Republic of Indonesia

National Action Plan for Climate Change Adaptation (RAN-API)

Synthesis Report

Ministry of National Development Planning/
National Development Planning Agency (BAPPENAS)
2012

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Foreword

As the largest archipelago nation in the world, Indonesia is one of the countries that are most vulnerable to the negative impacts of climate change. Generally, the global climate change model has predicted that Indonesia will experience an increase in temperature, intensity of rainfall that will increase the risk of floods and droughts, and extended dry seasons. The impact of climate change will among others take the following forms: extended dry seasons, floods, increased frequency of extreme climate occurences, that affect community health and sources of living, degrade biodiversity, and instability of the economy. The largest threats of climate change in Indonesia are the increase of sea surface temperature, changes in the intensity and patterns of rainfalls, and the increase of the sea surface level.

For anticipating the negative impacts of climate change, the Government of Indonesia has implemented various endeavors to adapt to climate change, including the formulation of the national policy document for overcoming the impact of climate change, such as the Indonesia Adaptation Strategy (Bappenas, 2011), the National Action Plan for Adaptation to Climate Change of Indonesia (DNPI, 2011), the Indonesia Climate Change Sectoral Road Map (Bappenas, 2010), the National Action Plan for Climate Change Mitigation and Adaptation (Ministry of the Environment, 2007), and the sectoral adaptation plans compiled by Line Ministries/Government Agencies. For harmonization and operationalization of policy documents, it is necessary to have a National Action Plan for Climate Change Adaptation (RAN-API).

The RAN-API is a national action plan document on adaptation to the impacts of climate change, which involves integrated coordination among all the stakeholders, from the government, civil society organizations, international cooperation agencies and other stakeholders. Briefly, RAN-API contains the action plan for adaptation of priority sectors and cross-sectors in the short-term (2013-2014), mainstreaming of the adaptation action plan into the National Medium-Term Development Plan (RPJMN) of 2015-2019 that will be formulated, and the long-term adaptation policy direction. The RAN-API strengthens endeavors on mitigation that have been formulated in the RAN-GRK (National Action Plan for Green House Gas Emission Reduction).

Formulation of the RAN-API was conducted in a participatory manner through intensive discussions and consultations with the related Technical Ministries/Government Agencies, Local Government, and stakeholders, supported by the development partners. Collaboration in the RAN-API formulation is an invaluable asset for the implementation of adaptation action. This Synthesis Report summarize the key strategies, policies, and actions. While the full document is under process for regional consultation, this Synthesis Report hopefully can provide the adaptation action plan in general.

Finally, I would like to express my appreciation to all the parties who have contributed to the formulation of this document and hope that that this document will provide current progress on national adaptation action plan.

Jakarta, November 2012

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Chapter 1: Introduction

1.1 Background

Ample scientific evidence has substantiated that climate change is already occurring and felt by the entire global community. Various short-term, medium-terms, as well as long-term strategies have been initiated by many nations. These are deemed necessary as delays in the implementation of adaptation steps is believed to lead to greater economic losses in future years. In Indonesia, the economic impact of climate change is estimated to be very significant even though it is still difficult for being accurately estimated. Nevertheless, several studies have shown that economic losses that are directly as well as indirectly attributed to climate change in Indonesia in 2100 could reach 2.5 percent, namely four times the average global GDP loss due to climate change (World Bank, 2010). In fact, if the probability of a disaster occurring due to climate change is also taken into account then the economic losses could reach 7 percent of GDP (World Bank, 2010; ADB, 2010).

To protect the poor who are vulnerable to climate change impact and to prevent economic losses that could degrade development achievements, it is necessary to carry out adaptation activities integratedly and systematically. Most of the Ministries/Government Agencies have formulated their action plans for climate change adaptation in their respective sectors. Nevertheless, there are still many sectoral adaptation activities for which their implementation needs to be synergized to ensure community resilience against the impact of climate change can be enhanced and that development targets in the respective sectors could still be realized.

The issue of adaptation to climate change is an integral part of the formulation of the national as well as sectoral development plans through the strengthening of adaptation programs and activities in an integrated and sustainable manner. National development with the agenda of adaptation to the impact of climate change has the final goal of attaining a development system that is adaptive and resilient to climate change. Sustainable development that accommodates activities of adaptation to climate change can now reduce vulnerability so as not sacrificing the capacity of the next generation to meet their needs. This needs to be realized because climate change will affect all aspects of development in all sectors.

It is imperative that long-term and fundamental action programs be supported by scientific analyses, in the form of analyses on direct impacts (at the site or sector level) as well as analyses that are indirect at the higher level (regional and national levels), such as the impact of climate change on social conditions and on economic growth. Likewise analyses on the implication of policy change in responding to climate change problems on the ability of the sector to meet the target of contributing to the national economic growth because the social and economic impact of climate change cannot be partially seen for the respective development sectors. It is expected that with such analyses, the adaptation program could be implemented more effectively and more integrated manner and yield a greater impact in supporting attainment of the goals of national development that is sustainable and is adaptive or resilient to climate change.

1.2 Purpose, Objective, and Benefit

The purpose of formulating the RAN-API (National Action Plan for Climate Change Adaptation) is to produce a national action plan on adaptation to the impact of climate change that is coordinated with all of the stakeholders, from the government, social organizations, civil society, the private sector, and other stakeholders.

The objectives of formulating the RAN-API document are to :

- Provide direction for the mainstreaming of issues on climate change adaptation into national development planning process;
- Provide direction for sectoral and cross sectoral adaptation actions that are more integrated in the short-term (2013-2014), medium-term (2015-2019) and long-term (2020-2025);
- Provide direction for priority adaptation actions in the short-term that can be proposed and obtain international funding;
- As direction for sectors and regions in developing adaptation actions that are in synergy and that endeavor to develop a more effective communication and coordination system.

Benefits of the RAN-API:

- Encourages the development of synergy in the implementation of inter-sector and inter regional programs and activities in order to enhance resilience against the impacts of climate change in the context of supporting attainment of national development targets;
- Encouraging the formation of a better coordination system among sectors and between the central and regional government in the development of policies and action plans of climate change adaptation.

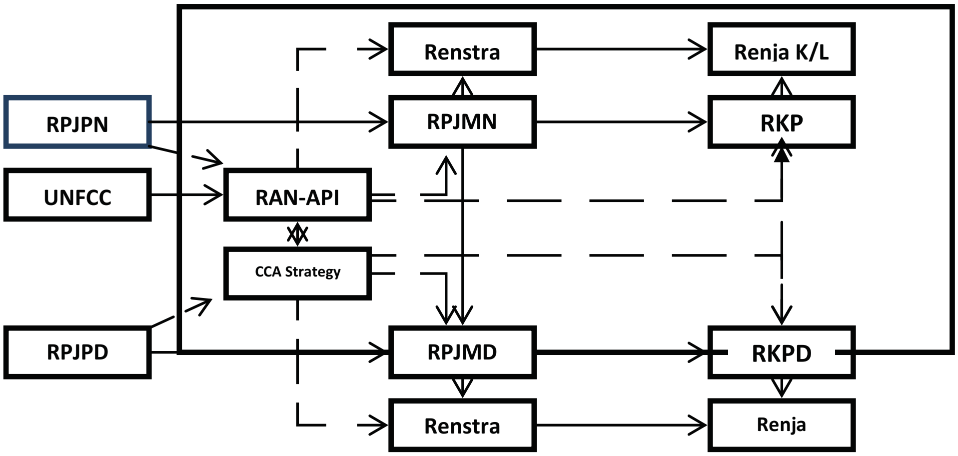
1.3 Position of the RAN-API

The RAN-API is a planning document that more specifically describes the national development strategy and action plan that is resilient to climate change (*climate resilient development*). RAN-API is not a separate document that has a legal formal basis of its own, but is the main input and direction in the formulation of the Government Annual Plan (RKP) as well as of the National Medium-Term Development Plan (RPJMN) in the future to ensure that in the future there are more responsive to the impacts of climate change. At the regional level, the RAN-API is a basis for regional governments in formulating a climate change adaptation strategy as direction in the formulation of the regional development planning document that is resilient to climate change. The position of the RAN-API in the national and regional development planning system is shown in Figure 1.1.

1.4 Approach of Formulating the RAN-API

Formulation of the RAN-API is conducted through a participatory approach that is carried out through a series of workshops, discussions, and bilateral meetings that involved various parties, namely the related Ministries/Government Agencies, CSO's (Civil Society Organizations), and International Cooperation Agencies. In the process of formulating the RAN-API, the National Development Planning Agency (Bappenas) together with the Ministry of Environment (KLH), the National Council on Climate Change (DNPI), and the Meteorological, Climatological, and Geophysics Agency (BMKG) assist by a Drafting Team, form the Core Team that acts as facilitator in the process of analyzing and formulating priority strategies and action plans for adaptation in their respective ministries and government agencies.

Formulation of the RAN-API has been based on various documents on climate change policies that have already been formulated beforehand, namely among others: The National Action Plan for Climate Change Mitigation and Adaptation (RAN MAPI) (2007), Second National Communication (2010), Indonesia Climate Change Sectoral Road Map (2010), RAN-API Indonesia (2011), Indonesia Adaptation Strategy (2011) and the Sectoral Adaptation Action Plan. The formulation of the action plan and stragey of adaptation has also been based on the Strategic Plans of Line Ministries/Government Agencies (*Renstra K/L*) and Work Plan of Ministries/Government Agencies.



Note: RPJPN: National Long-Term Development Plan; RPJPD: Regional Long-Term Development Plan; Renstra: Strategic Plan; RPJMN: National Medium-Term Development Plan; RPJMD: Regional Medium-Term Development Plan; Renja K/L: Work Plan Line Ministry/Government Agency; RKP: Government Work Plan; RKPD: Regional Government Work Plan

Figure 1.1 The Position of the National Action Plan in the Context of National Development

The studies to the development planning and policy documents of ministries/government agencies are meant to identify programs and activities that have already and are still being carried out in the respective ministries/government agencies in relation to climate change adaptation. Scientific studies that are related to climate change and its impact in Indonesia are made through a desk-review approach by utilizing finding of existing studies in various policy documents and most recent studies that are being conducted by experts.

By taking into account the findings of existing scientific studies, the gap analyses and synergies of programs and activities in the respective sectors, and consultations with ministries/government agencies and other stakeholders, thus the national action plan for adaptation to climate change is formed that contain indicative adaptation programs and activities for the short-term (2013-2014), medium-term (2015-2019) and long-term (2020-2025).

Chapter 2: Climate Change and Its Impact in Indonesia

Global agreement for taking steps to overcome the impact of climate change needs to be scrutinized and followed-up by taking various appropriate mitigation and adaptation measures. Thereby, the formulation of the RAN-API should be based on a full scientific conviction on climate change itself. One of the importtant scientific bases for discussing issues on climate change is currently the Fourth Assessment Report (AR4) that was issued by the Intergovernmental Panel on Climate Change (IPCC) in 2007. By using various observation data and outputs of a global climate model, the report affirmed the contribution of human activities (antrophogenic factor) in increasing the concentration of green house gases (GHG) in the atmosphere that has accelerated the increase in the average global surface temperature to reach 0.74°C ± 0.18° in the 1906–2005 period (IPCC, 2007). The trend of global warming is now strongly believed to have been contributed by climate change in various places around the world.

In spite of being very comprehensive, the AR4-IPCC report very little discusses climate change for specific regions such as Indonesia. Therefore, it is essential to have climate change studies that has a regional and local scope for providing detailed information on climate change trends in Indonesia that had occurred in the past, at the present time, and in the future. There have already been sufficient studies that are related to climate change risks in Indonesia, at least in the last decade. Facts that are related to regional and local climate change, and analyses on projection of climate change based on the IPCC model have also at one time been brought up.

This chapter presents a general view on the climate change condition in Indonesia in the regional context of Indonesia and also an analysis of the potential impacts in various sectors, that are currently are occurring as well as the projection for the future, in relation to the climate hazard potential on account of the increasing trend of earth surface temperature, the sea level rise, and changes and shifts in rainfall pattern, and the increased probability of extreme weather and climate to occur. The information expected to be yielded could become the initial scientific bases for formulating this RAN-API (National Action Plan for Climate Change Adaptation), that would be synthesized with finding of studies that have thus far been conducted. In addition, criticisms will also be brought forward on the current management of climate information, and rationales on the need to have continuous endeavors for providing updated information on the climate and to make a national climate change projection in accordance with the latest scientific developments on the climate.

2.1 Brief Overview of the Climate in Indonesia

Generally, the climate in Indonesia is affected by the monsoon circulation that controls the annual pattern of rainfall in most of the regions. A monsoon is a large scale atmospheric circulation system that is linked to the difference in thermal traits or by the warming between continent and oceans. The monsoon system that occurs between the Asian continent and ocean areas and the surrounding seas is the largest and most complex monsoon system. In addition, there is a link between the Asian monsoon and the Australian monsoon and the role of local atmospheric circulation above the islands in Indonesia and its surroundings, that is known as the Maritime Continent. All these together form the Asian-Australia monsoon system that is essential in regulating the water cycle and the thermodynamic energy in the Earth's climate system.

2.1.1 Pattern of Annual Rainfall and Surface Temperature

Rainfall is deemed to be the most important climate element in Indonesia, because as an equatorial tropical region, the annual variation of surface temperature in the Indonesia regions is not too significant and it is more determined by an artifical change of the position of the sun that moves between 23.5º NL and 23.5º SL. This gives cause to the annual temperature variation with two peaks as shown in Figure 2.1. It should be noted that the humidity variation (around Jakarta in this illustration) does not follow the pattern of change of the sea surface temperature nor of the land, which shows that the supply of water steam to the observation area is not dominantly controlled by local factors. Spatially, the surface temperature variation is more affected by the factor of site height/elevation (topography). The largest temperature change on land is in fact occurring in the daily time scale (diurnal variation) that triggers the formation of sea/land wind circulation, namely the local atmosphere circulation that is found in islands in Indonesia (Van Bemmeln, 1913; Hadi et al., 2000).

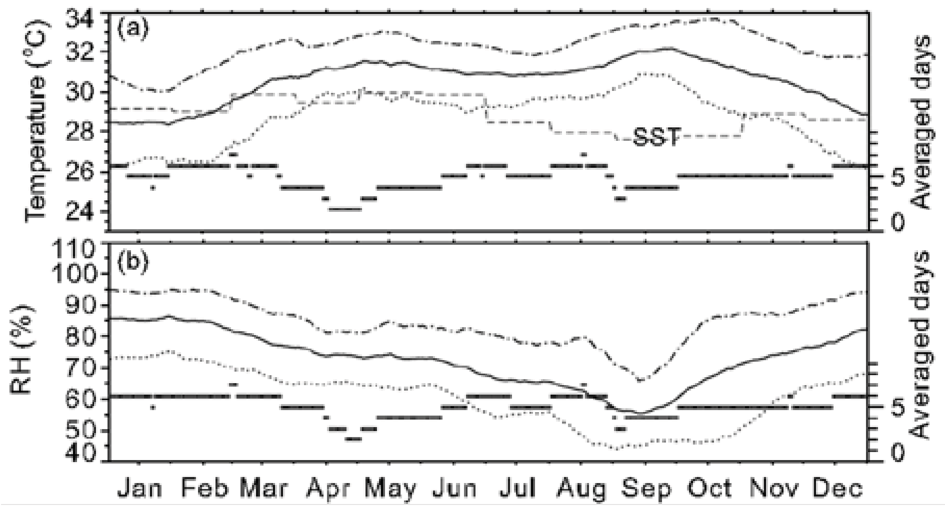


Figure 2.1 The annual composite variation for (a) temperature and (b) relative humidity in the day time (average from 8 am to 2 pm local time) in the region of Serpong in 1993-1999. The total days of observations, or total number of observations available, are indicated by the box symbol. Full line, dotted line, and dot-dash lines respectively indicate the average value, minimum and maximum. The intermittent dash line in (a) shows the monthly average SST in the coastal area of Jakarta in 1986-1994 (Hadi et al., 2002)

In contrast to the surface temperature, the rainfall in Indonesia is much varied in spatial and temporal terms. There are generally annual and bi-annual cycles in the seasonal patterns of rainfall in Indonesia (Chang and Wang, 2005). Several studies have attempted to categorize the rainfall seasonal patterns in various regions in Indonesia, on the basis three types of rainfalls, namely the monsoonal, the equatorial, and the local (Boerema, 1938; Aldrian and Susanto, 2003). This classification is up to now adopted by Meteorological, Climatological, and Geophysics Agency (BMKG) as shown in Figure 2.2.

Nevertheless, various regions still require a more detailed climate classification, considering the local factors, such as topography. Dambul and Jones (2007) for example, have classified the types of rainfalls in Kalimantan into six categories. In addition, the local topographical effect may lead to the occurrence of two peaks of rainfall in Lembang, Bandung at around March and November-December from the Bosscha Observatory data (Vôute, 1933) that differ from the typical monsoonal rainfall (one peak around December-January-February) in the surrounding areas. Likewise the data recorded by

Lekkerkerker (1916), show that Palembang has rainfall type that is an equatorial mixture (having two peaks) and that is monsoonal (a clear dry season in the June-August period).

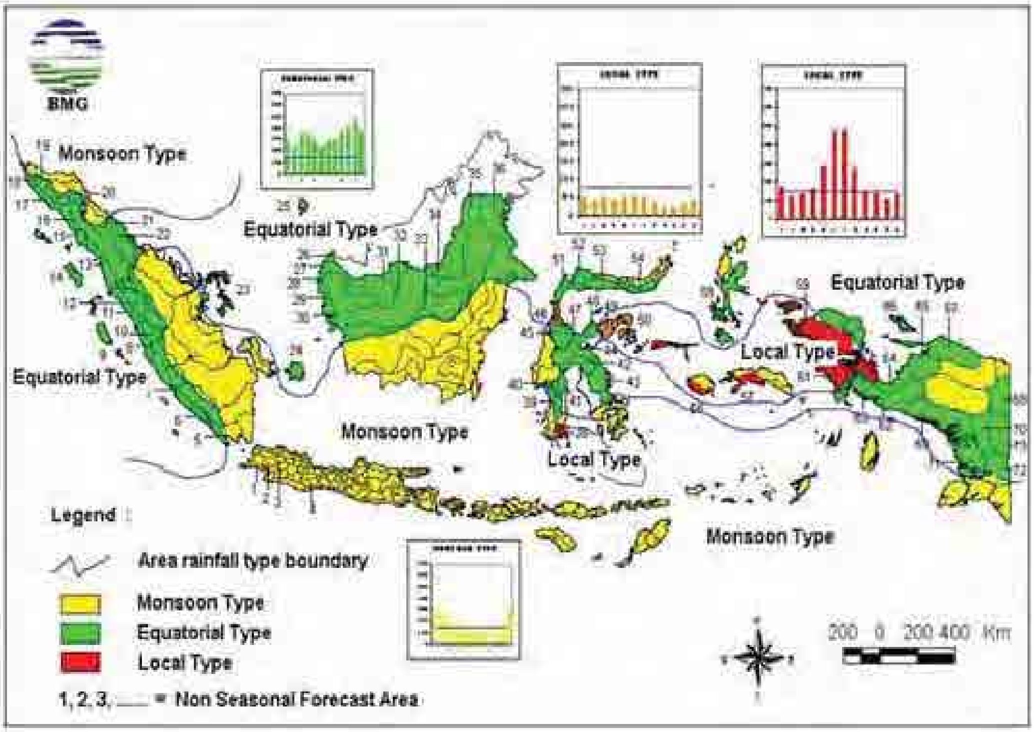


Figure 2.2 Map of rainfall types in Indonesia that is used by Meteorological, Climatological, and Geophysics Agency (BMKG; Makmur, 2012)

2.1.2 Climate Variability

2.1.2.1 Daily Variation of Convectivity Activities (Diurnal Convective Activity)

On average, the diurnal variations of convectivity activity is a pattern of daily weather pattern that is dominant in affecting the islands in Indonesia. Convection is one of the processes for the formation of clouds due to the elevation of moist air from the lower layer until reaching a sufficiently high layer in the atmosphere. The diurnal variation generally results in rainfall in the regions of Indonesia that occur in the afternoon to nighttime on land and in the nighttime untill morning above the seas (e.g. Nitta and Sekine, 1994). The series of satellite images in Figure 2.3 illustrate how diurnal convective activities affect the evolution of daily weather above Java island.

Even though the daily time scale is more related to a short-term weather pattern, changes in the characteristics of the diurnal variation of the convection activity are closely related to climate change. Kitoh and Arakawa (2005), have shown that global warming will reduce the diurnal convective strength and results in less rainfall on land. In addition, the characteristics of air flow in the meso scale could be affected by changes in the soil cover in the coastal areas that ultimately modifies the characteristics of the diurnal convection.

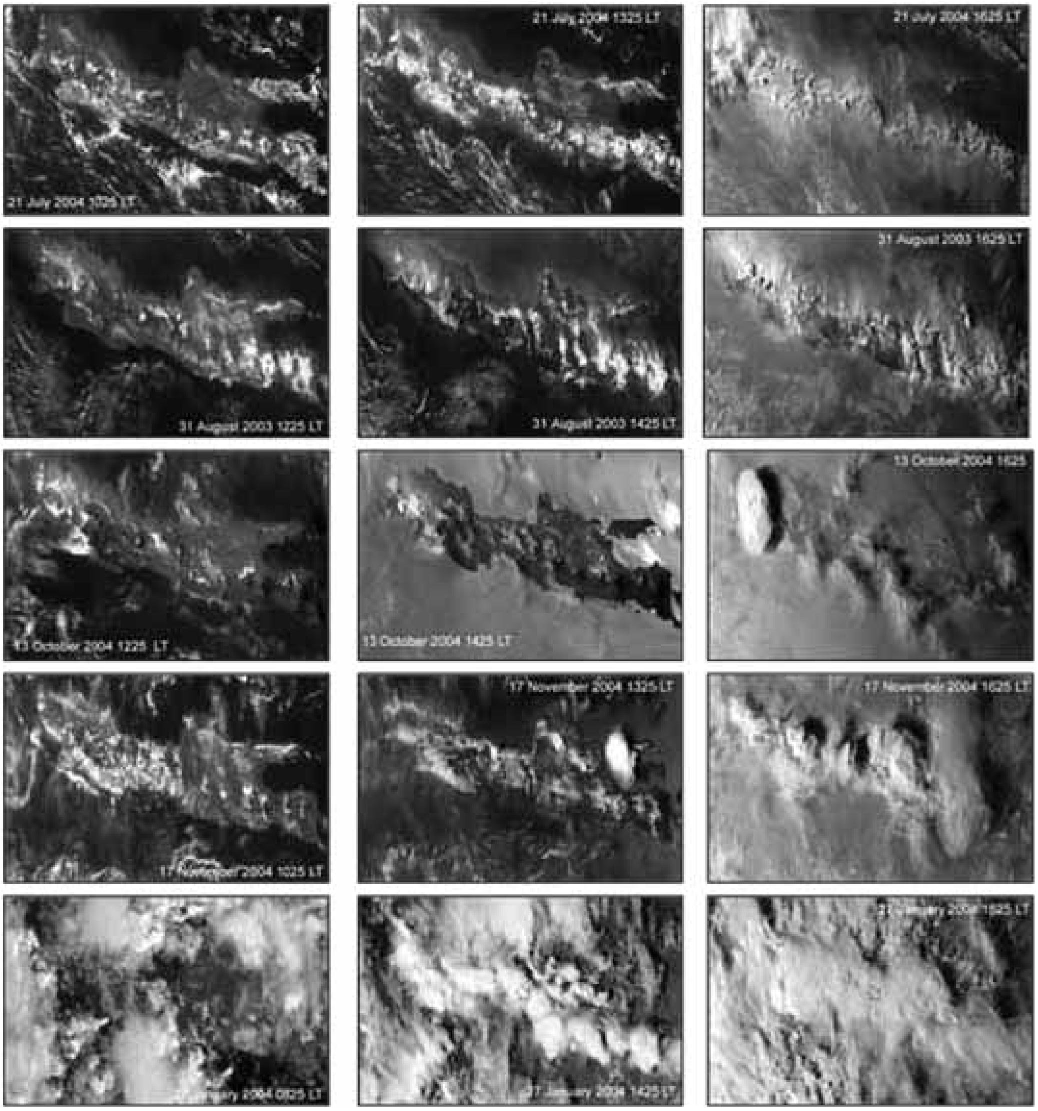


Figure 2.3 The satellite image on a Visible channel shows the evolution of the diurnal convective activities in various scales.The respective left column, central column, and right column shows the observation time in the morning, noon, and afternoon, while each row shows the different dates

2.1.2.2 Intra-Seasonal Variations

As referred to before, various regions in Indonesia are subject to a rainy season and dry season while in some of other regions the delineation of the seasonal period are not too clear (e.g. Dambul and Jones, 2007). In fact, for regions that have a clear seasonal period delineation, the nature of rainfall in one season is not the same from year to year. In one rainy season for example, a heavy rainfall does not occur continuously because there is the monsoon break phenomena that is an intrinsic part of the monsoon circulation system itself (Webster and Fasulo, 2003). How such monsoon break occurs is not yet fully understood, and it may involve various different mechanisms for each monsoon region.

Generally, the phenomenon that is related to meteorological disturbances that affect convective activities and the nature of seasonal rainfall is known as the 'intra-seasonal variation' (ISV/VIM). Activities of various atmosphere phenomena related to the VIM/ISV lead to what is probably often being perceived to by the general public as seasonal irregularities (rainfall occurring during the dry season or draught during a wet season). Various studies have also identified the VIM/ISV as the trigger to the occurrence of extreme weather in Indonesia. Wheeler (2002) stated that the Madden-Julian Oscillation (MJO) has causes the anomaly of rainfall throughout January 2002 and had triggered floods at various locations, including the quite large floods in Jakarta. On the other hand, the floods in Jakarta in 2007 had been more attributed to the cold surge phenomenon (Wu et al.,2007; Trilaksono et al, 2011). Cold surge is a meteorological phenomenon that is characterized by the existence of cold air mass from the Eurasia land towards the east and southeast so that it has led to the strengthening of the winds to the south on the lands of South East Asia when the Asian cold monsoon season is occurring. Conversely, from the direction of the Indian Ocean to the west of Australia there is the 'southerly surge, phenomenon (Davidson, 1984) that results in strengthening of the wind going northward. The southerly surge occurrence could shift the position of convergence area among tropical areas (intertropical convergence zone: ITCZ) to the north thus causing a decline of rainfall especially above Java Island and Nusa Tenggara Islands in the December-January-February period.

The cold surge as well as the southerly surge are phenomena that are related to the synoptic process that normally occur within a period of several days and occur during the occurrence of the cold monsoon season in Asia. In the same period, there is also a unique synoptic weather pattern in the South East Asia and Indonesia region, namely the phenomena of the Borneo vortex (e.g., Chang et al., 2005) that is characterized by a whirlwind around the South China Sea and in the northern part of Kalimantan island. In relation to climate change, the study findings of Juneng and Tanggang (2010) reveals and indication of a trend of the shifting of the center of the Borneo vortex in the last several decades.

A quite comprehensive analysis on the affect of the VIM/ISV on the monsoon circulation in the Indonesia-Australia regions is presented by Wheeler and McBride (2005). Nevertheless, the interaction among the various phenomena pertaining to the VIM in the area of Indonesia has not yet been fully understood and for this many studies still need to be conducted. To illustrate, a compilation of information on the phenomena related to the VIM is shown in Table 2.1. The existence of VIM makes the climate pattern in the Indonesian Maritime Continent (BMI) to become more complex and the analysis on climate change must be conducted by using data that are more detailed and and the analysis must be made more accurately.

2.1.2.3 Inter Annual Variations

The rainfall pattern in Indonesia also has an inter-annual variation that is already documented by Braak (1929). Various studies up to now (e.g. Chang et.al; Hendon, 2003; Wang et al., 2000) have substantiated that the inter-annual variation of rainfall in Indonesia is affected by a climate phenomena that is related to the anomaly variation of temperature of the sea surface (ASPL) in the Central and East Pacific and by anomaly of sea surface pressure in the West Pacific (northern Australia) that is known as the El Nino Southern Oscillation (ENSO) phenomena. The increase (decrease) of the ASPL in this region signals the occurrence of the El Nino (La Nina) phenomena that can result in the longer dry (wet) season and that results in the decrease (increase) of volume of seasonal and annual rainfall in most of the regions in Indonesia.

In addition to being the effect of ENSO from the Pacific Ocean, the inter annual variation of rainfall in the monsoon region is also attributed to a similar phenomena in the Indian Ocean, that is known as the phenomenon of the Indian Ocean Dipole (IOD) (Saji et al., 1999). A positive (negative) Dipole Mode

(DM) is related to the reduction (increase) of rainfall in Indonesia (especially in the western part). The El Nino occurrence at the same time as a DM positive, such as had occurred in 1997/1998 can result in extreme draught in almost all regions of Indonesia.

Table 2.1 Phenomenas that are related to inter-seasonal variation (VIM) in the tropical regions of Indonesia

Name (type) of phenomenon	Description	Effect on the nature of seasonal rainfall in Indonesia	The relevant literature (studies in the regions of Indonesia)
Madden-Julian Oscillation;MJO	Movement of convestion center from the Indian Ocean that moves to the east towards the Pacific Ocean at the speed of around 5-10 m/s and a general duration of around 30-60 days. The MJO can result in changes to the weather in the areas that it passes by affecting several important atmospheric and sea parameters, such as the direction and speed of the wind at the lower and upper level, the clouds condition, rainfall, and sea surface temperature.	The route of the MJO around the earth is subdivided into 8 phases that determine the affect of the MJO to a region; the MJO can increase or decrease the convective activities in the BMI.	Wheeler (2002); Wheeler and McBride (2005); Hidayat and Kizu (2010)
Equatorial atmospheric waves (Rossby waves and Kelvin waves)	Disruptions that spread by zones on the equator regions and can affect the convection characteristics in the regions that they pass.	The route of the equatorial wave is characterized by affecting and being affected by convective activities so that it can modify the nature of seasonal rainfall.	Widiyatmi et al. (1999), Wheeler and Kiladis (1999), Noersomadi and Hadi (2010)
Monsoon break	This is a period of 'small draughts' in between active monsoon periods; the occurrence is characterized by wind changes that is dominant in the area of 100° – 180° EL, from previously westerly to become easterly during the Asia monsoon cold season.	The decline in convective activities in the Australia-Indonesia monsoon region.	Wheeler dan McBride (2005); Murakami and Sumi (1982)
Cold surge	Flow of cold air mass from the Eurasian lands accompanied by the drastic decline in temperature and increase in surface pressure in most of the South East Asian region during occurrence of the cold monsoon season in Asia.	Results in sudden changes to the pattern of air flow of synoptic scale in the lower layer thereby triggering extreme rainfall in several monsoon regions in South East Asia.	Wu et al. (2007) and Trilaksono (2011)
Southerly surge	Occurs during the cold monsoon season in the Asian continent, when there a strengthening of wind from the BBS to the north and the location of the *intertropical-convergence zone*; ITCZ becomes closer to the equator	Reduces cloud formation in the vicinity of the region that is affected by the Australian monsoon so that the potential of rainfall declines.	Davidson (1984)

For analyzing and monitoring climate phenomena that are related to ENSO as well as IOD, experts have developed various indices. There are currently over ten ENSO indices, and some of these are indices that are computed on the basis of the ASPL in the NINO region (NINO1+2, NINO3, NINO4, NINO3.4) in the Pacific Ocean. The Dipole Mode Index (DMI) is an index that is computed on the basis of the difference between the ASPL in the Western Indian Ocean (around offshore of East Africa) and the Eastern Indian Ocean (around offshore to the south west of Sumatra Island). Figure 2.4 shows the map of correlation coefficient between the index of NINO 3.4 an DMI with a time series of rainfall from data of the TRMM (Tropical Rainfall Measuring Mission) satellite for the 1998 to 2011 period.

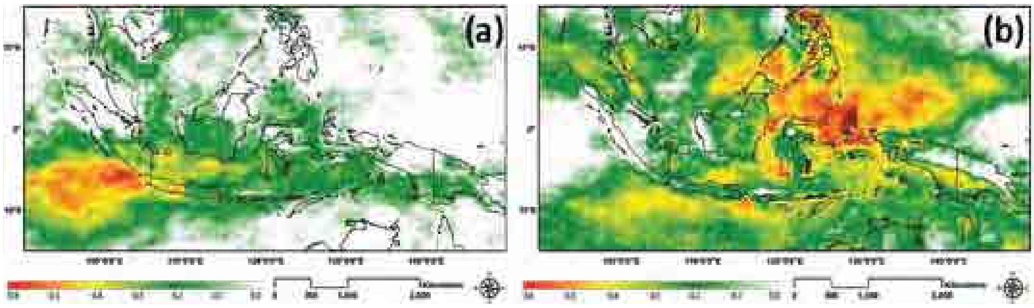


Figure 2.4 Map of dispersion of correlataion coefficient between time series of rainfall based on data from the Tropical Rainfall Measuring Mission (TRMM) satellie data with (a) Dipole Mode Index (DMI) and (b) index of ASPL NINO 3.4. The red colour shows a negative correlation value (the El Nino and Dipole Mode (+) is correlated with the decline of rainfall that is higher than the green colour

Figure 2.4(a) shows that the IOD has more influence to a portion of the Indonesian region around the Indian Ocean near the Sunda Strait up to the Java Sea. On the other hand, the affect of ENSO is broader in almost all regions of Indonesia with the exception of a small portion of Sumatra island near the eastern part of the Indian Ocean (Figure 2.4 [b]) In this case, the negative correlation in the map indicates that the occurrence of El Nino and DM (+) that is represented by a positive index value is correlated with the decline of rainfall in the region that it affects. It should be noted that rainfall in a portion of the region in the western coast of Sumatra is generally even does not show a significant correlation with ENSO nor IOD.

In order to know whether the decline of rainfall due to El Nino as well as DM (+) respresents drought or not, it is necessary to conduct a correlation analysis between the ENSO index value and DMI with the anomaly of rainfall in the form of standardized precipitation index (SPI). SPI is the simple index that was developed by McKee et al (1993) to describe the level of (local) drought in a certain region on the basis of the statistical distribution of rainfall that is observed in the region and over a sufficiently long period (over 30 years). To illustrate, Figure 2.5 shows the correlation between the index of NINO 3.4 and DMI with 6 monthly SPI in the regions of Malang in East Java.

The El Nino phenomenon is generally related to drought conditions in Indonesia's regions. For example, D'Arrigo et al. (2008) noted that out of the 37 El Nino occurrences since 1850, 21 are related to drought. Falcon et al. (2004) has in fact linked the Nino 3.4 index directly to paddy production. Nevertheless, it should be noted that the impact of El Nino to the climate condition in Indonesia depends on its strength/intensity. Figure 2.5 for example shows that the level of meteorological drought (significant fall in volume of seasonal rainfall) contain a degree of uncertainty if the NINO 3.4 index is less than 1.

It should also be noted from Figure 2.5 that even though La Nina in many ways brings impacts that are the opposite of El Nino, these are not too significant in terms of floods. The big floods that occur in Jakarta for example, do not occur in years when La Nina is forceful. Therefore, repetition of floods should be difficult to be associated directly (as having directly the impact of) the ENSO and IOD occurrences.

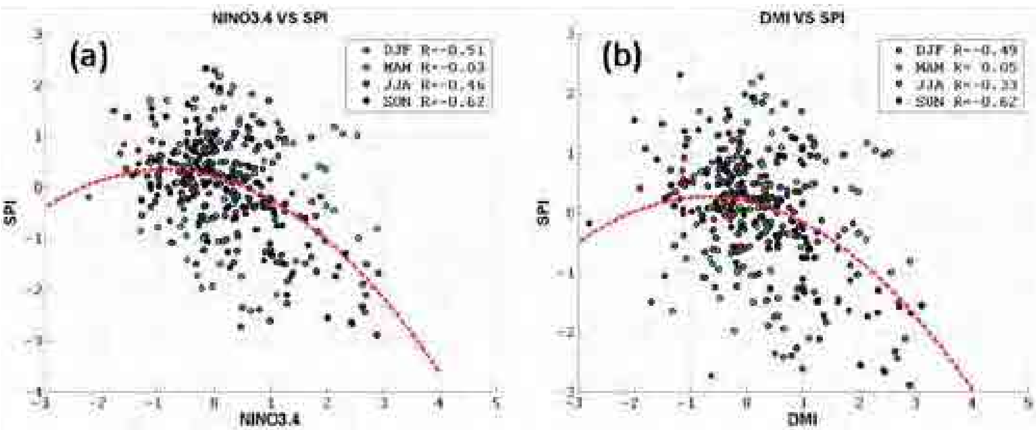


Figure 2.5 Correlation between the drought index SPL, that is estimated from rainfall data in the region of Malang in East Java, with (a) index ENSO (ASPL in NINO3.4) and (b) DMI. Index of ENSO that is positive(negative) signifies the occurrence of El Nino (La Nina), while a DMI that is positive (negative) signifies the occurrence of positive DMI and negative DMI. A value of the SPI that is increasingly negative indicates the levelof drought that is increasing. The data dots are marked by colours that differentiate seasonal periods, namely red for December-January-February (DJF), green for March-April-May (MAM), blue for June-July-August (JJA) and black for September-October-November (SON). The dotted red line is the quadratic curve from matching results

2.1.2.4 Inter-decadal Variations

Atmospheric phenomena with a 10-12 years oscillation period (ten-to-twelve oscillation; TTO) have already for some time been identified by researchers (e.g., Labitzke and Van Loon, 1995). Findings of rainfall data analyses in many locations have also often exhibited signals with similar period repetition, that are also correlated to black spots activities on the Sun (sunspots). On the other hand, the physics mechanism that explains the relation between sunspots and rainfall is still subject to much debate. Studies related to climate inter-decadal variation is currently much based on findings on the ASPL variations in the Pacific, that is known as the Pacific Interdecadal Oscillation (PDO; Mantua et al., 1997; Mantua dan Hare, 2002) or as the Interdecadal Pacific Oscillation (IPO; Folland et al., 1999; Power et al., 1999).

Teleconnection (link on the basis of statistical correlation) between rainfall in the monsoon region and the PDO that has also already been much studied (e.g., Krishnan dan Sugi, 2003), even though the physics mechanism that explain the relation between the two has not yet been much done for the regions in Indonesia, but the observation data of rainfall in various locations show that the existence of the anomaly wet and dry periods is quite significant in a inter decade time scale. Figure 2.6 shows data on rainfall in Lombok showing that the 1960s is a period with rainfall that is below average than in the last 30 years. The same is also recorded in the rainfall data that is observed in Tarakan, East Kalimantan (KLH, 2012c).

Nevertheless, the link between climate variation and extreme climate still need to be further carefully studied. To illustrate, as is the case with ENSO, the PDO can be subdivided into the cool phase and warm phase, with each occurring at around 10-20 years intervals. In the last one hundred years, the period around 1948-1976 is the cool phase, while the period of around 1980-1998 is considered as being in the warm phase of the PDO. It is known that the La Nina phenomenon occurs more in the cool phase of the PDO/IPO. Conversely, El Nino occurs more during the warm phase. Nevertheless, a negative anomaly of rainfall in the inter decade scale have in fact occurred during the cool phase of the PDO that at a glance seems as being contradictive under the assumption that La Nina creates more positive rainfall anomaly in Indonesia. Another note is that the occurrence of El Nino simultaneously with strong DM (positive) can occur during the cool phase as well as in the warm phase. The year of 1976/77 is a transition period of the PDO phase that is signified also by the occurrence of climate shift.

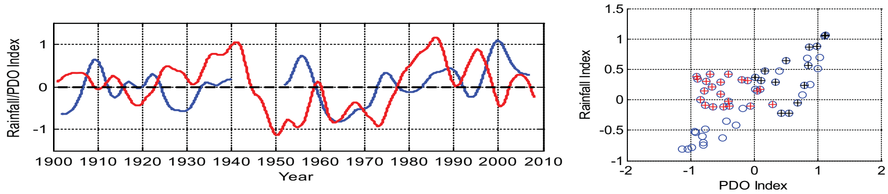


Figure 2.6 The graph of the PDO index and index of rainfall are respectively represented by red and blue lines (left) and a scatter plot (right) showing the correlation between the average annual rainfall and the PDO index that has ben shifted around 14 years backward. The mark (+) coloured red and black each indicates data of the 1973-1983 period and 1994-2007 period. The smoothing of data with the moving average method has beforehand been applied for showing the variation of inter decade scale (KLH, 2012b).

2.1.3 Maritime Climate and Sea Surface Level

As is the case with the weather and climate condition on land, the condition on sea waters in Indonesia is very much affected by the Asia-Australia monsoon circulation, even though with characteristics that may be very different. In contrast to the situation on land, the temperature of the sea surface is not much affected by sun radiation but is also affected by sea flow and vertical movements of sea water in terms of upwelling as well as downwelling. As shown in Figure 2.1 the Java Sea has a minimum value in September even though the air temperature is almost maximum.

Generally, the SPL (SST= Sea Surface Temperature) in Indonesian waters in January is above 28°C and in August the SPL/SST is lower than 27°C. The decline of the SPL around August is mainly due to the waters in the Indian Ocean south of Java and Sumatra islands undergoing *upwelling* (Susanto et al., 2001) as a result of the blowing of the easterly wind during the Australian Cold monsoon season. The easterly wind also cause the migration of colder sea water mass from the Indian Ocean to the Java Sea and to the Riau islands through the Banda Sea, so that the SPL tends to decline in those regions. On the other hand, around January the propogation of western winds and the migration of warm surface sea water from the Pacific Ocean making the SPL becoming higher.

The TML (Sea Surface Level) fluctuates daily due to the sea ebb-tide. In addition, the monsoon circulation also affects the seasonal TML in the waters of Indonesia. Generally, the TML rises in January and falls in August. The rise and fall of the TML is affected by the pattern of flows in the areas of Indonesia. During the cold Asian monsoon season, the *Indian Ocean South Equatorial Current* (IOSEC) moves to the west in the range of 10° – 20° SL and the mesoscale eddies in the South China Seas is not clearly visible. The existence of the strong surface flow in the South China Sea leads to the increase of the TML in the waters of western Kalimantan up to the eastern part of Vietnam.

The climate variation such as the ENSO and IOD affects the temperature as well as the surface level of the sea. Figure 2.6 (a) shows a correlation of the IOD index and the TML on the basis of the altimeter data ((AVISO, 2009) from 1993 to 2011. The IOD has a quite high impact to the TML characteristics in the Indian Ocean south of Java and west of Sumatra. Meanwhile, there is a low to medium correlation between the IOD and TML in the Pacific and in the *Indonesian Through Flow/* ITF, including the Java Sea, Makassar Strait, Banda Sea, Arafura, and Sulawesi Sea. The effect of the IOD to the TML characteristics in these regions is suspected to be more due the existence of the ITF that brings warm water mass to the IOD area in the Indian Ocean.

As is the case with rainfall, statistically the strong effect of the ENSO to the Areas in Indonesia can be seen from the spread of the correlation coefficient value between the index of the NINO 3.4 and the TML (Figure 2.6 (b). In this respect, ENSO can be said to affect almost the entire regions in Indonesia with the exception of the South China Sea, a portion of the Karimata Strait, and to the south of Papua. The highest influence of ENSO is in the Pacific Ocean and in the ITF Route in the Indonesian region and in part of the Indian Ocean to the south of Java, Nusa Tenggara, and western Sumatra. The high influence of ENSO in the Indian Ocean may also indicate that ENSO is more dominant in affecting the characteristics of the IOD rather than the converse.

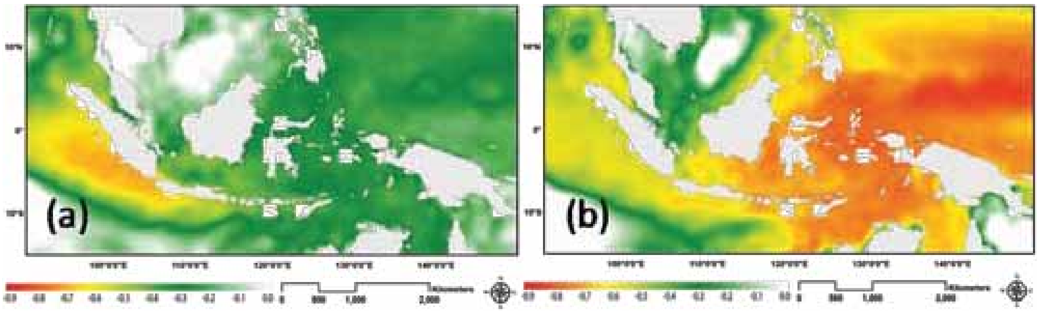


Figure 2.7 Similar analysis result with Figure 2.3, for Sea Level Surface (TML) with (a) DMI and (b) NINO index 3.4

A Bappenas report (2010b) states that at the time that El Nino occurs, the TML in Indonesia regions declined around 20 cm below normal and at the time that La Nina occurs it rose by 10-20 cm. According to Sofian et al. (2007), the increase of the TML in the transition period between El Nino and La Nina, and also under the La Nina condition is due to the strengthening of trade winds in the Pacific Ocean thereby bringing a water mass from the East Pacific around Peru to the Indonesia waters. This is characterized by the shift of warm water pool to the Westren Pacific area so that the TML in the Indonesian water become 1 meter higher than the TML around Peru.

The increase of the TML, momentarily and in a certain period, is due to the irregular occurrence of the weater and climate, such as tropical stroms and other weater disturbances A tropical storm that occur on the waters near the coastline can result in the high rise of the sea surface, that is known as the storm surge. Even the duration of a storm surge is relatively short it can cause a quite significant destruction in the coastline areas. Some of the coastline areas also experience momentary rise in sea surface height, that is known as a rob flood phenomena. To illustrate, the Hagibis storm that started forming on 21 November 2007 has already caused a rise in the sea surface of around 20 cm in the Jakarta Gulf at its peak on 26 November 2007 (yielded by the ADCIRC and SWAN couple model, Dietriec, et al, 2011, that has been verified through a *pasut* observation data). The time difference of lateness in responding to the sea surface is attributed to the duration of propagation (wave stress) from the location where the Hagibis storm in the South China Sea was formed and the reduction of wave energy due to the wind blowing from the southern direction.

2.2 Analysis of Climate Change in Indonesia Based on Observed Data

According to IPCC (2007), study on climate change and its impact can be done through bottom-up approach, based on observed data, as well as top-down approach, based on climate model simulation result. According Meehl et al. (2000), climate change occurs if there's a change on average value (mean) and/or climate parameter variation observed on one climate period (30 years, based on WMO operational definition) compared to previous climate period. Basically, a longer historical climate observation will provide better information on to what extend climate change has already occurred in a certain region.

2.2.1 Trend of Surface Temperature Change Trend

A general linier trend analysis is used for observing surface temperature changes, such as reported by the IPCC (2007). Nevertheless, an analysis of surface temperature change in Indonesia is specifically difficult to be made due to inadequate representative observed data (Manton et al., 2001; IPCC, 2007).

Table 2.2 Surface temperature change trends from various studies on climate in Indonesia

No.	Literature source	Linier trend	Period of data	Notes
1	Harger (1995)	1.35-1.64°C for 100 years	1949 - 1992	Observation data from 33 stations in Indonesia
2	KLH (2007)	0.047° C/year (minimum) and 0.017° C/year (maximum)	1980 - 2002	The trend analysis of maximum and minimum temperature for 33 stations (if estimated on average then the value is obtained of around 3.2 °C/100 year)
3	Bappenas (2010c)	0.5° C /100 years	20th century	Observation data in Jakarta and Ampenan (Lombok) which from the standpoint of length of data recording is deemed to be most representative
4	KLH	0.63° C /100 years in Malang (KLH, 2012a), 0.20° C /100 years in Tarakan (KLH, 2012c), -0.14° C /100 years in Palembang (KLH, 2012d)	20th century	Study made in regions of Malang, Tarakan, and palembang, on the basis of data of the University of Delaware and local observation in the 20th century (1910-2010); the trend value is generally positive for the last 25 years.

Table 2.2 presents a summary of information on the analysis results of temperature change trends that have been attempted to be made by several studies.

If it is assumed that the temperature increase in the last one hundred years is caused by global warming that is attributed to the increased concentration of GHG on the entire Earth, then the linear trend of temperature change should be not much different than what was yielded by the IPCC (2007), namely of around 0.56–0.92 °C/100 year. With its very extensive waters, the increase in surface temperature will be must absorbed by the deep sea and stored in the form of ocean heat content. Therefore, a smaller trend of temperature increase compared to the IPCC estimate is more reasonable. On this basis, it can be estimated that the affect of global warming to the surface temperature increase in Indonesia is not greater than 1.0 °C during the 20th century. It should once again be noted a more certain value will be rather difficult to obtain considering the inadequate consistent data recording for Indonesia.

Increasing trends that are higher than 1.0 °C have indeed been reported in various studies. The trend that is estimated from data of the last 25 years of the 20th century yields figure that are higher than the trend estimated 100 years data. To illustrate, the linear increase of temperature of around 2.36 ºC/100 years for the Malang region based on a trend analysis of data of the last 25 years.

If a projection is made on the basis of that trend, then it is estimated that by 2030 there will be an increase of 1 ºC in the Malang region. This value is higher than the trend obtained from data of the last 100 years that is only around 0.53 ºC/100 year (KLH, 2012a). This may indicate that there is an acceleration in global warming that is now occurring. But, it should be noted that the temperature change of the surface over a long period is also not independent from the influence of climate diversity with an inter-decade scale. Such trend can be seen in Figure 2.7 which shows an average temperature variation for the entire regions in Indonesia that is estimated from the CRU data, namely one of the global climate data base from the *University of East Anglia* that are often used as alternative for local observation data. In addition, the trend of local temperature change due to the heat island effect is also believed as being quite dominant in affecting data being observed in urban areas (Bappenas, 2010c).

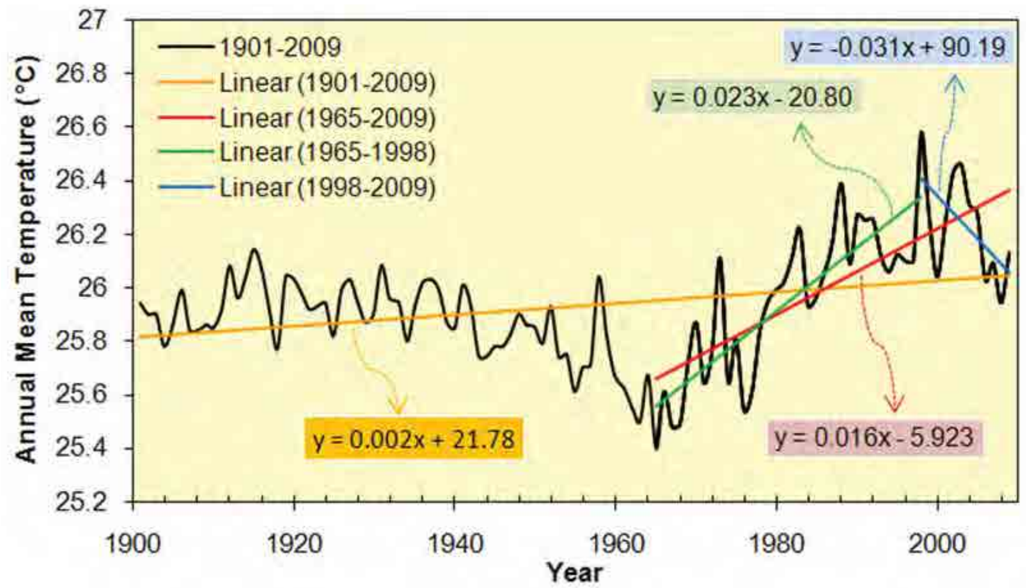


Figure 2.8 Trend of average annual temperature for land areas in Indonesia (6°NL - 11°08'SL and 95°'EL - 141°45'EL) on the basis of data from CRU TS3.1.

2.2.2 Trend of Rainfall Changes

Rainfall changes varies greatly to time and space so that the linier trend analysis does not provide significant information. This is in sharp contrast to the linier temperature increase that even though of only around 1°C, is quite comparable with the magnitude of seasonal changes of the monthly average temperature in tropical regions.

On the basis of the analysis on seasonal rainfall in Indonesia as contained in the report of the *Second National Communication* (KLH, 2010), the increase of rainfall for December-January-February (DJF) occurs in almost all of Java island and in the eastern part of Indonesia, such as Bali, NTB, and NTT. For the rainfall in June-July-August (JJA), a significant decreasing trend is seen in almost all of Indonesia, with the exception of Pandeglang (West Java), Makassar (South Sulawesi), Manokwari, Sorong (Papua), and Maluku (Figure 2.8).

Another study made by Bappenas (2010c), shows that the trend of rainfall changes is not only different between seasons but also for each month. Figure 2.9 shows the average value for every 30 years period of rainfall computed as a moving average for every 5 years from data of Jakarta stations. The diagram shows that the monthly increase in rainfall in the 1970s is more significant than in the 1900s, with an average 30 years value difference of around 100 mm. The changes from month to month vary and generally the rainfall in January-April is more sensitive to changes than in other months. Moreover, it also shows that the rainfall in January tends to fall again towards the 2000s, while the rainfall in February tends to increase. It can be concluded that at a certain level Jakarta is experiencing climate change from the standpoint from the change in the mean of the data of rainfall from one 30 years period to another 30 years period.

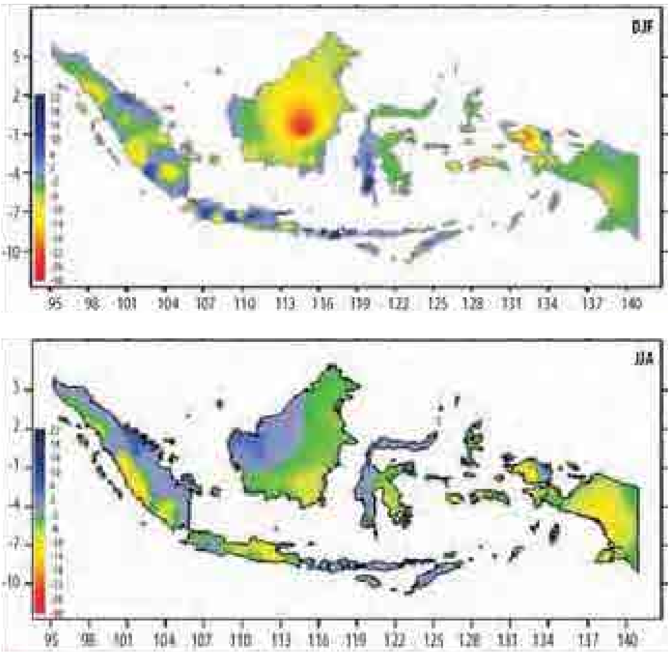


Figure 2.9 Trend of seasonal rainfall changes in the months of (a) DJF and (b) JJA in Indonesia (KLH, 2010).

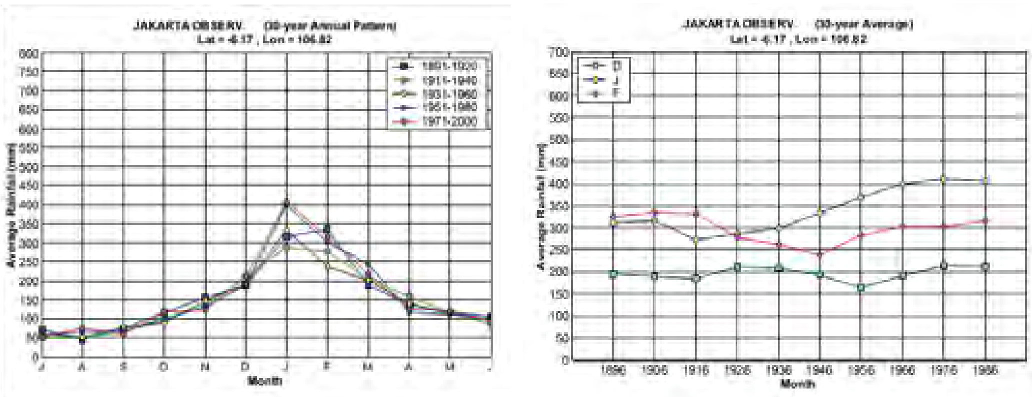
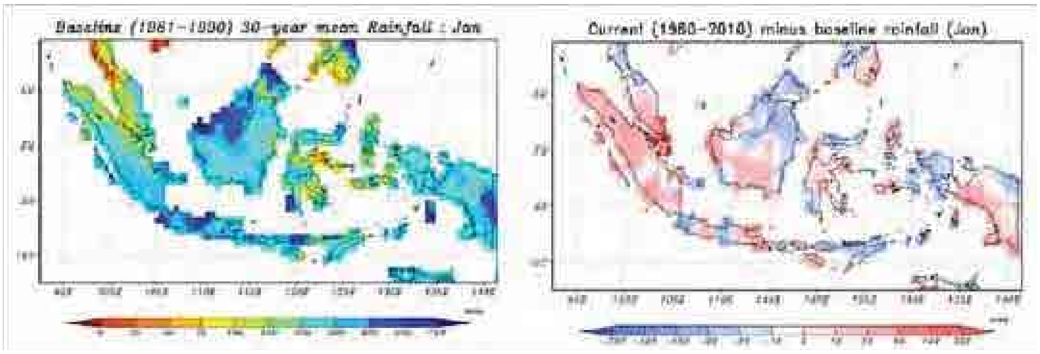


Figure 2.10 The change in the average value of rainfall of 30 years period for each month (a) in several periods and (b) graph of a moving average for the wet months of DJF (Bappenas, 2010c)

The trend of rainfall changes for each month also varies in spatial terms. Figure 2.8(b) and Figure 2.10(a) describes a quite varied pattern of rainfall changes for wet months (January is deemed as representing the wet months of DFJ). The changes in rainfall in almost all of Sumatra Island is depicted to have increased in Figure 2.8(b), while the decline and increase in rainfall have tended to be evenly distributed in Figure 2.10(a). Like Figure 2.8(b), Figure 2.10(a) also indicates that there is spatial variation in the rainfall changes pattern for the regions in Java-Bali, with the tendency of rainfall increases in West Java, East Java, and Bali and with a tendency to decline of rainfall in Banten and Central Java. The northern part of Sumatra island, the central to southern part of Papua Island experience a decline in rainfall is shown in the two diagrams. Nevertheless, there is difference in trend of rainfall changes for the areas in Kalimantan Island, central part of Sulawesi, Halmahera Island and the Nusatenggara Islands. Figure 2.8(b) shows an increasing trend for these areas, while Figure 2.10(a) shows the converse situation. It can be concluded that inspite of several differences, the two studies show a trend of rainfall change that spatially is very varied for Indonesia.

Figure 2.10 shows non uniform changes in the average value of rainfall for the areas in Indonesia in January of 1980-2010 compared to the baseline. In Sumatra Island, most of the regions experience an increase in average rainfall of 1050 mm. For other regions, there are regions for which the average rainfall increases but there are also regions for which the average rainfall has declined.



2.11 Rainfall trend analysis result on January from GPCC data: (a) average baseline 1961-1990 and (b) average difference period 1980 - 2010 (data until 2007) with baseline (Bappenas, 2010c)

In addition to looking at rainfall changes compared to the baseline period, Bappenas (2010a) has also conducted a polinomial extrapolation to look at rainfall trends that could occur until 2020. Table 2.3 compiles a projection of rainfall changes in Indonesia up to 2020. Temporally, the increasing trend of rainfall indicates that throughout Indonesia an increase occurs in the months of March to December, and for Sulawesi, Kalimantan, and Sumatra the rainfall in fact tends to increase in the period from December to April. Conversely, a declining trend of rainfall in the period of July-October is seen for some regions except Papua and Sumatra.

Table 2.3 Projected changes of average rainfall in Indonesia for the 2010-2020 periods (relative to 1980-2000) on the basis of the polynomial trend analysis of observed data (Bappenas, 2010a).

Region	Average Rainfall											
	Month (January to December)											
	J	F	M	A	M	J	J	A	S	O	N	D
Java-Bali	▼	▲	▲	▲	⊙	▲	⊙	⊙	▼	⊙	▼	▲
Sumatra	▲	▲	▲	▲	✦	⊙	▲	▲	▲	▲	✦	▲
Sulawesi	▲	▲	▲	▲	✦	▲	⊙	▼	✦	▼	✦	▲
Kalimantan	▲	▲	▲	▲	✦	⊙	▼	▼	▲	▼	✦	▲
Maluku	⊙	▲	▲	⊙	⊙	▲	▼	▼	⊙	▼	✦	▲
Nusa Tenggara	▼	▼	▲	⊙	⊙	⊙	⊙	⊙	▲	▼	⊙	▲
Papua	▲	▼	▲	▲	✦	▲	✦	▲	▲	⊙	▲	▲

Note:
▲ : most are increasing, ▼ : most are decreasing,
✦ : ▲ and ▼ evenly distributed, ⊙: most remain the same

2.2.3 Trend of Increases in Sea Surface Temperature (SST/SPL)

As explained previously,in addition to being affected by local warming, the SPL variation is more affected by the dynamic factors at the regional as well as global level. Nevertheless, the effect of global warming should also be reflected in the long-term trend of SLP change. Figure 2.12 shows the average SPL change of global, regional, tropical regions, and Indonesia waters in the period of 1854-2010, that is computed on the basis of data of the National Oceanic and Atmospheric Agency (NOAA) yielded from reconstruction (Smith dan Reynolds, 2004). The data shows that the trend of SPL increases is increasing through time since 1905 with an average increase of 0.7 °C/100 year. For Indonesia, the increasing trend is slightly higher than the global average as well as the tropical regions of around 0.8 °C/100 year or 1.5 °C/100 year if computed from 1945. Such increasing trend is still comparable with the trend increase of global temperature of 0.78 ± 0.18 °C (IPCC, 2007).

Figure 2.12 also shows that the SPL change also has a pattern with an almost 100 yearly cycle between 1860 and the 1960s. Such climate variation with such tendency is known to be linked to the phenomenon of the Atlantic Mutidecadal Oscillation (AMO). But after the 1960 such cycle has no clear repetion and the SPL has tended to continue to increase up to now. Several studies have identified that the 1976/77 period signifies a big change in the Pacific Ocean that is known as the climate shift (Miller et al., 1994). This change has affected the global trend of temperature change on the seas as well as on land, especially in the last 25-30 years period. The pattern of spatial trends in SPL changes in the West Pacific region and in Indonesia is shown in Figure 2.13 that is estimated by using data from the NOAA Optimum Interpolation (OI) with a resolution of 0.5° lat/lon (Reynolds et al., 2007) for the period of 1982-2011. The average increase of the SPL for the whole region in 30 years is 0.75°C.

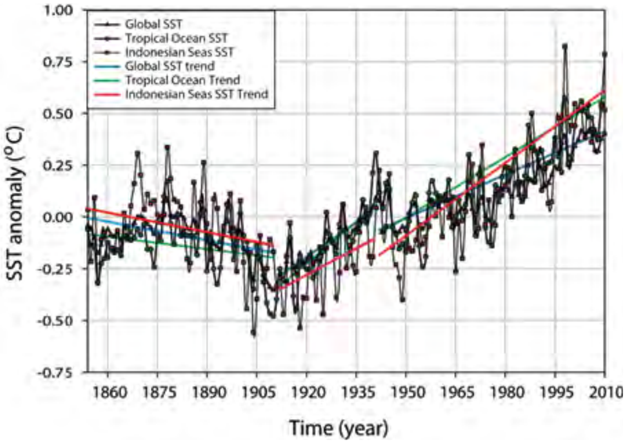


Figure 2.12 Time-series of SPL anomaly relative to the average SPL in 1901-2000 and its trend, globally (blue), tropical region (green), and Indonesian waters (red) that is estimated on the basis of the NOAA reconstructed data for the 1854-2010 period.

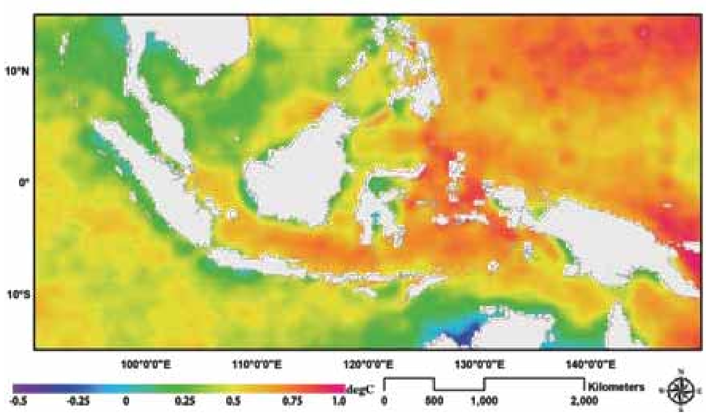


Figure 2.13 Linear trend of the increase of the SPL in 30 years from 1982 to 2011 that is estimated from data that is reconstructed from NOAA with a resolution of 0.5° lat/lon.

Generally, the SPL increase in the Pacific Ocean is higher than in the Indian Ocean. The SPL increase in the last 30 years as between -0.2°C and 1°C with the highest increase occurring on the Pacific Ocean to the north of Papua Island. While the lowest has occurred to the north of Australia. The increase of the SPL on Java Sea, Banda, Arafura, and on the most part of the eastern Indonesian waters is relatively high compared to the SPL increase in the South China Sea which is only 0-0.25 °C. The low increase of the SPL in the South China Sea may be caused by upwelling and fresh water flux from rivers and rain. Furthermore, the low increase of the SPL in the south of Java and Sumatra is more due to the intensity of upwelling on account of the high frequency of El Nino compared to La Nina from 1982 to the middle of 2000. While the increase of the SPL in the southern coastlines of Java in its eastern part, south of Bali, Lombok, and the islands of Nusa Tenggara is relatively high due to the transport of warm water from the Pacific Ocean through the Makassar Strait, Banda, and Timor.

2.2.4 Trends in the Increase of Sea Surface Level (SSL/TML)

The Sea Surface Level (SSL/TML) is significantly affected by climate change as well as by its variability. In the context of global warming, the increase in the SSL/TML is believed to have occurred due to two main mechanisms, namely thermal expansion which is attributed to the warming and expanding of the sea water volume, caused by the melting of glaciers and ice that cover the lands of the Antartica and Greenland (Cazenave and Llovel, 2010). There is also the modification of the hydrology cycle on land due the variation of climate and anthropogenic factors that also have an impact to the increase and decrease of water run-off leading to changes in the TML/SSL.

The trends of the SLR/TML in Indonesia has been studied on the basis of observed data from ebb-tide data as well a from altimeter data (Bappenas, 2010b). Figure 2.13 shows the dynamics of the TML/SSL from 1960 to 2010. From the characteristics of the SLR in Indonesia, a 30 to 50 yearly pattern can be discerned (1860–1910, 1910–1950, 1950–1990) or decadal variation, even though such viability is not clearly visible since 1990. If computed from 1960 to 2008, on the basis of the *Simple Ocean Data Assimilation* (SODA), then the SLR in Indonesia is 0.8 mm/year, that subsequently rose to 1.6 mm/year since 1960 and jumping to 7 mm/year since 1993.

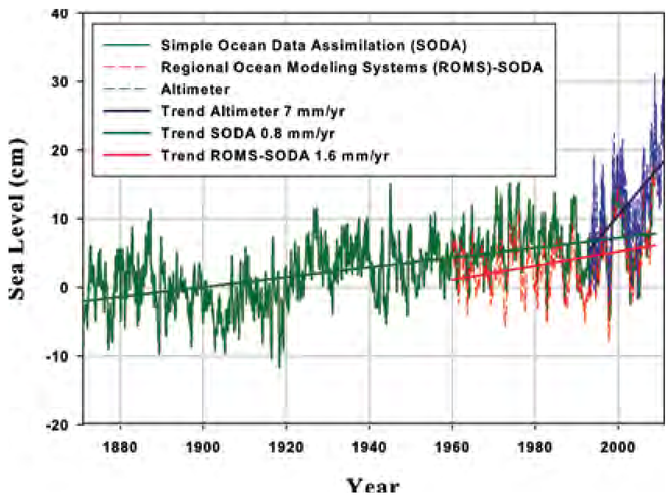


Figure 2.14 The variation in the average TML in Indonesian waters in 1860-2010 is estimated from data of SODA (full green line), ROMS-SODA (dotted red line), and altimeter (broken blue line). In addition, the diagram also shows a linier trend line that is estimated for each of those data.

The spatial pattern of the SLR in Indonesia is shown in Figure 2.15. that is estimated on the basis of altimeter data. Figure 2.15(a) shows that the highest SLR has occurred to the north of of Papua Island, Java Sea, Banda Sea, Indian Ocean and the majorpart of the waters of Indonesia to the east, with the highest SLR reaching 2.5 cm/year. In addition, Figure 2.15(b) shows that the TML has significantly increased in 2005-2011 relatively to the SLR in 1993-2004.

Generally, the altimeter data shows that the highest TML/SLR occurred in the western part of the Pacific Ocean of around 12 cm, while the smallest increase occurred in the Indian Ocean to the south of Java Island and Sumatra, South China Sea, and north of Sumatra. Generally, the difference in the TML/SLR increase between the Pacific Ocean and the Indian Ocean can result in a geostrofic flow from the Pacific Ocean to the Indian Ocean. It can also lead to an SPL change of a regional level, due to the increase in the intensity of warm water transport from the Pacific Ocean to the Indian Ocean, that can trigger changes in the pattern of local rainfall throughout Indonesia.

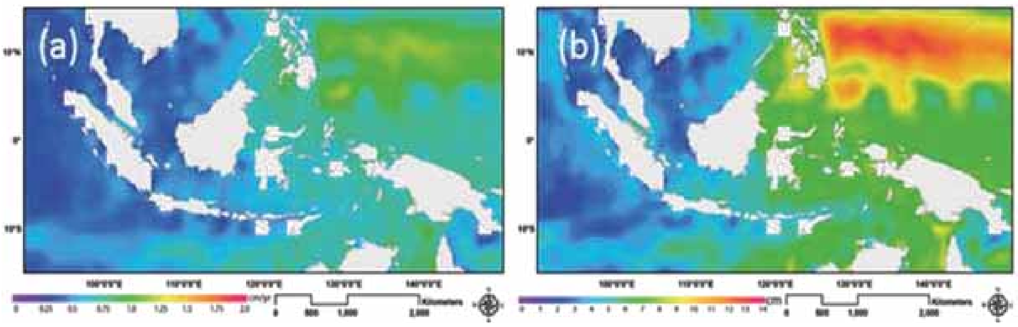


Figure 2.15 Spatial pattern of the SLR in the Indonesia waters that is indicated by: (a) trend of the increase of TML/SLR in the 1993-2011 period, and (b) difference of average TML/SLR in the 2005-2011 period relative to the average TML/SLR in the period of 1993-2005.

It should also be noted that the SLR estimation by using the ebb-tide data and altimeter needs to be carefully distinguished. The use ebb-tide data is needed for seeing the isostatic SLR, namely the local SLR value that is based on the highest change of the benchmark on land due to changes in the level of ground surface (*subsiden* atau *uplift*) in terms of the average TML/SLR. This data is needed compared to the pure eustatic SLR because of thermal expansion and addition of water mass due to ice melting that is measured by satellite altimeter.

To illustrate, a difference has been discerned in the value of the SLR in Jakarta since 2004, namely of 5.4 cm/year and 1.3 cm/year based on ebb-tide and altimeter, even though each of the measurement data do not differ significantly in the 1991-2003 period of around 0.52-0.56 cm/year. Such SLR difference has been confirmed by several studies such as Djaja et al. Abidin et al. (2004), Bayuaji et al. (2010) that use instrument of the *Global Positioning System* (GPS) and the *Synthetic Aperture Radar* (SAR). *Isostatic* SLR or *subsiden* could be caused by the increase in load of buildings and by taking of ground water, and by intrusion of sea water.

2.2.5 Trend of Occurrences of Extreme Weather and Climate

The occurrence of extreme weather and climate is an intrinsic part for kaotik climate system. The occurrence of extreme weather and climate is an intrinsic part for *kaotik* climate system. Nevertheless, the climate change that is currently occurring is believed to have the potential of increasing the frequency of extreme occurrences in various parts of the world. IPCC (2012) has issued a special report on a study finding on extreme occurrences (SREX) as guidance in the planning of adaptation to climate change. In that report extreme weather and climate occurrence itself is defined by the IPCC as follows :

The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.

In short, the occurrence of extreme weather and climate is merely referred to as “extreme occurrence”. Thus the definition of extreme occurrence depends on the threshold value that has been determined from statistical observed data and may be relative to the place, time, and purpose.

Figure 2.15 shows the trend of changes in probability of extreme daily rainfall on the basis of the *cumulative distribution function* (CDF) analysis from the TRMM satellite data. Figure 2.15(a) shows a threshold value for the highest rainfall with a probability of occurrence of 1 percent on the basis of 1998-2008 data. Figure 2.15(b) shows the probability distribution of rainfall occurrences with such threshold value in 2003-2008 relative to the probability in 1998-2002. This outcome indicates that there is a probability of extreme daily rainfall in some parts of Indonesia, with the exception several areas in Maluku, within a period of around ten years in 1998-2008.

The trend analysis on probability of extreme rainfall changes based on satellite data of TRMM provided sufficient description on the increasec probability of extreme occurrences, even though for climate change analysis, the length of the data is not yet adequate. Thereby, it is also necessary to have a trend analysis of changes in extreme values on the basis of monthly rainfall data. In Bappenas (2010a), the analysis and projection of extreme values are based on changes in the variance of monthly rainfall Table 2.4; also see the explanation for Table 2.3). In this case, the increase in the variance value (the widening probability distribution) indicates an increase in extreme occurrences (low as well as high) of monthly rainfall. It can be seen that on average the variance value of monthly rainfall does not show an increasing trend in the 2010-2020 period with the exception of the months of January-April. In addition to being used for looking at trends of extreme occurrences, the variance value (standard deviation) that is higher can also be interpreted as indicator for higher uncertainty. Thereby, the tendecy for the increased standard deviation value in such months of January-April can also indicate a trend of higher climate uncertainty.

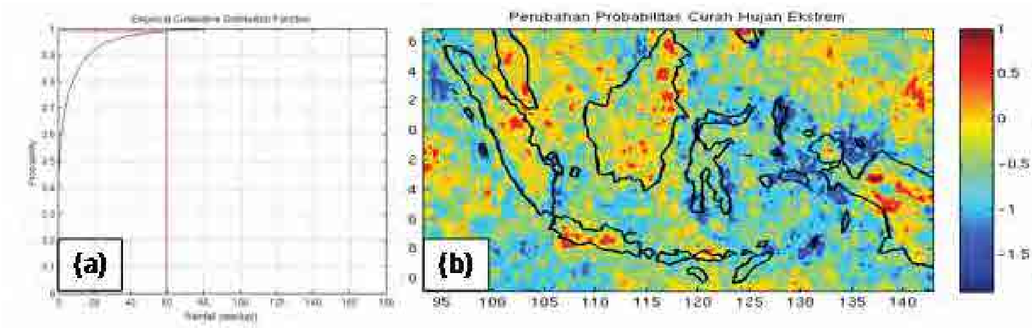


Figure 2.16 (a) The cumulative distribution function (CDF) with a threshold value for the highest 1 percent probability of rainfal on the basis of TRMM satellite data for the period of 1998-2008, (b) The probability distribution of extreme daily rainfall in the TRMM data for 2003-2008 is relative to the probability in 1998-2002.

The definition of extreme occurrences from rainfall data normally uses percentile values, such as the P85, P90, and P95. For example, P95 means a value that is in the most upper 5 percent of a distribution of rainfall in a data sample observed in a certain region. A study on probability of daily rainfall of above P90, P95, and P98 (extreme rainfall) that are linked to monthly rainfall classes has been conducted in Malang (KLH, 2012a; see 2.3.5). On the basis of that study it is known that the largest probability (greater than 10 percent) of extreme occurrences emerging is related to a monthly rainfall class of 250-450 mm. It can be concluded that extreme monthly rainfall is not always correlated with extreme daily rainfall. The fact is that extreme daily rainfall has a very high correlation with a 'moderate' monthly rainfall that is related to a transition season. In addition, such monthly rainfall can also be linked to more frequent 'breaks' in such months as January-April which are generally in the active monsoon season in the larger part of the Indonesia's regions. An increased frequency of the 'breaks' indicates higher seasonal uncertainty.

Table 2.4 Projected change of standard deviation of monthly rainfall in Indonesia's regions for the period of 2010-2020 (relative to 1980-2000) based on polynomial trend analysis of observed data (Bappenas, 2010a).

Region	Standard Deviation											
	Month (January to December)											
	J	F	M	A	M	J	J	A	S	O	N	D
Java-Bali	✸	✪ (red)	✪ (blue)	⊙	⊙	⊙	⊙	⊙	⊙	✪ (red)	⊙	⊙
Sumatra	✸	✸	✪ (red)	✪ (red)	⊙	⊙	⊙	✪ (red)	⊙	✪ (red)	✪ (red)	✪ (red)
Sulawesi	✸	✪ (red)	✪ (red)	⊙	✪ (red)	⊙	⊙	✪ (blue)	✪ (blue)	✪ (red)	⊙	⊙
Kalimantan	✪ (red)	✪ (red)	✪ (red)	✪ (red)	⊙	⊙	⊙	✪ (blue)	⊙	✪ (red)	⊙	⊙
Maluku	✪ (red)	✪ (red)	✪ (blue)	✪ (blue)	⊙	✪ (red)	⊙	⊙	⊙	⊙	⊙	⊙
Nusa Tenggara	✪ (red)	✪ (red)	✪ (red)	⊙	⊙	⊙	⊙	⊙	⊙	⊙	✸	⊙
Papua	✪ (red)	✪ (blue)	✪ (blue)	✪ (blue)	⊙	⊙	✪ (red)	✪ (red)	⊙	⊙	⊙	⊙

Note:
✸ : most are increasing (standard deviation), ✪ (red): most of the regions increasing,
✪ (blue): most of the regions decreasing, ⊙: no change or changes are insignificant

2.3 Climate Change Projection Based on AR4-IPCC Models

Climate projection can be understood as an effort to obtain a description on the climate response system to changes of radiative forcing, especially due to increased concentration of GHG and aerosol in the atmosphere up to a period far ahead into the future. Results of simulations using various global climate models have been used to analyze of the climate projection of up to 2100 by the IPCC (2007). Results of the climate projection very much depend on the scenario of increased GHG concentration in the atmosphere that is based on assumptions on the global social and economic conditions and the main technology supporting it. The scenario used in the AR4-IPCC is based on the Special Report on Emission Scenarios (SRES).

Even though the SRES contains many scenarios, there are only three scenarions, namely B1, A1B, and A2, that are most frequently used in various studies on climate change risks. The three scenarios respectively represent a GHG emission/concentration that is low (stablization at 550 ppm), medium (stabilization at 750 ppm), and high (without stablization) in 2100. The current global social and economic development indicates that scenario B1 cannot possibly be attained so that the analysis of climate projection should be focussed on scenario A1B and/or A2 only.

The following provides a discussion on results of several national as well as regional/local studies on projection on increase in surface temperature and rainfall change, In many ways, AR4-IPCC models cannot yet represent national nor regional/local climate conditions, especially in tropical regions. In order to be able to represent the regional/local climate condition in Indonesia, a downscaling method is applied to output of the AR4-IPCC models. In addition, the ensemble technique, namely the equalization of outputs of several models is implemented for consolidating the projection output that are quite different from each other (e.g., Bappenas, 2010c).

2.3.1 Projected Increase in Surface Temperature

The projected increase in surface temperature on the basis of AR4-IPCC models show a linear trend with an almost uniform rate of increase for the three B1, A1B, and A2 scenarios towards 2030. For example, Figure 2.17 shows the projection of average increase of temperature for the region of Malang in East Java. This trend is generally the same as for all regions in Indonesia because the AR4-IPCC models assume that the temperature increase is dominantly attributed by the GHG effect that is spread evenly throughout the atmosphere. Thereby, the projected increase in surface temperature throughout Indonesia due to GHG in the 2020-2050 period relative to the last climate period in the 20th century is around 0.8-1ºC (Bappenas, 2010c). As discussed previously, the pattern of seasonal changes is significantly affected by the artificial position of the sun so that the difference of monthly temperature in one year remains to be around 0-2 ºC.

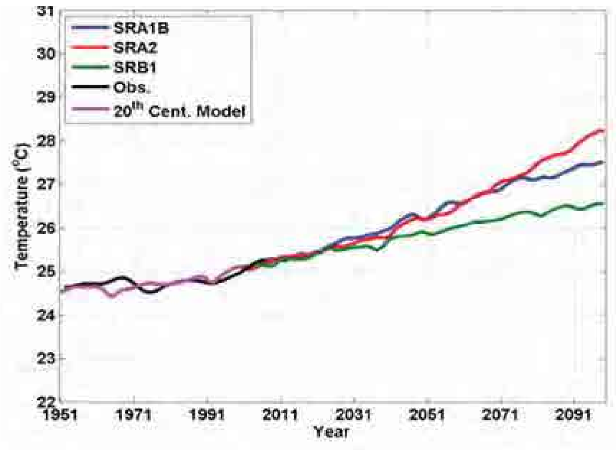


Figure 2.17 Projected average surface temperature for the region of Malang in East Java on the basis of output of the AR4-IPCC models after going through the downscaling process and through the ensemble equalization process. It also shows the historical data since 1951 to 2010 and results of the GCM model simulation for the 20th century for the three SRES scenarios of B1, A1B, and A2. The monthly time series data has been smoothed in order to yield a long term trend (KLH, 2012a).

2.3.2 Projected Rainfall Change

Outputs of the AR4-IPCC models generally show a more varied pattern of change of rainfall in Indonesia, in temporal as well as spatially. Even though the analysis of historical data and extrapolations up to 2020 have shown that there a quite significant trend of rainfall change, a projection on the basis of the seven GCM on average does not show that there is a significant change for the period of 2020-2050 (Bappenas, 2010c). This indicates that up to 2020-2050, natural climate variability is still functional compared the GHG effects in determining rainfall changes. Nevertheless, the rainfall changes towards 2050 need to be studied in greater detail.

Table 2.5 Summary of studies related to rainfall projection in Indonesia

No	Source Book	Main Conclusion	Projected Period	Notes
1	Naylor et al. (2007)	Quite large rainfall in the dry season (Juky-August-September;JAS)	2050	Output of model AR4-IPCC with scenario A2 and B1; regional scale analysis with *empirical downscaling*; projection results relative to observations in 1979-2004
2	Li et al. (2007)	Decine of rainfall in the dry seasonn (JAS)	2050-2099 (and 2101-30)	Output of the AR4-IPCC standard model under scanario A1B using 11 models (and 3 models); projection results are relative to CMAP data of 1979-1999 (and 1970-99)
3	KLH (2010)	Increase of rainfall in December-January-February (DJF), with the exception of norther parts of Sumatra and Kalimantan; reduction of rainfall in June-July-August (JIA), specifically in West Java and South Sumatra	2050 and 2080	Consolidation of output of 14 models of AR4=IPCC under scenarion A2 and B1 (*Second National Communication*)
4	Bappenas (2010c)	Significant change especially during the 2080s with the tendency of increased rainfall in the wet months and the reduction of rainfall in the transition months.	2001-2100 with *time-slice* 2020-50 and 2070-2100 analysis	Output of AR4-IPCC model under scenario A1B, A2, and B1 with emphasis on scenario A2; using the *selective ensemble averaging* method to 7 models (taking the average of the best 4); projection output is relative to observations in 1961-1990
5	KLH (2012a, 2012c, 2012d)	Generally the change in average rainfall up to 2030 is not too significant; in Malang there is an indication of a declining rainfall after the 2030d, consistnt with Naylor (2007)	2001-2100	Output of AR4-IPCC model under scenarios A1B, A2, and B1; local/regional analysis from several *statistical downscaling* methods.

To supplement the above, Table 2.5 presents a summary of results of various studies related to rainfall projections in Indonesia. The report of the *Second National Communication* (SNC; KLH, 2010) shows tendencies of 14 GCM models to changes of seasonal rainfall in Indonesia on the basis of two emission scenarios, namely the SRES A2 and B1 for the 2025 and 2050 period. In terms of the “agreement” among climate models, there are among others a tendency for the decline of rainfall in the dry season of June-July-August (JJA), a transition of September-October-November (SON) in Java Island and Island of Nusa Tenggara, and the increase of rainfall in the wet season of December-January-February (DJF).

This trend seems to run counter to projection results for most of the regions in other islands. While, the projection of rainfall in the region of Malang (KLH, 2012a) also shows a trend of declining rainfall in the JJA months, that indicate a strengthening of of the Australian monsoon. This result is consistent with projection studies of Naylor et al. (2007) stating that by 2050 the rainy season on Java island will experience delays of up to 30 days.

2.3.3 Projected Increase of Sea Surface Temperature and of Sea Surface Level

The projected SPL (Sea Surface Level) shows that the average increase is 1-1.2 °C by 2050 relative to 2000 (Bappenas, 2010b) . This trend of increase is still within the range of the global temperature increase, so that it is still consistent with results yielded by the AR4-IPCC models for surface temperature. Nevertheless, as mentioned previously, the effect of global climate variability to the SPL variation in Indonesia is very significant. To illustrate, the El Nino and DM (+) in 1997/98 has resulted in large changes in the environment of Indonesia's waters that had led to the degradation of corral reefs in various regions.

The sea level rise (SLR) can significantly threaten large and small islands in Indonesia. By 2050, the SLR due to global warming is projected to reach 35-40 cm relative to the situation in 2000. On this basis, the maximum SLR in Indonesia can reach 175 cm by 2100 (Bappenas, 2010b). On the basis of these results and by taking into account climate variability, a summary of SLR projection in Indonesia is shown in Table 2.6.

This trend may not be linear but can be exponential if dynamic ice melting is taken into account. Figure 2.18 shows results of estimates on the average increase of the SLR for Indonesia's waters if taking into account the ice melting factor. On the basis of this result, the maximum SLR in Indonesia can reach 175 cm by 2011 (Bappenas, 2010b).

Table 2.6 Projected average increase of the TML without addition of dynamic ice melting in Indonesia's waters (Bappenas, 2010b)

Periode	SLR Projection	Level of Confidence
2030	22.5±1.5cm	Medium
2050	37.5±2.5cm	Medium
2080	60.0±4.0cm	High
2100	80.0±5.0cm	High

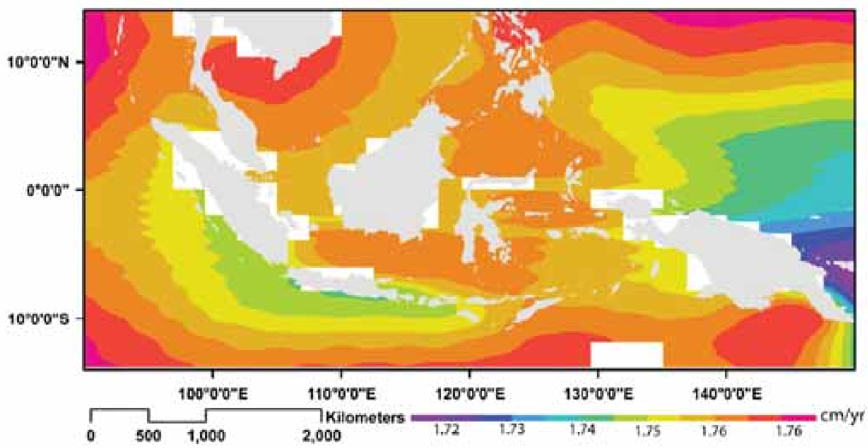


Figure 2.18 Estimate on rate of increase of the TML (Sea Surface Level) in Indonesia on the basis of models with addition of dynamic ice melting (Bappenas, 2010b)

2.3.4 Projected Occurrence of Extreme Weather and Climate

In addition to the SLR, information on projected occurrence of extreme weather and climate (extreme occurrences) is actually very important for formulating the adaptation plan. On the other hand, it is not easy to make a projection on extreme occurrences because it requires more detailed data and time. The IPCC itself has issued a special report on extreme occurrences (SREX) only recently (in 2012) eventhough the data used are still based on AR4 models and scenarios that were issued around 2007. Therefore, it is understandable that comprehensive studies on extreme occurrences in Indonesia are still very limited.

For climate occurrences, one of the endeavors is through the analysis of ENSO and IOD occurrences as proxy to extreme occurrences. As referred to previously, the threat that emerge from the ENSO/IOD occurrences, originate from at least two sources:

Intensity of occurrence, that if exceeding a certain threshold will affect all of Indonesia. For example, the combination of the occurrences of El Nino – DM(+) and La Nina – DM(-) each tending to lead to extreme conditions of drought and floods in all seasons. The consecutive occurrences of El Nino with a medium intensity, the more so if a strong intensity, also has the potential to bring about the threat of drought.

The transition from the period of El Nino to La Nina and/or DM (+) or the reverse, is suspected to be able to increase uncertainty of seasonal rainfall and the probability of extreme rainfall occurrences.

Analysis of ENSO projection have among others been conducted on the basis of outputs of the MRI-CGCM model, the results of which indicate the existence of increased ENSO frequency that usually occurs once in every 3-7 years to become once in every 2 years (Bappenas, 2010c). Nevertheless, it should be noted that various estimates related to the ENSO index variance in the future show an inconsistency between the GCM, especially with regard to its intensity (IPCC, 2007;2012). Thereby, results of extreme occurrences projections on the basis of analysis of ENSO/IOD projections and its impact on the probability of extreme occurrences in Indonesia are still limited and require further research. Studies on changes in probabilities of extreme occurrences in Indonesia have been more focused on extreme rainfall occurrences. The extreme occurrences that are related to temperature changes, such as heat wave, have not shown siginicant trends, in terms of historical data (e.g., Manton et al., 2001) nor from GCM outputs, at least up to 2050.

In spite of being constraint by data availability, the endeavors to project extreme daily rainfall have been conducted for more regional/local scope on the basis of projections of monthly rainfall. On the basis of the pattern of linkages between monthly rainfall and extreme daily rainfall (90^{th} percentile) in Malang, for example, it can be shown that there is a trend of increasing extreme rainfall in this regions of around 7 percent in the decades of 2010-2030 relative to the decade of 2001-2010 (Figure 2.18). Eventhough there are still quite big differences between results from observations and projected values, these endeavors have at least provided a description on the probability of increased occurrences of extreme weather in the studies areas in the 2020s.

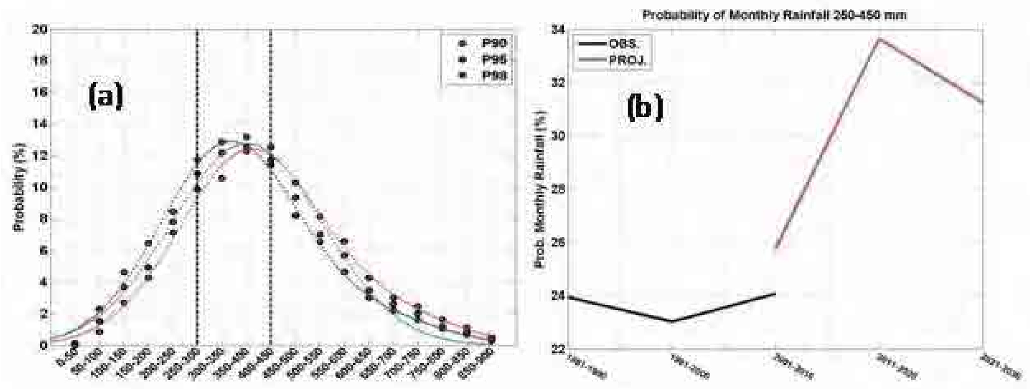


Figure 2.19 Analysis results of extreme occurrences for the region of Malang in East Java: (a) relation between the probability of extreme daily rainfall and monthly rainfall, (b) analysis of projection of probability of monthly rainfall and the value that indicates daily extreme rainfall (250-450 mm; KLH, 2012a).

In the future, various climate projection studies need to be renewed in line with endeavors of the IPCC which is in the process of preparing its *5th Assessment Report*, AR5. The AR5 will stress the importance of decadal and inter-decadal climate variation predictions, through near term scenarios that limits the projection up to 2035 as well as long-term scenarios that cover the period up to 2100 and in fact up to 2300. In the short-term scenario, the AR5 models have renewed the effect of carbon cycle so that these are more realistic. The long-term projection can use the new scenario of the *Representative Concentration Pathways* (RCP) (Moss et al., 2008, 2010) that makes possible a parallel process between the climate model and the *integrated assessment models* (IAMs) in affecting the projection results.

2.4 Analysis of the Potential Impacts of Climate Change

Climate change is known to have a wide impact in various sectors. Several studies have shown the impact of climate change that is related certain important sectors, such as agriculture, forestry, fisheries, coastal areas and small islands, water resources, health,renewable energy, spatial planning, housing and infrastructure, and the reduction of natural disaster risks. Such impacts have a cross-sectoral nature, so that the implementation of adaptation to climate change requires understanding of the concept and comprehensive cooperation among the related sectors. Such impact of climate change is presented in the following Table 2.7, which is a summary of the compilation of results of analyses of climate change and the potential impact. The regions in Indonesia that face the risks of climate change hazards are shown in those tables, in which the ICCSR (Bappenas, 2010) can become a reference of mapping such risks of climate change.

Table 2.7 Summary of climate change impact to related sectors

Climate Change Indicators	Potential Hazards of Climate Change	Map of risk areas	Sectors Affected By Impact										
			Economic		Livelihood			Environment			Special Areas		
			AGR	ENE	HEA	HOU	INF	ECO	FOR	WAT	CSI	URB	DIS
Surface Temperature	Increased evapotranspiration that can lead to drought		v	v					v	v		v	v
	Expanded vector insects population spread					v	v		v			v	v
	Increased spread of diseases through the air medium				v	v							
	Change in pattern of population spread and migration of plant diseases		v										
	Increased surface temperature of 1°C that can reduce agricultural production by 0.6 ton/ha (IRRI [2007] in Bappenas [2010])		v										
Rainfall (CH)	Drought caused by a deficit in total precipitation		v	v					v	v		v	v
	Reduced availability of water (PKA) due to deficit in precipitation					v	v		v			v	v
	Floods from increased total, duration, and intensity of rain		v	v	v					v			v
	Landslides		v		v	v	v		v	v		v	v
	Decline of agricultural production due to increased temperature and change in ranfall		v			v	v			v			v
	Increased mosquito population due to many water inundations		v			v							
	Greater spread of diseases through the air medium and water inundations				v	v							
Sea Surface Temperature (SPL)	Change in pattern of fish migration due to change in circulation of sea flow on account of SPL increase distribution				v	v							
	Corral bleaching due to increased SPL and acidity of sea water		v					v			v		

Climate Change Indicators	Potential Hazards of Climate Change	Map of risk areas	Sectors Affected By Impact										
			Economic		Livelihood			Environment			Special Areas		
			AGR	ENE	HEA	HOU	INF	ECO	FOR	WAT	CSI	URB	DIS
Sea Surface Level (TML)	Broadening of sea water inundations in coatal areas that can push back the coastlines		v					v			v		
	Broadening of sea water intrusion areas through ground water and rivers		v			v	v				v		
Extreme climate occurrence ENSO IOD/DMI PIO/IPO	Consecutive drought years						v			v	v		
	Change/shift in seasonal rainfall pattern		v	v					v	v		v	v
	Triggered increase of probability of heavy rain, strong winds, storms and wave storms		v							v			
EDxtreme weather occurrence Heavy rain Storm Strong winds Storm wavesi	Increased frequency and intensity of erosion and abbrasion (due to change parallel flows and straight coastline resulting in changes to the coastlines		v					v			v		
	Increased probability of rob floods due to storms and wave storms		v					v			v		
	Destruction of infrastructure due to increased occurrence of extreme weather		v		v	v	v		v	v		v	v

Note : AGR: Food Security; ENE: Energy Security; HEA: Health; HOU:Housing; INF: Infrastructure; ECO: Ecosystem and Biodiversity; FOR:Forestry; WAT: Water Resourcesr; CSI:Coastal Areas and Small Islands; URB:Urban; DIS: Disaster Risk Reduction

Chapter 3: Purpose and Objectives of the RAN-API

3.1 Purpose of the RAN API

The impact of climate change as described in the preceding chapter makes us become aware of the threat of climate change to the social and economic life of a community. This underlines the importance of national policies in anticipating the threat of climate change. Systematic and integrated endeavors with a sound strategy, and a joint commitment and responsibility of all stakeholders are essential in anticipating the impact of climate change in the national and regional development agendas. Considerations on risks and impacts of climate change need to be translated into the national adaptation action plan and strategy, the medium term development plan, policies and regulations, and in the institutional structure. The RAN-API is one of the efforts for responding to the above problem and as a reflection of the preparedness of sectors in responding to and in anticipating the threat of climate change through programs that are based on projections of future developments.

Adaptation endeavors refer to adjustments to the ecological, social, and economic systems, in responding to the impact of climate change that have occurred or that are anticipated to occur. This is based on the process, practice, and structure (of the endeavors) to reduce the potential losses and to take advantage of changes that occur due to climate change. Basically, adaptation to respond to climate change has often been linked to reduction of vulnerability. The level of vulnerability of a system to the impact of climate change is determined by three factors, namely the level of exposure, level of sensitivity, and adaptive capacity. The level of exposure indicates the degree, duration, or probability of a system to shocks or disturbances (Adger 2006 and Kasperson et al. 2005 in Gallopin 2006). The level of exposure is an internal condition that is very much influenced by the condition of man and its evironment. The condition of man can be discerned from the level of its social situation and of the man himself such as the population, institutions, economic structure, and so forth. While the environmental condition is an unification of the biophysical and natural condition, such as soil, water, climate, minerals and the structure and functions of the ecosystem. The condition of man and his environment determine the adaptive capacity of a system and is also very much influenced by the diversity of the climate. Adaptive capacity indicates the capability of a system to make adjustments to climate change so that the potential of negative impacts can be reduced and positive impacts can be maximized, in short the capacity to resolve consequences of climate change (*to cope with the consequences;* IPCC 2007). Thus adaptation efforts to climate change can be defined as endeavors to enhance resiliency of a system to the impact of climate change.

Resilience refers to the capacity of the social and ecological systems to absorp disruptions while the system remains capable to maintain its structure and functions (Hollings, 1973). The endeavors to develop resilience of the system are focused on the capacity to absorb distruptions and maintaing the functions of the system. In addition, efforts to develop the resilience of the system, comprise the capacity to innovate, restructure, and develop type system (Berke et al., 2003). In a resilient system, disturbances to the system can be absorbed and can become a potential that can be utilized for making innovations and for developing the system (Adger, 2006). Understanding of this will provide a basis on how to direct and allocate resources and to develop the capacity at the local, regional, and national levels.

In line with its objective, adaptation is "endeavors to adjust through strategies, policies, management, technology, and stance to minimize the (negative) impact of climate change, and if possible to utilize and maximize its positive impacts". Adaptation can also be interpreted as endeavors or actions, directly as well as indirectly, continuously as well as discontinuously, and permanently, to reduce impacts of climate change. Adapation can also be defined as endeavors to enhance resilience and/or reduce vulnerability of a natural system, livelihood, programs and activities, against the impact of climate change.

Each of the sectors already have their respective concrete development directions and targets, that are contained in the National Medium-term Development Plan (RPJMN), Strategic Plans (Renstra) of Line Ministries/Government Agencies, as well as in the Annual Government Work Plan (RKP) that are supported by analyses of their probable successes and failures. One of the threat is the variability and climate change. Thereby, in the context of the rationale/interest of national development in relation to the National Medium-Term Development Plan (RPJMN), Line Ministry/Government Agency Strategic Plan (Renstra) and Annual Government Work Plan (RKP), adaptation to climate change has the function of "rescuing and securing" realization of all development targets without being significantly affected by climate change.

In relation to the above, the main objective of the RAN-API is the implementation of a development system that is sustainable and is resilient to the impact of climate change. Thus, RAN-API is directed at (i) developing economic resilience, (ii) developing a livelihood resilient to the impact of climate change, (iii) maintaining sustainability of environmental services of the ecosystem. It is also realized that the impact of climate change can occur in certain regions, as shown in the preceding chapter, so that this require special attention of all of us, thereby requiring the strengthening of resiliency of special regions, such as urban areas, coastal areas, and small islands. Finally, in order to support the various strengthening in those sectors, it is necessary to have a supporting system for strengthening national resilience towards a development system that is sustainable and is resilient to climate change.

Programs and activities on adaptation to climate change also need to take into account endeavors to reduce vulnerabilities, particularly to social groups that are vulnerable to climate change, such as women, children, low income population, the aged, and so forth. These series of purposes of the RAN-API are described in the following resilience sectors, as shown in the following diagram (Figure 3.1).

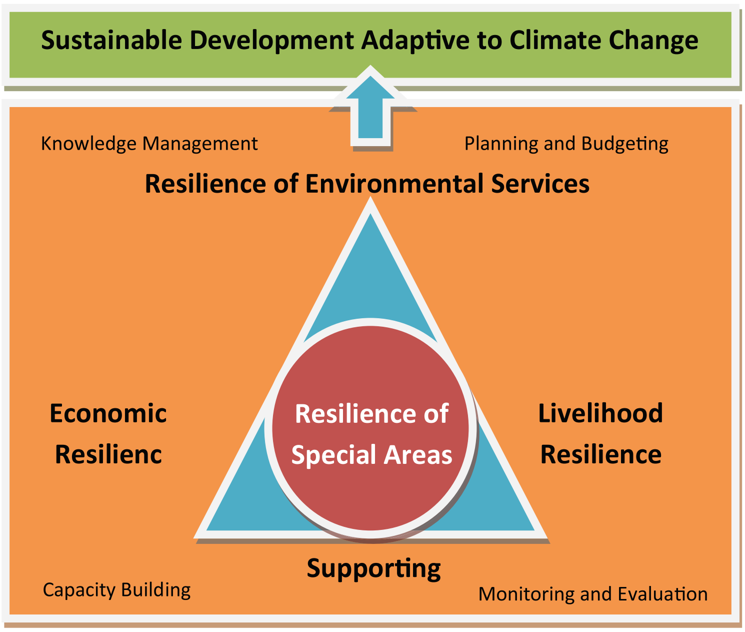


Figure 3.1 Main Goal of RAN-API

3.2 Objectives of RAN API

3.2.1 Economic Resilience

Economic resilience refers to the capacity of the sytem to maintain functions of the economic system and speedily recover when disruptions occur (Rose, 2009). The two fcators that determine the capacity of the system are food security and energy security. Disturbances that occur to these two factors attributed the not yet adequately developed capacity to adapt to climate change will directly affect economic resilience. RAN-API on economic resilience will only focus on these two factors.

3.2.1.1 Food Security

The overal target of food security is the realization of sustainable food security, in terms of supply, distribution and accessability, as well as in terms of self-reliance, soverignty, and security of food. The overall objective of food security will be hard to realize if the food agriculture development system does not have the resiliency against climate change and variability. Therefore,the main targets of RAN-API pertaining to food security are :

1. Reduced food production losses due to extreme climate occurrences and climate change.
2. Developed new growth regions for the production of food in regions with low climate risk and low emission.
3. Developed food security system of farmers and communities with a food pattern that is healthy and nutritious and balanced, and the realized food diversification to the optimum level.

The above three objectives are developed by taking into account economic aspects and the wellbeing of farmers, and its contribution to the mitigation of climate change and sustainability of the environment (*Climate Smart Agriculture*).

3.2.1.2 Energy Security

The objective of national energy development is the reduction of the share of oil consumption in the national energy consumption portfolio and increasing the share on non-oil energy. On the basis of Presidential Regulation No. 5 of 2006 on National Energy Policy, by 2025, the contribution of renewable energy, as one of the non-oil energy sources, will be increased to 17 percent of national energy demand. Two of the renewable energy sources that will have a significant effect on climate change are hydro power and biofuel. These two energy sources are targetted to contribute around 8 percent of the national energy need. Therefore, the adaptation action plan for ensuring the capacity of these two sources today and in the future in supporting national energy self-reliance is important. Thereby, the main objectives of the RAN-API regarding energy security are :

1. The developed energy sources from hydro power in regions that have low climate risk with a conducive ecosystem.
2. The developed vegetations for bioenergy (biomass and plant fuel) with a high productivity and that are resilient to climate change.
3. The optimized utilization of organic waste for the production of energy and gas, particularly in densely populated regions for reducing environmental pollution and enhancing the regional tolerance range to extreme rainfall occurrences.
4. The increased utilization of renewable energy in more rural areas that encourage preservation of the ecosystem and sustainable energy supply.

3.2.2 Livelihood Resilience

Livelihood resilience refers to the capacity of the community to maintain its living and in quickly restoring it when there is a disruptive occurrence (Uy et al., 2012). This is affected and determined by to what extent the relevant community has the resources that are required and can manage themselves before as well as during these are needed. Resilience of social life can be categorized into several sub areas, settlements, community housing, and infrastructure.

3.2.2.1 Health

As referred to above, climate change results in an increase in the surface temperature and in the variability of rainfall patterns, that both lead to the increase and spread of diseases and their vector through various mediums. In this respect, the RAN-API should encompass various objectives for community health in order to realize the objectives in resilience of the livelihood, namely the control of communicable and non communicable diseases on account of climate change. In order to realize such objectives, various objectoves in the sub area of community health need to be taken into account in the formulation of the adaptation action plan to climate change, among others :

1. The identification of vulnerability and risk factors on community health that can be attributed to climate change.
2. Strengthening of the alert system and utilization of the early warning system to the spread of communicable diseases and non communicable diseases that are attributed to climate change.
3. Strengthening of regulations, laws, and institutional capacity at the central as well as regional levels to risks on community health that can arise from climate change.
4. Strengthening of kwnoldge, innovation, and participation of the community in health adaptation to climate change.

3.2.2.2 Settlements

For supporting the livelihood that is resilient to the impact of climate change, the main objective in settlement is the creation of accessibility to housing that is adaptive to climate change and that is of reasonable standard and affordable. As referred to above, climate change leads to extreme rainfall patterns and weather that can result in the decline in the quality of the housing environment, particularly in areas with significant social vulnerabilities. In this respect, the targets of settlements are elaborated into the following :

1. Implementing research and studies for enhancing resilience of settlements that is adaptive to climate change.
2. Implementation of development and management of settlements that are integrated to endeavors to overcome the impact of climate change and are in line with sustainable development.
3. Enhanced understanding of stakeholders and general public on settlements that is resilient to climate change.
4. Increased access to reasonable and affordable housing.

3.2.2.3 Infrastructure

As is known, climate change results in changes to the patterns of rainfall, increase in the sea surface level, occurrences of extreme weather, that impact the quality of the national infrastructure. In order to support the livelihood that is sustainable and that is resilient to climate change, the main target of infrastructure is the enhanced coverage of services and strengthening of the infrastructure system that is reliable and of standard quality in facing the impact of climate change. This main objectives are elaborated into the following :

1. The developed concept of infrastructure resilience that is adaptive to climate change.
2. The reduced risk of the disrupted function of accesibility to roads and bridges due to the impact of climate change.
3. The provision of infrastructure on sanitation system and management of wastes that are resilient to climate change.
4. Management of infrastructure location that is integrated to the sptial plan in sustainable development.

3.2.3 Resilience of Environment Services

Environment services are services that are produced by various types of ecosystems that are beneficial to the environment and social life, such as water, oxygen, fertilization services. Climate change can disrupt such environmental services, namely in such forms as extreme drought that result in shortage of water, changes in types of vegetation due to change in weather patterns, water inundations due to the increase of sea water levels that cover fishing cultivation ponds and agricultural lands. Maintaining environmental services imply how to understand changes that will occur and to carry out adaptation activities to ensure that environmental services can be preserved. Environmental resiliency is not aimed at restoring the environmental pattern that has already been changed, even though endeavoring to implement a mechanism to prevent the same occurrence in that environment.

3.2.3.1 Ecosystem and Biodiversity

The general objective of ecosystem resiliency is the preservation of the forest ecosystem and core ecosystem from the impact of climate change, so that the existence of biodiversity and services of the ecosystem can be preserved. Biodiversity, as a key component in the ecosystem, is the provider of environmental services that holds the key to the sustainability of the ecosystem. The important roles of environmental services are in the provisioning services, regulating services, cultural services, and as supporting services. The preservation of the forest ecosystem, crucial zones, and biodiversity can ensure the availability of water and ecosystem services and become one of the key components for realizing food security, energy security, and livelihoods. These general targets can be attained if the disruptions and degradation mainly to the forest ecosystem can be reduced. Thereby the main objectives in resilience of the ecosystem and biodiversity are :

1. Reduction of the area extent of degraded forests due to forest fires during extreme climate years and due to illegal logging.
2. Increased forest coverage in priority river basin areas.
3. Reduction in the vanishing of endangered species due to climate change.
4. Development of a resilient ecosystem

These four objectives are developed by taking into account the principles of conservation and community welfare in the vicinity of forests (inluding traditional communities) and the role of Indonesia in mitigation of climate change.

3.2.4 Resilience of Special Areas

Climate change has different impacts to each areas in accordance their layouts, level of vulnerability, and characteristics of the respective areas. Resilience of special areas in the context of adaptation to climate change encompasses urban areas, coastal areas, and small islands. Resilience of urban areas encompass resilience of the urban areas itself and the interaction in the system of the urban system, in which the impact of climate change have direct affect on the spatial, physical features of the cities and to the economic networks of the urban community. Meanwhile, coastal areas and small islands have a high vulnerability due to the increase of sea surface level.

3.2.4.1 Resiliency of Urban Areas

In this RAN-API, the formulation of objectives for the urban area is made by attaining objectoves for the resilience of of special areas, such as urban areas, coastal areas, and small islands, and the reduction of natural disaster risks. The main objective of the urban area resilience is the creation of cities that are resilient to the climate, that can be realized through the attainment of among others the following objectives :

1. Integration of climate change adaptation into urban spatial planning.
2. Increased the quality of urban environment in the context of climate change adaptation.
3. Adjustment of urban infrastructure with the current threat of climate change.
4. Stability of livelihood in urban areas related to threat of climate change
5. Increased research and quality of information related to climate change in urban areas

3.2.4.2 Coastal Areas and Small Islands

In this RAN-API, formulation of objectives for Coastal Areas and Small Islands is conducted for attaining the objective of resilience in priority areas, namely the management of coastal areas and small islands that are vulnerable to the impact of climate change. To attain this objective, several of objectives are among others the following :

1. Increasing the capacity of community living in coastal areas and small islands related to the threat of climate change.
2. Management of quality of the environment of coastal areas and small islands in a sustainable manner.
3. Applying structural and non-structural adaptation measures in coastal areas and small islands that are vulnerable to climate change.
4. Integration of adaptation measures to climate change in the plan for managing coastal areas and small islands.
5. Increasing research and quality of information related to climate change for coastal areas and small islands.

3.2.5 Supporting System

The scope and achievements of the program in RAN API require support of resources, methodology for implementation, monitoring, and evaluation of performance to be able to overcome fragmentation of functions and main tasks of related Line Ministries/Government Agencies and for enhancing coordination.

Therefore, the supporting components that need to be strengthened are capacity building, development of data and information on the climate, research and development of science and technology, planning and budgeting, monitoring and evaluation and support the action program on adaptation to climate change.

Specifically, the components of the supporting system for the adaptation to climate change program must be able to be attained with measurable and explicit objectivs, such as the following :

1. Capacity building of stakeholders in climate change adaptation.
2. Development of climate information that is reliable and up-to-date.
3. Increasing research and development of science and technology that is related to climate change.
4. Planning and budgeting that can respond to climate change.
5. Monitoring and evaluation of climate change adaptation activities.

Chapter 4: Strategy and Action Plan

The effectiveness of programs for handling climate change of each sector in the context of supporting the implementation of a climate resilient development can be enhanced by developing synergy of adaptation action activities among sectors. Development targets of each sector cannot possible be optimally attained without being supported by other sectors. Therefore, the determination of adaptation action plans for each sector in the context of developing resiliency of the economy, social life system, ecosystem, and special areas against the impacts of climate change need to be viewed in terms of the interlinkages of programs among the sectors. This can become the basis for developing synergy and fill in the gap of adaptive actions that need to be developed for ensuring that the targets of the RASN API can be realized.

4.1 Economic Resilience

4.1.1 Sub-Sector of Food Security

The main strategy for attaining the objective of the sub-sector food security encompasses the following:

1. Adjustments and development of a farm enterprise system that is resilient to climate change;
2. Development and application of adaptive technology to impact of climate change;
3. Development and optimalization of land, water, and genetic resources.

The plan of actions on the food security may consist of:

1. Adjustment of food production system to climate change and variation
2. Expansion of food agricultral area
3. Restoration and development of agricultural infrastructure that is c*limate proof*
4. Acceleration of food diversification
5. Development of innovative and adaptive technology
6. Development of Information and communication system (climate and technology)
7. Supporting system

The technical implementation of the aforementioned action programs must be supported by scientific studies on vulnerability and impact of climate change to food security, and the policy synthesis and institutional development.

4.1.2 Sub-Sector Energy Security

The main strategies for attaining the objectives of the sub-sector energy encompass the following:

1. Restoring and conserving rainfall catchment areas in river basin regions that become the sources of hydropower and geothermal energy stations.
2. Optimizing the utilization of organic wastes and biomass and developing energy sources from biofuels.

The action plan on the energy security may consist of:

1. Restoration and conservation of rainfall catchment areas to increase climate resilient of the area
2. Expansion of the utilization of renewable energy sources to increase climate resilient of the area
3. Development of innovative and adaptive technology for the cultivication of energy plantations
4. Supporting system

4.2 Livelihood Resilience

4.2.1 Sub-Sector Health

The main strategy for attaining objectives of the sub-sector health encompasses the following :

1. Stren*gthening and upda*ting of information on vulnerability and health risks to climate change.
2. Development of policies, plans, networks, and cooperation among institutions at the local, regional, and national level, that are related to to health risks to climate change.
3. Strengthening the capacity of early warning in relation to the threat of climate change to health at the community and government levels.

The action plan of the health sub sector may consist of:

1. Identification and controlling of factors of vulnerability and risk to community health that can be caused by climate change
2. Strengthening the system of awareness and utilization of the early warning system to the spread of communicable and non communicable diseases attributed to climate change
3. Strengthening of regulations, laws, and institutional capacity at the central and regional levels against risks to community health caused by climate change.
4. Increasing knowledge, innovation, and participation of the general public in relation to health adaptation to climate change

4.2.2 Sub-Sector: Settlement

The main strategy for attaining the objective of the sub-sector settlement, encompasses the following :

1. Providing supporting facilities for acitivies on studies and research pertaining to resilient settlement that is adaptive to climate change.
2. Development of settlement structure that is resilient to climate change and that is affordable.
3. Dissemination of information on settlement that is resilient to climate change to governments of various levels.
4. Formulation of action programs of adaptation to climate change in the settlement sub sector that are based on the needs settlement sub sector in facing the impact of climate change.

The action plan for settlement sub sector may consist of:

1. Studies and research
2. Development and management of settlement
3. Community empowerment endeavors
4. Increasing access to reasonable and affordable housing

4.2.3 Sub-Sector: Infrastructure

The main strategy on the sub-sector infrastructure is as follows :

1. Adaptation in terms of structure, components, design, as well as location of infrastructure that is resilient to climate change.
2. Restoration of existing infrastructure that is vulnerable to climate change in terms of its structure, function, as well as its location.
3. Facilitation of studies and research on the concept of resilient infrastructure to climate change.

The action plan on the infrastructure may consist of:

1. Studies on the concept of infrastructure resiliency
2. Improving access to roads and bridges
3. Strengthening of institutions
4. Integration to sustainable development

4.3 Resilience of Environmental Services

4.3.1 Sub-Sector: Ecosystem and Biodiversity

The strategy for attaining the objectives of the sub-sector ecosystem and biodiversity may consist of:

1. Securing the availability of water and protection against extreme climate (securing water availability and protecting from extreme weather),
2. Avoiding ecosystem and biodiversity loss, and
3. Ensuring sustainable water supply and conservation of ecosystem and biodiversity

The action plan on the ecosystem and biodiversity may consist of:

1. Restoration/Improving Spatial Planning and Usage System of Land
2. Management and Utilization of Productive Areas in a Sustainable Manner
3. Enhancing Management of Conservation and Essential Ecosystem Areas
4. Rehabilitation of Degraded Ecosystems
5. Reducing Threat To Ecosystems
6. Developing Information and Communication System
7. Supporting Program

4.4 Resilience of Special Areas

4.4.1Sub-Sector Urban Area

The various strategies for attaining the objectoves of the sub-sector urban area are as follows:

1. Adjustment of urban spatial plan to the threat of climate change.
2. Management of urban environment in a sustainable manner.
3. Increasing the quality of urban infrastructure.
4. Capacity building of urban communities in facing the threat of climate change.
5. Developing and optimizing research and information system on climate change in urban areas.

The action plan for the sub-sector urban area may consist of :

1. Integration of spatial plan and adaptation efforts
2. Increasing the quality of the environment
3. Increasing the quality of urban infrastructure
4. Stability of social live of urban communities
5. Increasing research and quality of information

4.4.2 Sub-Sector of Coastal Areas and Small Islands

The strategy to be pursued for attaining the objectives of the sub-sector of coastal areas and small islands encompasses the following:

1. Ensuring the stability of social life of coastal communities and small islands against the threat of climate change.
2. Increasing the quality of the environment of coastal areas and small islands.
3. Implementing development of adaptation structures in coastal areas and small islands.
4. Adjusting spatial plans of urban areas against the threat of climate change
5. Developing and optimizing research and the information system on climate change in coastal areas and small islands.

The action plan for the sub sector of coastal areas and small islands may consist of :

1. Community live capacity development
2. Management of the quality of the environment
3. Application of structural and non structural adaptation actions
4. Integration of adaptation measures into the spatial plan
5. Increasing research and quality of information

4.5 Supporting System

The strategy of adaptation to climate change in RAN-API is to be in line with the five objectives of the supporting system. Capacity building is one of the objectives that is aimed at improving the capacity of stakeholders and communities in adapting to climate change. Capacity building put simply is also linked to endeavors for improving and enhancing the capacity that previously is low/weak or that had a high level of vulnerability to a level that is enhanced with regard to certain knowledge and skills and reducing factors that are deemed vulnerable to climate change. The program for increasing such capacity covers several levels, namely the level of the individual, institutional level, and the community level. In addition, endeavors of adaptation to climate change will also not yield effective results if they do not take into account the magnitude of vulnerability and estimated impacts/risks that they bring about. We do not know the difference of the levels of vulnerability and impacts of the respective regions. It is also necessary to conduct various studies for identifying the various causes of climate change. Other studies are directed at the identification of the strategy for adapting to the disaster from climate change. In that respect, it is necessary to have a strategy for developing the knowledge management against the risk and vulnerability in relation to climate change.

Various changes and cosequences that are measurable are essential for being able to accurately respond and adapt to climate change. Adaptation to climate change is also a key aspect that must be integrated in the development plans at the local, regional, and national levels. This is necessary for developing a development design that is resilient to the impact of climate change and to anomolous disturbances of the weather that occur today and anticipating its impacts in the future. Finally, monitoring and evaluation efforts provide information on the progess attained by the program, various problems that must be anticipated, the lessons learned, and so forth. Stakeholders that are related to the program of adaptation to climate change will subsequently analyze the information produced by the monitoring and evaluation in order to formulate the strategy for the future.

The action plan with regard to the supporting system may consist of :

1. Enhancing the capacity of stakeholders in adaptation to climate change
2. Development of climate information that is reliable and up to date
3. Increasing research and developing science and technology that are related to adaptation to climate change
4. Planning and budgeting that are responsive to climate change
5. Monitoring and evaluation of activities on adaptation to climate change

Table 4.1 Summary of National Action Plan for Climate Change Adaptation for 2013-2025

Economic Resilience: Food Security				
No	**Action Plan**	**Scope**	**Priority Location**	**Institution Involved**
1	Cluster 1: Adjustment of Food Production System to Climate Change and Variation	• Adaptation of food production system to climate variations and change through the development of types of crops, planting patterns and cultivation technology that is more resilient to extreme climate variation occurrences • Development of a climate information system, an integrated crop calendar information system and an early warning system, in terms of threats of droughts and floods as well as of organic disturbances that adversely affect crops, cattle, and fish. • Development of aquaculture production, fisheries as alternatives source of foods and better fisheries security	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and Fishery, Ministry of Public Works, Meteorological Climatology and Geophysics Agency, Disaster Management Agency.
2	Cluster 2: Expansion of Food Agricultral Area	• Expansion of agricultural food areas by taking into account the probability of changes in climate risks, environmental support by not reducing the area conservation functions. • Research and Development for better food production through a sustainable agriculture system • Expansion of aquaculture in potential areas	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and fishery
3	Cluster 3: Restoration and Development of Agricultural Infrastructure that is *Climate Proof*	• Developing a system that already takles into account climate change so that the system can function as expected under condition when the climate has changed • Development of water management technology which adapted to climate change • Rehabilitation and conservation of watershed to increase water absorbtion in order to reduce drought threats.	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and fishery, Ministry of Public Work
4	Cluster 4: Acceleration of Food Diversification	• Accelerating food diversification through the development of various healthy food outputs from commodities that are more resilient to the impact of climate changes and that are water efficient, particularly local food outputs (sago, 'ganyong', roots, beans, and other local food outputs). • Promotion of Food Mixed Policy	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and fishery
5	Cluster 5: Development of Innovative and Adaptive Technology	• Development of more adaptive innovative technology against the threat of climate change, • Development of varieties that are resistant to drought and floods, technology for managing cattle and fish, • Assembling of superior seeds that are adaptive to the threat of climate change and plant diseases and bioprocess technology that is anticipative to climate change • Develops indingenous technology, including local wisdom	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and fishery , Disaster Management Agency
6	Cluster 6: Development of Information and Communication System (Climate and Technology)	• Development of climate information system and communications • Development the capacity for analysis, prediction/estimation of climate/weather, developing networks climate information system, crop calender, development of network and institutions of system for communication,	33 Provinces in Indonesia that are Priority Areas in line with the issue and focus of activities	Ministry of Agriculture, Ministry of Marine and fishery , Disaster Management Agency , Ministry of Public Work