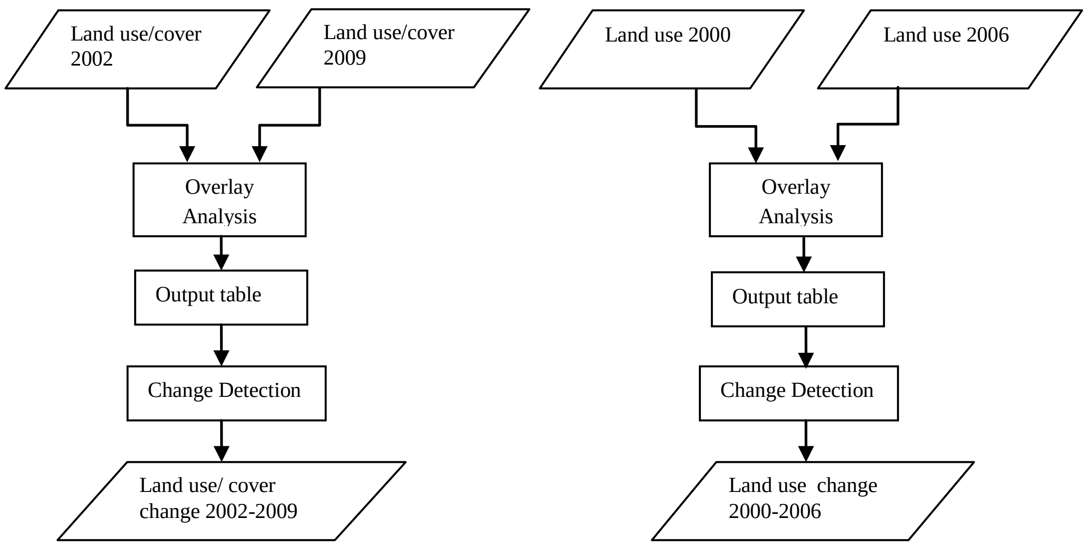
APPENDICES

Appendix 1. The workflow of digital image classification



Appendix 2. The workflow of land use/cover change analysis



Appendix 3. Questionnaire Forms :

This questionnaire is form of collecting data which is used for my research, with the purposed to understand good and services provided by ecosystem such as forest, cropland and plantation and etc in Samarinda. The result of this questionnaire is to know what are the important goods and services provided by ecosystem in samarinda.

GENERAL DATA :

Date of observation :

Location of Observation :

RESPONDENT DATA :

Respondent Name :

Occupation :

Education :

ECOSYSTEM GOODS/SERVICES DATA :

1. What are the goods/services provided by ecosystem (such as forests, fields, gardens, shrub, etc.) for you? Select / give the number on a blank column from the list below, sort by priority (at least 3 types of options, where number 1 shows the priority, and the next number shows decrease priority).

Purification of air		Provisioning of fuel wood	
Climate regulation		Provisioning of medical plant	
Gas regulation		Recreation	
Water purification		Education and research	
Water supply		Aesthetic/ natural beauty	
Regulating of Soil fertility		Biodiversity	
Floods prevention/protection		Waste decomposition	
Erosion control/protection		others (added in the column below)	
Provisioning of foods		....	
Provisioning of timbers		....	

2. Do you think there is the impact of ecosystem changes (such as changes in the forest, cropland or plantation to coal mining or housing area)? Choice the answer below.
   a. Yes b. No
3. If your answer in the question 2 is Yes, then, what are the impact of the changes on ecosystem? Please mention !
   ....

Appendix 4. Error matrix of land cover classification 2002

Classified Data	Unclassified	built-up-bare	mixed trees	shrub/ agriculture	swamp	water	cloud	shadow
Unclassified	0	0	0	0	0	0	0	0
built-up-bare	0	43	0	1	0	0	0	0
mixed trees	0	1	23	6	0	0	0	0
Agriculture-shrub	0	0	9	49	1	0	0	0
Swamp	0	0	0	1	8	0	0	0
Water	0	0	0	0	0	10	0	0
Cloud	0	4	0	1	0	0	0	0
Shadow	0	0	1	0	0	0	0	0
Column Total	0	44	33	58	9	10	0	0

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
built-up-bare	44	44	43	97.73%	97.73%
mixed trees	33	30	23	69.70%	76.67%
agriculture-shrub	58	59	49	84.48%	83.05%
swamp	9	9	8	88.89%	88.89%
water	10	10	10	100.00%	100.00%
cloud	0	1	0	---	---
shadow	0	1	0	---	---
Totals	154	154	133		

Overall Classification Accuracy = 86.36%

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8118

Conditional Kappa for each Category.

Class Name	Kappa
Unclassified	0
built-up-bare	0.9682
mixed trees	0.7030
agriculture-shrub	0.7281
swamp	0.8820
water	1
cloud	0
shadow	0

Appendix 5. Error matrix of land cover classification 2009

Classified Data	Unclassified	built-up-bare	mixed trees	agriculture-shrub	swamp	water	cloud	shadow
Unclassified	0	0	0	0	0	0	0	0
built-up-bare	0	48	1	2	0	0	0	0
mixed trees	0	0	22	11	0	0	0	0
agriculture-shrub	0	1	6	21	1	0	0	0
swamp	0	0	0	0	6	0	0	0
water	0	0	0	0	0	16	0	0
cloud	0	0	0	0	0	0	0	0
shadow	0	0	1	0	0	0	0	0
Column Total	0	49	30	34	7	16	0	0

ACCURACY TOTALS

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Unclassified	0	0	0	---	---
built-up-bare	49	51	48	97.96%	94.12%
mixed trees	30	33	22	73.33%	66.67%
agriculture-shrub	34	29	21	61.76%	72.41%
swamp	7	6	6	85.71%	100.00%
water	16	16	16	100.00%	100.00%
cloud	0	0	0	---	---
shadow	0	1	0	---	---
Totals	136	136	113		
Overall Classification Accuracy =	83.09%				

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.7721

Conditional Kappa for each Category.

Class Name	Kappa
Unclassified	0
built-up-bare	0.908
mixed trees	0.5723
agriculture-shrub	0.6322
swamp	1
water	1
cloud	0
shadow	0

Appendix 6. Land Conversion Matrix (2000 – 2006)

Land use/cover	Built-up		Mining		Forest		Mix Vegetation		Agriculture		Shrub		Swamp		River		Total Area 2000	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Built-up	**6653.38**	**9.44**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6653.38	9.44
Mining	0.00	0.00	**293.17**	**0.42**	0.00	0.00	0.00	0.00	0.00	0.00	40.49	0.06	0.00	0.00	0.00	0.00	333.67	0.47
Forest	0.00	0.00	0.00	0.00	**197.08**	**0.28**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	197.08	0.28
Mix vegetation	70.43	0.10	436.13	0.62	0.00	0.00	**11144.22**	**15.82**	1.00	0.00	5.37	0.01	0.00	0.00	0.00	0.00	11657.15	16.55
Agriculture	622.79	0.88	41.01	0.06	0.00	0.00	0.00	0.00	**6338.20**	**9.00**	18.52	0.03	0.00	0.00	0.00	0.00	7020.53	9.97
Shrub	3905.48	5.54	1938.57	2.75	0.00	0.00	0.65	0.00	849.97	1.21	**34876.88**	**49.51**	0.00	0.00	0.00	0.00	41571.54	59.01
Swamp	15.32	0.02	7.94	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**333.83**	**0.47**	0.00	0.00	357.09	0.51
River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2660.62**	**3.78**	2660.62	3.78
Total area 2006	11267.40	15.99	2716.81	3.86	197.08	0.28	11144.88	15.82	7189.17	10.20	34941.26	49.60	333.83	0.47	2660.62	3.78	70451.05	100.00

Appendix 7. Land Conversion Matrix (2002-2009)

Land use/cover type	Built-up-Bare		Mining		Mixed trees		Paddy field		Agriculture/Shrub		Swamp		Water		Cloud		Shadow		Total Area 2002	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
Built-up/Bare	**3688.72**	**5.24**	38.15	0.05	27.74	0.04	0.00	0.00	262.65	0.37	0.08	0.00	109.29	0.16	1.99	0.00	0.45	0.00	4129.07	5.86
Mining	0.00	0.00	**175.77**	**0.25**	2.24	0.00	0.00	0.00	287.35	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	465.36	0.66
Mixed trees	1152.57	1.64	1652.22	2.35	**7741.09**	**10.99**	0.00	0.00	7669.90	10.89	6.80	0.01	5.87	0.01	140.67	0.20	139.06	0.20	18508.20	26.27
Paddy field	0.00	0.00	0.00	0.00	0.00	0.00	**250.91**	**0.36**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250.91	0.36
Agriculture/Shrub	5038.18	7.15	1681.17	2.39	4962.07	7.04	0.00	0.00	**15411.86**	**21.88**	34.59	0.05	18.70	0.03	204.42	0.29	145.62	0.21	27496.61	39.03
Swamp	47.33	0.07	2.24	0.00	26.06	0.04	0.00	0.00	95.17	0.14	**16.57**	**0.02**	0.00	0.00	0.00	0.00	0.59	0.00	187.97	0.27
Water	136.38	0.19	0.00	0.00	0.00	0.00	0.00	0.00	6.96	0.01	0.45	0.00	**1607.17**	**2.28**	0.00	0.00	1.83	0.00	1752.80	2.49
Cloud	380.77	0.54	61.23	0.09	721.59	1.02	0.00	0.00	853.25	1.21	0.57	0.00	58.49	0.08	**64.28**	**0.09**	36.46	0.05	2176.64	3.09
Shadow	241.88	0.34	32.76	0.05	286.23	0.41	0.00	0.00	358.15	0.51	1.26	0.00	3.86	0.01	5.82	0.01	**3.29**	**0.00**	933.27	1.32
Total area 2009	10685.84	15.17	3643.54	5.17	13767.03	19.54	250.91	0.36	24945.29	35.41	60.32	0.09	1803.39	2.56	417.19	0.59	327.31	0.46	55900.82	79.35

Appendix 8. Distribution of the second choice of important ecosystem services

Sub-district	Location observation	Ecosystem services								Respondent per sub-district
		Purification of air	Prevention of floods	Provisioning of foods	Recreation	Water Resources	Provisioning of fuelwood	Provisioning of timber	Provisioning of medicinal plants	
Samarinda Utara	Tanah Merah	-	5	-	-	-	-	-	-	20
	Lempake	1	4	-	-	-	-	-	-	
	Sempaja Selatan	1	3	1	-	-	-	-	-	
	Pelita	4	-	-	1	-	-	-	-	
Samarinda Ulu	Gunung Kelua	3	-	2	-	-	-	-	-	20
	Sidodadi	3	-	2	-	-	-	-	-	
	Air Putih	4	-	1	-	-	-	-	-	
	Jawa	2	1	2	-	-	-	-	-	
Samarinda Ilir	Sungai Pinang Luar	3	-	2	-	-	-	-	-	20
	Karang Mumus	4	-	1	-	-	-	-	-	
	Sambutan	2	3	-	-	-	-	-	-	
	Makroman	-	5	-	-	-	-	-	-	
Sungai Kunjang	Teluk Lerong	-	4	1	-	-	-	-	-	20
	Karang Asam	-	2	3	-	-	-	-	-	
	Karang Anyar	-	4	1	-	-	-	-	-	
	Loa Bakung	2	2	1	-	-	-	-	-	
Samarinda Seberang	Sungai Keledang	-	1	4	-	-	-	-	-	20
	Rapak Dalam	-	1	4	-	-	-	-	-	
	Mesjid	1	-	-	-	3	-	-	1	
	Sengkotek	-	-	4	1	-	-	-	-	
Palaran	Simpang Pasir	-	-	-	-	3	1	1		20
	Handil Bhakti	1	-	4	-	-	-	-	-	
	Rawa Makmur	-	5	-	-	-	-	-	-	
	Bukuan	1	2	1	1	-	-	-	-	
Total Respondent		**32**	**42**	**34**	**3**	**6**	**1**	**1**	**1**	120

Appendix 9. Distribution of the third choice of important ecosystem services

Sub-district	Location observation	Ecosystem services								Respondents per Sub-district
		Purification of air	Prevention of floods	Provisioning of foods	Recreation	Water Resources	Provisioning of fuelwood	Provisioning of timber	Provisioning of medicinal plants	
Samarinda Utara	Tanah Merah	2	-	-	-	-	1	1	1	20
	Lempake	3	-	1	-	1	-	-	-	
	Sempaja Selatan	2	-	1	1	-	1	-	-	
	Pelita	1	-	4	-	-	-	-	-	
Samarinda Ulu	Gunung Kelua	1	-	3	1	-	-	-	-	20
	Sidodadi	1	-	3	1	-	-	-	-	
	Air Putih	-	-	1	4	-	-	-	-	
	Jawa	-	1	3	1	-	-	-	-	
Samarinda Ilir	Sungai Pinang Luar	1	-	2	2	-	-	-	-	20
	Karang Mumus	-	-	4	1	-	-	-	-	
	Sambutan	2	-	2	-	1	-	-	-	
	Makroman	4	-	-	-	1	-	-	-	
Sungai Kunjang	Teluk Lerong	-	1	2	2	-	-	-	-	20
	Karang Asam	-	2	2	1	-	-	-	-	
	Karang Anyar	-	1	3	1	-	-	-	-	
	Loa Bakung	-	2	2	1	-	-	-	-	
Samarinda Seberang	Sungai Keledang	-	4	-	1	-	-	-	-	20
	Rapak Dalam	-	2	-	3	-	-	-	-	
	Mesjid	-	5	-	-	-	-	-	-	
	Sengkotek	-	2	-	3	-	-	-	-	
Palaran	Simpang Pasir	-	5	-	-		-	-	-	20
	Handil Bhakti	-	4	-	-	1	-	-	-	
	Rawa Makmur	-	-	2	3	-	-	-	-	
	Bukuan	1	1	-	2	1	-	-	-	
Total Respondent		**18**	**30**	**35**	**28**	**5**	**2**	**1**	**1**	120

Appendix 10. Recapitulation of Respondents

Sampling Technique	Random Sampling		
Total Respondent	120 people		
Location of observation	6 sub-district		
Respondent per sub-district	20 people		
Job of respondent	government officer	22	people
	private employee	34	people
	private	23	people
	teacher	3	people
	retiree	2	people
	farmer	33	people
	student	3	people
Education of respondent	illiterate	1	people
	elementary school	4	people
	Junior high school	21	people
	Senior high school	82	people
	Bachelor/diploma	12	people

Type of ecosystem services	Choice of Respondent		
	Rank 1	Rank 2	Rank 3
Purification of Air	48	32	18
Prevention of Floods	37	42	30
Provisioning of foods	35	34	35
Water resources	0	6	5
Provisioning of timber	0	1	1
Provisioning of fuel wood	0	1	2
Provisioning of medical plant	0	1	1
Recreation	0	3	28
Total Respondent	120	120	120

There is an impact of Ecosystem change	Yes	118	respondents
	No	2	respondents

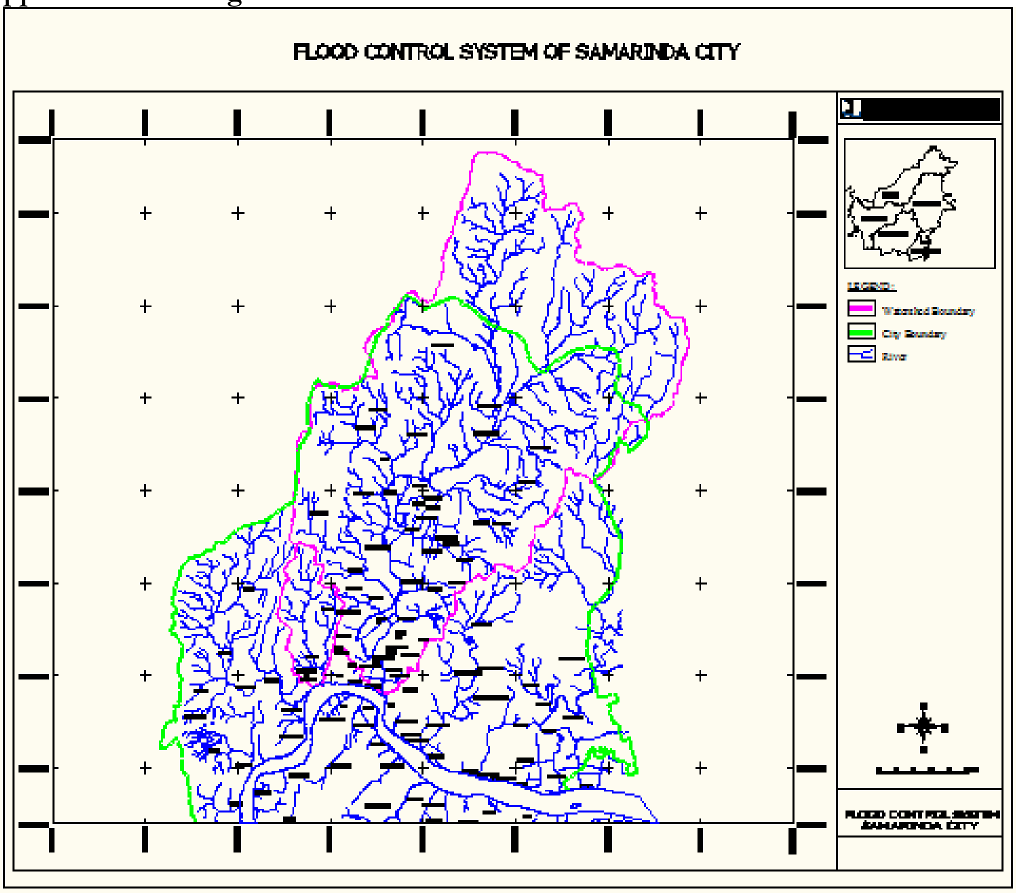
What of the impact	Floods	116	respondent
	Erosion	2	respondent
	No	2	respondent

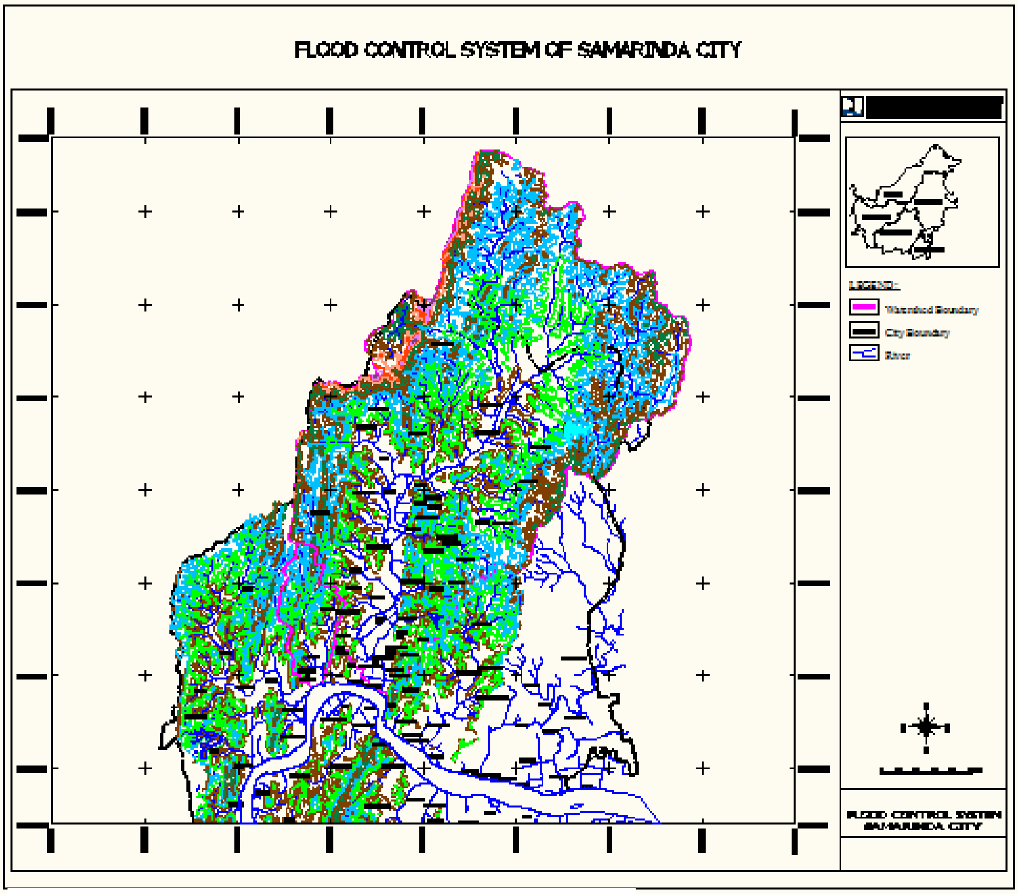
Appendix 11. Number of visitor to forest (Kebun Raya Samarinda)

Month	Year					
	2005	2006	2007	2008	2009	2010
January	21,111	26,446	18,237	24,665	23,236	25,320
February	14,207	8,146	7,220	10,888	6,947	8,761
March	13,495	8,933	11,495	13,586	9,349	8,335
April	7,811	12,476	11,736	9,650	8,372	7,606
May	17,873	9,735	14,671	13,161	13,937	10,098
June	22,209	16,082	22,278	25,590	20,489	11,050
July	21,912	22,742	21,669	24,357	16,177	8,428
August	13,365	9,534	12,918	12,596	7,606	2,731
September	13,440	9,363	7,724	2,996	50,234	38,668
October	4,484	43,660	55,062	52,709	6,950	7,018
November	29,585	9,380	9,200	4,522	13,784	9,013
December	9,912	12,410	21,050	13,265	9,674	7,824
Total	191,409	190,913	215,267	209,993	188,764	146,862

Source : Management board of Samarinda Park

Appendix 12. Karangmumus watershed





Source : Dinas Binamarga dan Pengairan Samarinda